Anekant Education Society's

Tuljaram Chaturchand College of Arts, Science & Commerce, Baramati

(*Empowered Autonomous*)

Three/Four Year Honours/Honours with Research B.Sc. Degree Program in Mathematics
(Faculty of Science)

CBCS Syllabus

S.Y.B.Sc. (Mathematics)

For Department of Mathematics

NEP-2.0

Choice Based Credit System Syllabus

(2024 Pattern)

(As Per NEP-2020)

To be implemented from Academic Year 2025-26

Title of the Programme: B.Sc. (Mathematics)

Preamble

AES's Tuljaram Chaturchand College has made the decision to change the syllabus of across various faculties from June, 2023 by incorporating the guidelines and provisions outlined in the National Education Policy (NEP), 2020. The NEP envisions making education more holistic and effective and to lay emphasis on the integration of general (academic) education, vocational education and experiential learning. The NEP introduces holistic and multidisciplinary education that would help to develop intellectual, scientific, social, physical, emotional, ethical and moral capacities of the students. The NEP 2020 envisages flexible curricular structures and learning based outcome approach for the development of the students. By establishing a nationally accepted and internationally comparable credit structure and courses framework, the NEP 2020 aims to promote educational excellence, facilitate seamless academic mobility, and enhance the global competitiveness of Indian students. It fosters a system where educational achievements can be recognized and valued not only within the country but also in the international arena, expanding opportunities and opening doors for students to pursue their aspirations on a global scale.

In response to the rapid advancements in science and technology and the evolving approaches in various domains of Mathematics and related subjects, the Board of Studies in Mathematics at Tuljaram Chaturchand College, Baramati - Pune, has developed the curriculum for the third semester of S.Y.B.Sc. (Mathematics), which goes beyond traditional academic boundaries. The syllabus is aligned with the NEP 2020 guidelines to ensure that students receive an education that prepares them for the challenges and opportunities of the 21st century. This syllabus has been designed under the framework of the Choice Based Credit System (CBCS), taking into consideration the guidelines set forth by the National Education Policy (NEP) 2020, LOCF (UGC), NCrF, NHEQF, Prof. R. D. Kulkarni's Report, Government of Maharashtra's General Resolution dated 20th April and 16th May 2023, and 13th March, 2024 and Circular of SPPU, Pune dated 31st May 2023.

A Mathematics degree equips students with the knowledge and skills necessary for a diverse range of fulfilling career paths. Graduates in Mathematics find opportunities in various fields, including Financial Planner, Market Research Analyst, Data Scientist, teaching, Insurance underwriter, operations research analyst, software developer, and many other domains. After graduating with a degree in mathematics, students can embark on a multitude of rewarding and diverse career paths. The analytical and problem-solving skills honed during their studies equip them with a strong foundation for success in various fields. Many graduates choose to pursue careers in academia and research, where they can contribute to the advancement of mathematical knowledge through teaching, publishing papers, and conducting ground breaking research. Others may opt for careers in the financial sector, such as investment banking or actuarial science, utilizing their expertise in mathematical modelling and statistical analysis to make informed decisions and manage risks. Additionally, the field of data science offers abundant opportunities for mathematics graduates, as they possess the ability to extract meaningful insights from complex data sets and develop algorithms that drive innovation in industries like technology, healthcare, and marketing. Moreover, mathematics graduates can find fulfilling careers in engineering, cryptography, software development, and operations research, to name just a few areas where their mathematical skills are highly sought after. Overall, a degree in mathematics opens doors to a wide range of intellectually stimulating and financially rewarding professions, allowing graduates to make significant contributions to society and thrive in a rapidly evolving world.

Overall, revising the Mathematics syllabus in accordance with the NEP 2020 ensures that students receive an education that is relevant, comprehensive, and prepares them to navigate the dynamic and interconnected world of today. It equips them with the knowledge, skills, and competencies needed to contribute meaningfully to society and pursue their academic and professional goals in a rapidly changing global landscape.

Credit Distribution Structure as per NEP 2020 (for NEP 2.0 2024 Pattern)

Level/ Difficulty	Sem	Subject DSC-1	Subject DSC-2	Subject DSC-3	GE/OE	SEC	IKS	AEC	VEC	CC	Total
4.5/100	I	2(T)+2(P)	2(T)+2(P)	2(T)+ 2(P)	2(T)	2 (T/P)	2(T) (Generic)	2(T)	2(T)	--	**22**
	II	2(T)+2(P)	2(T)+2(P)	2(T)+2(P)	2(P)	2 (T/P)	--	2(T)	2(T)	2(T	**22**
Exit option: Award of UG Certificate in Major with 44 credits and an additional 4 credits core NSQF course/Internship OR Continue with Major and Minor **Continue option**: Student will select one subject among the (subject 1, subject 2 and subject 3) as major and other as minor and third subject will be dropped.											

Level/ Difficulty	Sem	Credits Related to Major: Major Core	Major Elective	VSC	FP/OJT/CEP/RP	Minor	--	GE/OE	SEC	IKS	AEC	VEC	CC	Total
5.0/200	III	4(T)+2(P)	--	2 (T/P)	2(FP)	2(T)+2(P)	--	2(T)	--	2(T)	2(T)	--	2(T)	**22**
	IV	4(T)+2(P)	--	2 (T/P)	2(CEP)	2(T)+2(P)	--	2(P)	2 (T/P)	--	2(T)	--	2(T)	**22**
Exit option: Award of UG Diploma in Major and Minor with 88 credits and an additional 4credits core NSQF course/Internship OR Continue with Major and Minor														
5.5/300	V	8(T)+4(P)	2(T)+2(P)	2 (T/P)	2(FP/CEP)	2(T)	--	--	--	--	--	--	--	**22**
	VI	8(T)+4(P)	2(T)+2(P)	2 (T/P)	4 (OJT)	--	--	--	--	--	--	--	--	**22**
Total 3Years		**44**	**8**	**8**	**10**	**18**	**8**	**8**	**6**	**4**	**8**	**4**	**6**	**132**
Exit option: Award of **UG Degree in Major** with 132 credits OR Continue with Major and Minor														
6.0/400	VII	6(T)+4(P)	2(T)+2 (T/P)	--	4(RP)	4(RM)(T)	--	--	--	--	--	--	--	**22**
	VIII	6(T)+4(P)	2(T)+2 (T/P)	--	6(RP)	--	--	--	--	--	--	--	--	**22**
Total 4Years		**64**	**16**	**8**	**22**	**22**	**8**	8	**6**	**4**	**8**	**4**	**6**	**176**
Four Year **UG Honours with Research Degree** in Major and Minor with 176 credits														
6.0/400	VII	10(T)+4(P)	2(T)+2 (T/P)	--	--	4(RM) (T)	--	--	--	--	--	--	--	**22**
	VIII	10(T)+4(P)	2(T)+2 (T/P)	--	4 (OJT)	--	--	--	--	--	--	--	--	**22**
Total 4Years		**72**	**16**	**8**	**14**	**22**	**8**	8	**6**	**4**	**8**	**4**	**6**	**176**
Four Year **UG Honours Degree** in Major and Minor with 176 credits														

T = Theory **P** = Practical **DSC** = Discipline Specific Course **OE** = Open Elective **SEC** = Skill Enhancement Course
IKS = Indian Knowledge System **AEC** = Ability Enhancement Course **VEC** = Value Education Course **CC** = Co-curricular Course
VSC= Vocational Skill Course **OJT**= On Job Training **CEP**= Community Engagement Project **FP**= Field Project **RP**= Research Project

Anekant Education Society's

Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati

(Empowered Autonomous)

NEP-2.0

Course Structure for F.Y.B.Sc. (2024 Pattern as per NEP-2020)

Sem	Course Type	Course Code	Course Title	Theory / Practical	Credits
I	DSC-I (General)	-101-GEN		Theory	02
		-102-GEN		Practical	02
	DSC-II (General)	-101-GEN		Theory	02
		-102-GEN		Practical	02
	DSC-III (General)	MAT-101-GEN	Algebra and Calculus	Theory	02
		MAT-102-GEN	Algebra and Calculus Practical with Python	Practical	02
	Open Elective (OE)	MAT-103-OE	Basic Mathematics	Theory	02
	Skill Enhancement Course (SEC)	MAT-104-SEC	Scilab Software	Practical	02
	Ability Enhancement Course (AEC)	ENG-104-AEC		Theory	02
	Value Education Course (VEC)	ENV-105-VEC		Theory	02
	Generic Indian Knowledge System (GIKS)	GEN-106-IKS		Theory	02
				Total Credits Semester-I	**22**
II	DSC-I (General)	-151-GEN		Theory	02
		-152-GEN		Practical	02
	DSC-II (General)	-151-GEN		Theory	02
		-152-GEN		Practical	02
	DSC-III (General)	MAT-151-GEN	Geometry and Differential Calculus	Theory	02
		MAT-152-GEN	Geometry and Differential Calculus Practical with Geogebra	Practical	02
	Open Elective (OE)	MAT -153-OE	Applied Mathematics	Practical	02
	Skill Enhancement Course (SEC)	MAT -154-SEC	Maxima Software	Practical	02
	Ability Enhancement Course (AEC)	ENG-154-AEC		Theory	02
	Value Education Course (VEC)	COS-155-VEC		Theory	02
	Co-curricular Course (CC)	YOG/PES/CUL/ NSS/NCC-156-CC	To be selected from the CC Basket	Theory	02
				Total Credits Semester-II	**22**
				Cumulative Credits Semester I + Semester II	**44**

Course Structure for S.Y.B.Sc. Mathematics (2024 Pattern as per NEP-2020)

Sem	Course Type	Course Code	Course Title	Theory / Practical	Credits
III	Major Mandatory	MAT-201-MRM	Multivariable Calculus	Theory	2
	Major Mandatory	MAT-202-MRM	Laplace Transform	Theory	2
	Major Mandatory	MAT-203-MRM	Practical based on Multivariable Calculus and Laplace Transform	Practical	2
	Vocational Skill Course (VSC)	MAT-204-VSC	Practical based on Numerical Methods	Practical	2
	Field Project (FP)	MAT-205-FP	Field Project	Practical	2
	Minor	MAT-206-MN	Fundamentals of Linear Algebra	Theory	2
	Minor	MAT-207-MN	Practical based on Differential Equations	Practical	2
	Open Elective (OE)	MAT-208-OE	Fundamentals of Higher Mathematics	Theory	2
	Subject Specific Indian Knowledge System (IKS)	MAT-209-IKS	Vedic Mathematics	Theory	2
	Ability Enhancement Course (AEC)	MAR-210-AEC		Theory (Any One)	2
		HIN-210-AEC			
		SAN-210-AEC			
	Co-curricular Course (CC)	YOG/PES/CUL /NSS/NCC-211-CC	To be continued from Semester – II	Theory	2
				Total Credits Semester-III	**22**
IV	Major Mandatory	MAT-251-MRM	Vector Analysis	Theory	2
	Major Mandatory	MAT-252-MRM	Introduction to Linear Algebra	Theory	2
	Major Mandatory	MAT-253-MRM	Practical based on Vector Analysis and Linear Algebra	Practical	2
	Vocational Skill Course (VSC)	MAT-254-VSC	Set Theory and Logic	Theory	2
	Community Engagement Project (CEP)	MAT-255-CEP	Community Engagement Project	Practical	2
	Minor	MAT-256-MN	Multivariable Calculus	Theory	2
	Minor	MAT-257-MN	Practical based on Numerical Analysis	Practical	2
	Open Elective (OE)	MAT-258-OE	Basic Applications of Mathematics	Practical	2
	Skill Enhancement Course (SEC)	MAT-259-SEC	LaTeX Software	Practical	2
	Ability Enhancement Course (AEC)	MAR-260-AEC		Theory (Any One)	2
		HIN-260-AEC			
		SAN-260-AEC			
	Co-curricular Course (CC)	YOG/PES/CUL /NSS/NCC-261-CC	To be continued from Semester – III	Theory	2
				Total Credits Semester-IV	**22**
				Cumulative Credits Semester III + Semester IV	**44**

Programme Specific Outcomes (PSOs)

PSO 1-Proficiency in Mathematical Concepts: Graduates will have a deep understanding of fundamental mathematical concepts and theories across various branches of mathematics, including calculus, algebra, geometry, probability, and statistics.

PSO 2-Problem-Solving Skills: Graduates will possess strong problem-solving skills and the ability to apply mathematical principles to real-world situations. They can analyze complex problems, develop logical reasoning, and devise creative strategies to find solutions.

PSO 3-Mathematical Modeling: Graduates will be proficient in mathematical modeling, which involves using mathematical techniques to describe and analyze real-world phenomena. They can formulate and solve mathematical models to address problems in diverse fields, including physics, economics, engineering, and social sciences.

PSO4-Computational and Analytical Skills: Graduates will be skilled in using computational tools and software, such as programming languages, statistical software, and mathematical modeling software. They can leverage these tools to perform numerical analysis, data visualization, and simulations.

PSO 5-Communication and Presentation: Graduates will possess effective communication skills, both written and oral, to convey complex mathematical ideas and results to both technical and non-technical audiences. They can present mathematical arguments, proofs, and findings in a clear and concise manner.

PSO 6-Research and Inquiry: Graduates will have the ability to engage in mathematical research and inquiry. They can critically evaluate existing mathematical theories, develop new mathematical models, and contribute to the advancement of mathematical knowledge through independent research or collaborative projects.

PSO 7-Interdisciplinary Collaboration: Graduates will be adept at collaborating with professionals from other disciplines, such as scientists, engineers, economists, and computer scientists. They can effectively communicate and work in multidisciplinary teams to solve complex problems that require mathematical expertise.

PSO 8-Lifelong Learning: Graduates will have developed a strong foundation for lifelong learning in mathematics. They will have the skills to stay abreast of new developments in the field, adapt to emerging technologies and methodologies, and continue their professional growth through self-directed study or advanced academic pursuits.

PSO 9-Advanced Mathematical Techniques: Graduates will have a command of advanced mathematical techniques, such as differential equations, mathematical analysis, linear algebra, number theory, and optimization. They can apply these advanced mathematical tools to solve complex problems and contribute to specialized areas of research.

PSO 10-Mathematical Software Development: Graduates will possess programming skills and the ability to develop mathematical software or algorithms. They can design, implement, and optimize software applications that facilitate mathematical calculations, simulations, data analysis, and modeling.

PSO 11-Mathematical Education and Teaching: Graduates interested in pursuing a career in education will have the necessary skills to teach mathematics at various levels. They can design and deliver effective lessons, develop curriculum materials, and assess student progress in mathematics. They can also inspire and motivate students to develop an appreciation for the subject.

PSO 12-Mathematical Finance and Risk Analysis: Graduates with an interest in finance and economics will have specialized knowledge in mathematical finance and risk analysis. They can apply mathematical models, stochastic calculus, and statistical methods to analyze financial markets, manage investment portfolios, assess risk, and make informed financial decisions.

CBCS Syllabus as per NEP 2020 for S.Y.B.Sc. Mathematics (2024 Pattern)

Name of the Programme : B.Sc. Mathematics
Program Code : USMT
Class : S.Y.B.Sc.
Semester : III
Course Type : Major Mandatory
Course Name : Multivariable Calculus
Course Code : MAT-201-MRM
No. of Teaching Hours : 30
No. of Credits : 2

Course Objectives:

1. To understand fundamental set concepts by exploring sets, operations on sets, and the notions of equivalence and countability.
2. To define and analyze functions by studying various types of functions, including real-valued functions, and their properties.
3. To examine the real number system by investigating the properties of real numbers, including the least upper bound principle.
4. To analyze sequences of real numbers by studying sequences, subsequences, convergence, and monotonicity.
5. To explore the properties of bounded sequences and understand their significance in real analysis.
6. To investigate advanced sequence concepts by studying operations on sequences, limit superior, limit inferior, and their implications.
7. To understand Cauchy sequences by examining their properties and importance in real analysis.

Course Outcomes:

CO1: Students will be able to represent vectors geometrically and algebraically and perform basic operations on vectors.
CO2: Students will demonstrate proficiency in computing dot and cross products and interpreting their geometric significance.
CO3: Students will be able to differentiate and integrate vector functions and interpret the results in terms of motion in space.
CO4: Students will be able to compute arc length and curvature of space curves and apply them in practical scenarios.
CO5: Students will understand the concept of partial derivatives and apply them to functions of several variables.
CO6: Students will be able to calculate directional derivatives and use them to analyze the rate of change of multivariable functions in given directions.
CO7: Students will apply optimization techniques to find maximum and minimum values of functions of several variables and solve constrained optimization problems using Lagrange multipliers.

Topics and Learning Points

	Teaching Hours
Unit 1: Vectors	**05**
1.1 Vectors	
1.2 The dot product	
1.3 The cross product	
Unit 2: Vector Functions	**09**
2.1 Vector functions and space curves	
2.2 Derivatives and integrals of vector functions	
2.3 Arc length and curvature	
2.4 Motion in space: Velocity and Acceleration	
Unit 3: Partial Derivatives	**09**
3.1 Functions of several variables	
3.2 Limits and continuity	
3.3 Partial derivatives	
3.4 Tangent planes and linear approximations	
3.5 The chain rule	
Unit 4: Optimization Techniques	**07**
4.1 Directional derivatives	
4.2 The gradient vector	
4.3 Maximum and minimum values	
4.4 Lagrange multipliers	

Text Book:

James Stewart, *Calculus with Early Transcendental Functions*, Cengage Learning, Indian Edition

Unit 1: Sections 12.2 to 12.4, **Unit 2:** Sections 13.1 to 13.4,
Unit 3: Sections 14.1 to 14.5, **Unit 4:** Sections 14.6 to 14.8.

Reference Books:

1. G. B. Thomas, *Thomas' Calculus*, Pearson, Edition 2012.
2. Tom M. Apostol, *Calculus Vol. II*, John Wiley.
3. Shanti Narayan and R. K. Mittal, *A text-book of Vector Calculus*, S. Chand and Company.
4. J. E. Marsden, A. J. Tromba and A. Weinstein, *Basic Multivariable Calculus*, Springer.
5. D. V. Widder, *Advanced Calculus*, Printice Hall of India.

CO-PO Mapping

Weightage: 1 – weak or low relation, 2 – moderate or partial relation, 3 – strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO01	3	3	3	3	3	3	3
PO02	2	3	3	3	3	3	3
PO03	1	1	1	1	2	2	3
PO04	2	2	3	3	3	3	3
PO05	2	3	3	3	3	3	3
PO06	1	1	2	2	2	2	2
PO07	1	1	2	2	2	2	3
PO08	2	2	3	3	3	3	3
PO09	1	1	2	2	2	2	2
PO10	1	1	1	1	1	1	1
PO11	1	1	1	1	1	1	1
PO12	2	2	2	2	3	3	3
PO13	1	1	1	1	2	2	2

Justification for the mapping

PO1: ***Comprehensive knowledge and understanding*** - CO1 to CO7 are rated 3 because they all contribute to a deep understanding of vector calculus, including vector operations, differentiation, integration, curvature, and optimization.

PO2: ***Practical, professional, and procedural knowledge*** - CO1 is rated 2 since basic vector operations are foundational but not directly practical and CO2 to CO7 are rated 3 because computing dot/cross products, differentiating/integrating vector functions, and applying optimization techniques are essential in applied mathematics and engineering.

PO3: ***Entrepreneurial mindset and knowledge*** **-** CO1 to CO4 are rated 1 as they provide foundational knowledge without a direct entrepreneurial link, CO5 and CO6 are rated 2 as understanding partial derivatives and directional derivatives can support innovation in applied fields and CO7 is rated 3 since optimization techniques, including constrained optimization, are critical in business, economics, and engineering applications.

PO4: ***Specialized skills and competencies*** - CO1 and CO2 are rated 2 because vector operations and dot/cross products are fundamental but not specialized skills and CO3 to CO7 are rated 3 as vector calculus, curvature, partial derivatives, and optimization techniques are essential in advanced mathematical applications.

PO5: ***Capacity for Application, Problem-Solving, and Analytical Reasoning*** - CO1 is rated 2 as basic vector operations contribute to problem-solving but are introductory and CO2 to CO7 are rated 3 since they involve applying mathematical concepts to real-world problems, particularly in physics and engineering.

PO6: ***Communication skills and collaboration*** - CO1 to CO7 are rated 1 or 2 since these topics primarily develop individual analytical skills, but discussing solutions and interpretations requires communication.

PO7: ***Research-related skills*** - CO1 and CO2 are rated 1 since fundamental operations have limited research applications, CO3 to CO6 are rated 2 as they introduce concepts applicable in research and CO7 is rated 3 because optimization techniques and Lagrange multipliers are widely used in research.

PO8: ***Learning how to learn skills*** - CO1 and CO2 are rated 2 as they help develop mathematical intuition and CO3 to CO7 are rated 3 because higher-level vector calculus concepts require continuous learning and problem-solving.
PO9: ***Digital and technological skills*** - CO1 and CO2 are rated 1 since vector operations are usually done manually and CO3 to CO7 are rated 2 because computational tools (e.g., MATLAB, Python) can be used to analyze functions, curvature, and optimization problems.
PO10: ***Multicultural competence, inclusive spirit, and empathy*** - CO1 to CO7 are rated 1 as vector calculus concepts have minimal direct relation to cultural or social competence.
PO11: ***Value inculcation and environmental awareness*** - CO1 to CO7 are rated 1 since mathematical concepts do not directly address values or environmental concerns.
PO12: ***Autonomy, responsibility, and accountability*** - CO1 to CO4 are rated 2 as solving mathematical problems fosters independent thinking and CO5 to CO7 are rated 3 because advanced problem-solving in partial derivatives and optimization demands self-directed learning and accountability.
PO13: ***Community engagement and service*** - CO1 to CO4 are rated 1 as their impact on community engagement is limited and CO5 to CO7 are rated 2 since optimization and problem-solving techniques can be applied to social, economic, and engineering challenges.

CBCS Syllabus as per NEP 2020 for S.Y.B.Sc. Mathematics (2024 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** S.Y.B.Sc.
Semester	**:** III
Course Type	**:** Major Mandatory
Course Name	**:** Laplace Transforms
Course Code	**:** MAT-202-MRM
No. of Teaching Hours	**:** 30
No. of Credits	**:** 2

Course Objectives:

1. To equip the students with the knowledge of Laplace and Fourier Transforms and their Inverses.
2. To train the students to convert Differential Equations into algebraic equations by applying Laplace transform and solve them.
3. To develop proficiency in manipulating Fourier Series to analyze periodic functions and solve differential equations with periodic boundary conditions.
4. To understand the significance of these mathematical tools in various applications such as electrical circuits, control systems, heat transfer, vibrations, and signal analysis.
5. To analyze the advantages and limitations of Laplace Transforms and Fourier Series compared to other mathematical methods.
6. Apply Laplace Transforms and Fourier Series techniques to model and solve real-world problems in engineering, physics, signal processing, and other related fields.
7. To interpret and visualize the results obtained from numerical computations.

Course Outcomes:

CO1: Students will be able to demonstrate thorough understanding of the principles and concepts of Laplace Transforms, Inverse Laplace Transforms and Fourier Series.
CO2: Students will be able to understand the required conditions for transforming variables in functions by the Laplace transform.
CO3: Students will be able to find Laplace transforms of derivatives, integrals and periodic functions.
CO4: Students will be able to solve differential equations with initial conditions using Laplace transform.
CO5: Students will be able to understand some special functions such as Gamma Function, Unit Step function and Dirac Delta Function.
CO6: Students will be able to apply Laplace Transforms and Fourier Series techniques to model and analyze engineering and physical systems, including electrical circuits, control systems, heat transfer problems, and vibrations.
CO7: Students will be able to develop the skills and motivation to seek out and engage with advanced topics related to Laplace Transforms, Fourier Series, and related mathematical techniques.

Topics and Learning Points

	Teaching Hours
Unit 1: The Laplace Transform	**10**
1.1 Laplace Transform of some elementary functions	
1.2 Some important properties of Laplace Transform	
1.3 Laplace Transform of derivatives, Laplace Transform of Integrals	
1.4 Methods of finding Laplace Transform, Evaluation of Integrals	
1.5 The Gamma function, Unit step function and Dirac delta function	
Unit 2: The Inverse Laplace Transform	**09**
2.1 Inverse Laplace Transform of some elementary functions	
2.2 Some important properties of Inverse Laplace Transform	
2.3 Inverse Laplace Transform of derivative and integrals	
2.4 Convolution Theorem	
2.5 Evaluation of Integrals	
Unit 3: Applications of Laplace Transform	**04**
3.1 Solution of Ordinary Differential Equations with constant coefficients	
Unit 4: Fourier Series	**07**
4.1 Fourier series	
4.2 Odd and even functions	
4.3 Half range Fourier sin and cosine series	
4.4 The Fourier Integral, Dirichlet Conditions	

Text Book:

Murray R. Spiegel, *Schaum's Outlines Laplace Transforms*, McGraw-Hill Education.

Unit 1: Chapter 1, **Unit 2:** Chapter 2,
Unit 3: Chapter 3, **Unit 4:** Chapter 6.

Reference Books:

1. Phil Dyke, *An Introduction to Laplace Transforms and Fourier Series*, Springer.
2. Rajendra Thete, *A Textbook of Laplace Transform and Fourier Series*, Advent Publishing.
3. Joel L. Schiff, *The Laplace Transforms - Theory and Applications*, Springer- Verlag, New York 1999.
4. N. W. McLachlan, *Laplace Transform and their Applications to Differential Equations*, Dover.
5. Georgi P. Tolstov, *Fourier Series*, Lushena Books.

CO-PO Mapping

Weightage: 1 – weak or low relation, 2 – moderate or partial relation, 3 – strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO01	3	3	3	3	3	3	3
PO02	2	2	2	3	2	3	3
PO03	1	1	1	2	1	2	1
PO04	2	2	2	3	2	3	3
PO05	2	3	3	3	2	3	3
PO06	1	1	1	2	1	2	2
PO07	2	2	2	3	2	3	3
PO08	2	2	2	3	2	3	3
PO09	1	1	1	2	1	2	2
PO10	1	1	1	1	1	1	2
PO11	1	1	1	1	1	1	1
PO12	2	2	2	3	2	3	3
PO13	1	1	1	2	1	2	2

Justification for the mapping

PO1: ***Comprehensive knowledge and understanding*** - CO1 ensures a deep understanding of Laplace Transforms, Inverse Laplace Transforms, and Fourier Series and CO2 to CO7 reinforce knowledge by applying theoretical concepts to mathematical and engineering problems.

PO2: ***Practical, professional, and procedural knowledge*** – CO4, CO6 and CO7 involve solving differential equations and applying Laplace Transforms in practical scenarios like electrical circuits and control systems whereas CO1, CO2, CO3 and CO5 provide foundational knowledge necessary for practical applications.

PO3: ***Entrepreneurial mindset and knowledge*** **-** CO4 and CO6 develop problem-solving skills relevant to industry applications and other COs contribute marginally by providing theoretical foundations.

PO4: ***Specialized skills and competencies*** - CO4, CO6 and CO7 emphasize advanced problem-solving skills essential for specialized fields whereas other COs lay the groundwork for these skills.

PO5: ***Capacity for Application, Problem-Solving, and Analytical Reasoning*** - CO4 and CO6 focus on applying Laplace Transforms to real-world problems. Also, CO2 and CO3 contribute by establishing necessary mathematical skills.

PO6: ***Communication skills and collaboration*** - CO4 and CO6 require explaining mathematical solutions effectively in technical and collaborative settings.

PO7: ***Research-related skills*** - CO4, CO6, and CO7 enhance research skills by fostering critical thinking and problem-solving in advanced topics.

PO8: ***Learning how to learn skills*** - CO4, CO6, and CO7 encourage independent learning and exploration of advanced mathematical techniques.

PO9: ***Digital and technological skills*** - CO4 and CO6 require computational approaches for solving complex equations.

PO10: ***Multicultural competence, inclusive spirit, and empathy*** - CO7 promotes collaborative learning and teamwork in solving complex mathematical problems.
PO11: ***Value inculcation and environmental awareness*** - Mathematical techniques indirectly contribute to sustainability in engineering and applied sciences.
PO12: ***Autonomy, responsibility, and accountability*** - CO4, CO6, and CO7 require independent learning, responsibility, and decision-making.
PO13: ***Community engagement and service*** - CO4 and CO6 support real-world applications that can benefit communities through engineering and applied mathematics.

CBCS Syllabus as per NEP 2020 for S.Y.B.Sc. Mathematics (2024 Pattern)

Name of the Programme	: B.Sc. Mathematics
Program Code	: USMT
Class	: S.Y.B.Sc.
Semester	: III
Course Type	: Major Mandatory
Course Name	: Practical based on Multivariable Calculus and Laplace Transforms
Course Code	: MAT-203-MRM
No. of Teaching Hours	: 60
No. of Credits	: 2

Course Objectives:

1. To introduce vector functions and space curves, helping students understand their parametric representations and applications.
2. To develop concepts of curvature, velocity, and acceleration, emphasizing their geometric and physical significance.
3. To familiarize students with multivariable calculus topics, including level curves, partial derivatives, and tangent planes.
4. To apply concepts of directional derivatives, gradients, and optimization techniques to find maximum and minimum values of functions.
5. To introduce the fundamental concepts of Laplace and inverse Laplace transforms and their properties for solving differential equations.
6. To develop an understanding of Fourier series expansion and its applications in representing periodic functions.
7. To enable students to apply Laplace and Fourier methods in solving real-world problems in engineering and science.

Course Outcomes:

CO1: Students will be able to analyze vector functions, compute derivatives, and describe space curves.
CO2: Students will demonstrate understanding of curvature, velocity, and acceleration in the motion of particles in space.
CO3: Students will be able to compute and interpret partial derivatives, directional derivatives, and gradients in multivariable functions.
CO4: Students will apply multivariable calculus techniques to find tangent planes, linear approximations, and optimize functions using maximum and minimum values.
CO5: Students will be able to compute Laplace and inverse Laplace transforms of elementary functions and use their properties effectively.
CO6: Students will be able to solve differential equations using the Laplace transform and apply the inverse Laplace transform using partial fractions.
CO7: Students will be able to expand functions in Fourier series and verify Dirichlet conditions for their convergence.

Topics and Learning Points

	Teaching Hours
Practical based on Multivariable Calculus:	**30**

1) Vector functions and space curves
2) Curvature, velocity and acceleration
3) Level curves and partial derivatives
4) Tangent planes and linear approximations
5) Directional derivatives and gradient
6) Maximum and minimum values

Practical based on Laplace Transforms:	**30**

1. Laplace transforms of elementary functions
2. Properties of Laplace transform
3. Inverse Laplace transform using partial fractions
4. Solving differential equations using Laplace transform
5. Fourier series expansion
6. Verification of Dirichlet conditions for Fourier series

CO-PO Mapping

Weightage: 1 – weak or low relation, 2 – moderate or partial relation, 3 – strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO01	3	3	3	3	3	3	3
PO02	2	3	3	3	3	3	2
PO03	1	1	1	1	2	2	2
PO04	2	2	3	3	3	3	3
PO05	3	3	3	3	3	3	3
PO06	1	1	1	1	1	1	2
PO07	2	2	3	3	2	2	3
PO08	3	3	3	3	3	3	3
PO09	1	1	2	2	2	2	2
PO10	1	1	1	1	1	1	1
PO11	1	1	1	1	1	1	1
PO12	2	2	2	3	3	3	2
PO13	1	1	1	1	1	1	1

Justification for the mapping

PO1: *Comprehensive knowledge and understanding* - All COs are mapped strongly as they cover fundamental concepts of vector calculus, Laplace transforms, and Fourier series, ensuring students gain a deep theoretical understanding.

PO2: *Practical, professional, and procedural knowledge* - Strong relation with CO2–CO6 since they involve mathematical techniques applicable in physics and engineering and moderate relation with CO1 and CO7, as they contribute indirectly to professional knowledge.

PO3: *Entrepreneurial mindset and knowledge* - Weak relation with CO1 to CO4 since they are primarily theoretical and not directly linked to entrepreneurship whereas moderate relation with CO5 to CO7, as Laplace transforms and Fourier series are widely used in applied sciences and technology-driven fields.

PO4: *Specialized skills and competencies* - Strong relation with CO3–CO7, as these involve specialized mathematical skills like computing gradients, optimizing functions, solving differential equations, and applying Fourier and Laplace transforms and moderate relation with CO1 and CO2, as they introduce necessary computational techniques.

PO5: *Capacity for Application, Problem-Solving, and Analytical Reasoning* - Strong relation with all COs, as each involves problem-solving, analytical thinking, and mathematical reasoning.

PO6: *Communication skills and collaboration* - Weak relation with CO1–CO6 since these topics are more focused on computation than communication and moderate relation with CO7, as Fourier series applications require interpretation and presentation of periodic functions.

PO7: *Research-related skills* - Strong relation with CO3, CO4, and CO7, as these topics contribute to advanced research in applied mathematics and moderate relation with CO1, CO2, CO5, and CO6, as they provide foundational knowledge useful in research.

PO8: *Learning how to learn skills* - Strong relation with all COs, as mastering multivariable calculus, Laplace transforms, and Fourier series requires continuous learning and adaptation.

PO9: *Digital and technological skills* - Weak relation with CO1 and CO2, as they do not directly require computational tools and moderate relation with CO3–CO7, as these topics often involve the use of software for solving mathematical problems.

PO10: ***Multicultural competence, inclusive spirit, and empathy*** **-** Weak relation with all COs, as mathematical computations have limited direct connection to multicultural competence.
PO11: ***Value inculcation and environmental awareness*** - Weak relation with all COs, as the course does not directly address environmental concerns.
PO12: ***Autonomy, responsibility, and accountability*** **-** Strong relation with CO4–CO6, as solving optimization problems and differential equations requires independent learning whereas moderate relation with CO1–CO3 and CO7, as they contribute to developing self-discipline in learning.
PO13: ***Community engagement and service*** **-** Weak relation with all COs, as the topics covered do not directly involve community engagement.

CBCS Syllabus as per NEP 2020 for S.Y.B.Sc. Mathematics (2024 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** S.Y.B.Sc.
Semester	**:** III
Course Type	**:** Vocational Skill Course
Course Name	**:** Practical based on Numerical Methods
Course Code	**:** MAT-204-VSC
No. of Teaching Hours	**:** 60
No. of Credits	**:** 2

Course Objectives:

1. To introduce the need and importance of numerical methods in solving mathematical problems.
2. To develop an understanding of different types of numerical errors and their propagation in computations.
3. To familiarize students with numerical techniques for solving algebraic and transcendental equations.
4. To introduce interpolation methods for estimating unknown values from given data.
5. To equip students with numerical differentiation and integration techniques for approximating derivatives and integrals.
6. To apply numerical methods for solving ordinary and partial differential equations.
7. To enhance computational skills using numerical algorithms and improve problem-solving abilities.

Course Outcomes:

CO1: Students will be able to understand the significance of numerical methods and their applications in real-world problems.
CO2: Students will be able to analyze different types of errors and determine their effects on numerical computations.
CO3: Students will be able to apply numerical techniques such as Bisection, Regula-Falsi, and Newton-Raphson methods to solve equations.
CO4: Students will be able to use interpolation techniques like Newton's and Lagrange's formulas to estimate missing data points.
CO5: Students will be able to implement numerical differentiation and integration techniques for approximating derivatives and definite integrals.
CO6: Students will be able to solve ordinary and partial differential equations using methods such as Euler's and Runge-Kutta methods.
CO7: Students will be able to develop computational algorithms for numerical methods and apply them to practical scientific problems.

Topics and Learning Points

Teaching Hours

Theory: **12**

1. **Basics of Numerical Methods & Errors:** Absolute, Relative, Percentage errors, Bisection Method, Regula-Falsi Method and Newton-Raphson Method
2. **Interpolation & Curve Fitting:** Newton's Forward and Backward Interpolation Formulae, Lagrange's Interpolation Formula and Least Squares Approximation
3. **Numerical Differentiation and Integration:** Numerical Differentiation, Trapezoidal Rule, Simpson's 1/3 Rule and Simpson's 3/8 Rule
4. **Numerical Solutions of Differential Equations:** Euler's Method, Modified Euler's Method, Runge-Kutta Method and Finite Difference Methods for PDEs

List of practical: **48**

1. Error Analysis: Compute absolute, relative, and percentage errors in given numerical computations.
2. Solving Algebraic and Transcendental Equations using the Bisection Method.
3. Implementation of the Regula-Falsi Method for finding roots of equations.
4. Solving nonlinear equations using the Newton-Raphson Method and analyzing convergence.
5. Newton's Forward and Backward Interpolation: Estimating unknown values from given data.
6. Lagrange's Interpolation: Using Lagrange's formula for interpolation of tabulated data.
7. Curve Fitting: Fitting a straight line and quadratic curve using the least squares method.
8. Numerical Differentiation: Using finite differences to approximate derivatives.
9. Numerical Integration using Trapezoidal Rule and comparing with analytical results.
10. Numerical Integration using Simpson's 1/3 and 3/8 Rules.
11. Solving First-Order Differential Equations using Euler's Method.
12. Implementation of Runge-Kutta Method (RK4) to solve first-order ODEs.

Text Book:

S. S. Sastry, *Introductory Methods of Numerical Analysis*, PHI Learning Pvt. Ltd., 5th Edition.

Reference Books:

1. R. W. Hamming, *Numerical Methods for Scientists and Engineers*, McGraw-Hill.
2. Ralph G. Stanton, *Numerical Methods in Science and Engineering*, Printice-Hall.
3. Francis Scheid, *Numerical Analysis*, Schaum's Outline.
4. Rajasekaran S., *Numerical Methods in Science and Engineering: A Practical Approach*, S. Chand.
5. Brian Bradie, *A Friendly Introduction to Numerical Analysis*, Pearson Education India.

CO-PO Mapping

Weightage: 1 – weak or low relation, 2 – moderate or partial relation, 3 – strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO01	3	2	3	3	3	3	3
PO02	2	3	3	3	3	3	3
PO03	1	1	2	2	2	2	3
PO04	2	2	3	3	3	3	3
PO05	3	3	3	3	3	3	3
PO06	1	1	2	2	2	2	2
PO07	2	2	3	3	3	3	3
PO08	3	3	3	3	3	3	3
PO09	2	2	3	3	3	3	3
PO10	1	1	1	1	1	1	1
PO11	1	1	1	1	1	1	1
PO12	2	2	3	3	3	3	3
PO13	1	1	2	2	2	2	2

Justification for the mapping

PO1: ***Comprehensive knowledge and understanding*** - Numerical methods involve a deep understanding of mathematical principles, which directly aligns with this PO. CO1 provides a foundation, CO3, CO4, CO5, CO6, and CO7 apply advanced techniques, while CO2 moderately supports this understanding.

PO2: ***Practical, professional, and procedural knowledge*** - Practical numerical methods, error analysis, interpolation, differentiation, and solving differential equations contribute to professional problem-solving. CO1 provides a base, while CO2–CO7 focus on application.

PO3: ***Entrepreneurial mindset and knowledge*** **-** Developing algorithms for real-world problems (CO7) directly supports an entrepreneurial mindset. The application of numerical techniques in solving practical problems (CO3–CO6) also plays a role. CO1 and CO2 contribute weakly as they are more theoretical.

PO4: ***Specialized skills and competencies*** - Specialized numerical techniques require specific mathematical skills, making CO3–CO7 highly relevant. CO1 and CO2 provide foundational support.

PO5: ***Capacity for Application, Problem-Solving, and Analytical Reasoning*** - The entire course focuses on applying numerical methods to problem-solving, making all COs strongly aligned.

PO6: ***Communication skills and collaboration*** - While communication isn't a primary focus, explaining numerical results and collaborating on computational projects are necessary, leading to moderate alignment for CO3–CO7.

PO7: ***Research-related skills*** - Research in numerical methods requires strong problem-solving skills, making CO3–CO7 highly relevant. CO1 and CO2 provide foundational understanding.

PO8: ***Learning how to learn skills*** - Since numerical methods evolve with advancements in computing, all COs strongly contribute to continuous learning.

PO9: ***Digital and technological skills*** - Computational methods rely on programming and software, making CO3–CO7 highly relevant. CO1 and CO2 provide conceptual understanding.

PO10: ***Multicultural competence, inclusive spirit, and empathy*** - While numerical methods don't directly contribute, their applications in global scientific collaboration justify a weak relation.
PO11: ***Value inculcation and environmental awareness*** - Environmental modeling uses numerical methods, but the course itself does not explicitly address values and environmental concerns.
PO12: ***Autonomy, responsibility, and accountability*** - Independent problem-solving in numerical methods demands responsibility, making CO3–CO7 strongly aligned. CO1 and CO2 provide background knowledge.
PO13: ***Community engagement and service*** - Numerical techniques have indirect applications in societal issues, making CO3–CO7 moderately relevant, while CO1 and CO2 contribute minimally.

CBCS Syllabus as per NEP 2020 for S.Y.B.Sc. Mathematics (2024 Pattern)

Name of the Programme : B.Sc. Mathematics
Program Code : USMT
Class : S.Y.B.Sc.
Semester : III
Course Type : Field Project
Course Name : Field Project
Course Code : MAT-205-FP
No. of Teaching Hours : 60
No. of Credits : 2

Course Objectives:

1. To provide students with practical exposure to mathematical applications in real-world scenarios.
2. To develop students' ability to identify, analyze, and solve mathematical problems through research and fieldwork.
3. To enhance students' data collection, interpretation, and problem-solving skills using mathematical tools and techniques.
4. To foster independent learning, critical thinking, and creativity in applying mathematical concepts.
5. To enable students to use computational tools, models, and simulations for mathematical problem-solving.
6. To improve students' teamwork, communication, and presentation skills through project-based learning.
7. To encourage interdisciplinary learning by applying mathematics to various fields such as science, economics, and engineering.

Course Outcomes:

CO1: Students will be able to identify and define real-world problems that can be analyzed mathematically.
CO2: Students will be able to apply appropriate mathematical techniques to collect and analyze data.
CO3: Students will be able to develop mathematical models and validate them with real-world applications.
CO4: Students will be able to work collaboratively in a team to investigate and solve mathematical problems.
CO5: Students will be able to use software tools and computational techniques for mathematical computations.
CO6: Students will be able to document their findings effectively in a structured research report.
CO7: Students will be able to present their research findings clearly through oral and visual presentations.

CO-PO Mapping

Weightage: 1 – weak or low relation, 2 – moderate or partial relation, 3 – strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO01	3	3	3	2	2	2	2
PO02	2	3	3	2	3	3	3
PO03	2	2	3	3	2	2	2
PO04	2	3	3	3	3	3	3
PO05	3	3	3	2	3	2	2
PO06	1	1	2	3	2	3	3
PO07	2	3	3	2	3	3	3
PO08	3	3	3	2	3	2	2
PO09	1	2	2	2	3	3	2
PO10	1	1	1	3	1	2	2
PO11	1	1	1	2	1	1	2
PO12	2	3	3	2	3	3	3
PO13	1	2	2	3	2	2	3

Justification for the mapping

PO1: *Comprehensive knowledge and understanding* - CO1, CO2, and CO3 are strongly related as students gain mathematical knowledge to identify problems, analyze data, and develop models. Also, CO4, CO5, CO6, and CO7 have a moderate relation as teamwork, computational techniques, and research communication contribute to mathematical understanding.

PO2: *Practical, professional, and procedural knowledge* - CO2, CO3, CO5, CO6, and CO7 are strongly related since they emphasize mathematical techniques, modeling, software tools, and research documentation whereas CO1 and CO4 have a moderate relation, as problem identification and teamwork support professional knowledge.

PO3: *Entrepreneurial mindset and knowledge* - CO3 is strongly related because developing mathematical models has applications in industry and entrepreneurship and CO1, CO2, CO4, CO5, CO6, and CO7 have a moderate relation as they contribute indirectly to problem-solving, collaboration, and innovative thinking.

PO4: *Specialized skills and competencies* - CO2, CO3, CO4, CO5, CO6, and CO7 are strongly related as they develop mathematical, computational, and research-related skills and CO1 has a moderate relation as problem identification is a foundation for specialization.

PO5: *Capacity for Application, Problem-Solving, and Analytical Reasoning* - CO1, CO2, CO3, and CO5 are strongly related as they emphasize mathematical problem-solving, data analysis, and model development. Also, CO4, CO6, and CO7 have a moderate relation, as collaboration and presentation support problem-solving indirectly.

PO6: *Communication skills and collaboration* - CO4, CO6, and CO7 are strongly related because teamwork, research documentation, and presentations require strong communication skills, CO3 and CO5 have a moderate relation as they involve conveying mathematical results and CO1 and CO2 have a weak relation since they primarily focus on analysis.

PO7: *Research-related skills* - CO2, CO3, CO5, CO6, and CO7 are strongly related as they emphasize data analysis, modeling, computational tools, and research communication and CO1 and CO4 have a moderate relation as problem identification and teamwork are crucial in research.

PO8: ***Learning how to learn skills*** - CO1, CO2, CO3, and CO5 are strongly related as students develop self-learning abilities through mathematical problem-solving and CO4, CO6, and CO7 have a moderate relation as teamwork and research reporting help in independent learning.

PO9: ***Digital and technological skills*** - CO5 and CO6 are strongly related as they emphasize using software tools for mathematical computations and research documentation, CO2, CO3, CO4, and CO7 have a moderate relation as data analysis, modeling, teamwork, and presentations involve technology and CO1 has a weak relation as problem identification does not directly involve technology.

PO10: ***Multicultural competence, inclusive spirit, and empathy*** - CO4 is strongly related as teamwork fosters inclusivity, CO6 and CO7 have a moderate relation since research documentation and presentations require awareness of diverse perspectives and CO1, CO2, CO3, and CO5 have a weak relation as they primarily focus on mathematical problem-solving.

PO11: ***Value inculcation and environmental awareness*** - CO4 is moderately related as collaboration promotes ethical teamwork, CO7 has a moderate relation as presentations may involve ethical considerations and CO1, CO2, CO3, CO5, and CO6 have a weak relation as they focus on technical knowledge rather than value-based learning.

PO12: ***Autonomy, responsibility, and accountability*** - CO2, CO3, CO5, CO6, and CO7 are strongly related as they require independent problem-solving, research, and reporting whereas CO1 and CO4 have a moderate relation as problem identification and teamwork require responsibility.

PO13: ***Community engagement and service*** - CO4 and CO7 are strongly related since teamwork and research presentations encourage societal interaction, CO2, CO3, CO5, and CO6 have a moderate relation as they contribute indirectly to problem-solving for community-based issues and CO1 has a weak relation as it focuses more on identifying problems rather than direct community engagement.

CBCS Syllabus as per NEP 2020 for S.Y.B.Sc. Mathematics (2024 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** S.Y.B.Sc.
Semester	**:** III
Course Type	**:** Minor
Course Name	**:** Fundamentals of Linear Algebra
Course Code	**:** MAT-206-MN
No. of Teaching Hours	**:** 30
No. of Credits	**:** 2

Course Objectives:

1. To understand the fundamental concepts of vector spaces and their properties, including subspaces, sums, direct sums, linear independence, span, bases, and dimensions.
2. To explore the theory of linear maps and their applications, including null spaces, ranges, and transformations on polynomial spaces with both real and complex coefficients.
3. To investigate eigenvalues and eigenvectors, including the concepts of invariant subspaces, diagonalization, and applications of polynomials to operators.
4. To develop a comprehensive understanding of inner product spaces, including inner products, norms, orthonormal bases, orthogonal projections, and linear functionals.
5. To analyze upper-triangular and diagonal matrices, and understand their significance in relation to eigenvalues, eigenvectors, and invariant subspaces.
6. To explore advanced topics in linear algebra, such as adjoints, self-adjoint operators, and spectral theory, and their applications in mathematical modeling and analysis.
7. To enhance problem-solving skills through practical exercises, assignments, and applications of linear algebra concepts in real-world scenarios.

Course Outcomes:

CO1: Students will demonstrate proficiency in analyzing and manipulating vector spaces, subspaces, and linear transformations, as well as determining bases and dimensions of vector spaces.
CO2: Students will be able to apply linear maps to solve problems with real and complex coefficient polynomials, including identifying null spaces, ranges, and transformations.
CO3: Students will be able to compute eigenvalues and eigenvectors of matrices, and interpret their significance in the context of invariant subspaces and diagonalization.
CO4: Students will be able to utilize inner product spaces for norms, orthonormal bases, orthogonal projections, and understanding vector-linear functional duality.
CO5: Students will apply linear algebra to solve real-world problems across diverse fields, showcasing the capacity to model phenomena using matrices and transformations.
CO6: Students will analyze the structure and properties of upper-triangular and diagonal matrices, and their role in understanding the behavior of linear transformations and eigenvalues.
CO7: Students will be able to understand advanced topics such as adjoints, self-adjoint operators, and spectral theory, and apply them in analyzing complex systems and phenomena.

Topics and Learning Points

	Teaching Hours
Unit 1: Vector Spaces	**08**
1.1 Vector space and its properties	
1.2 Subspaces, sums and direct sums	
1.3 Linear independence and span	
1.4 Bases and dimensions	
Unit 2: Linear maps and Polynomials	**07**
2.1 Linear maps	
2.2 Null spaces and ranges	
2.3 Polynomials with complex coefficients	
2.4 Polynomials with real coefficients	
Unit 3: Eigenvalues and eigenvectors	**07**
3.1 Invariant subspaces	
3.2 Polynomials applied to operators	
3.3 Upper-triangular matrices	
3.4 Diagonal matrices	
3.5 Invariant subspaces on real vector spaces	
Unit 4: Inner Product Spaces and Applications	**08**
4.1 Inner products	
4.2 Norms	
4.3 Orthonormal bases	
4.4 Orthogonal projections	
4.5 Linear functionals and adjoints	
4.6 Applications of linear algebra in various fields	

Text Book:

Sheldon Axler, *Linear Algebra Done Right*, Springer, 2nd Edition.

Unit 1: Chapters 1 and 2, **Unit 2:** Chapters 3 and 4,
Unit 3: Chapter 5, **Unit 4:** Chapter 6.

Reference Books:

1. S. Kumaresan, *Linear Algebra: A Geometric Approach*, Prentice Hall of India, New Delhi.
2. H. Anton and C. Rorres, *Elementary Linear Algebra with Applications*, Wiley.
3. K. Hoffmann and R. Kunze, *Linear Algebra*, Prentice Hall of India.
4. G. Schay, *Introduction to Linear Algebra*, Narosa, New Delhi.
5. A. Ramchandra Rao and P. Bhimasankaran, *Linear Algebra*, Tata McGraw Hill.

CO-PO Mapping

Weightage: 1 – weak or low relation, 2 – moderate or partial relation, 3 – strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO01	3	3	3	3	3	3	3
PO02	2	3	3	3	3	2	3
PO03	1	2	2	2	3	1	2
PO04	3	3	3	3	3	3	3
PO05	3	3	3	3	3	3	3
PO06	1	2	2	2	3	1	2
PO07	2	2	3	3	3	2	3
PO08	3	3	3	3	3	3	3
PO09	1	2	2	2	3	1	2
PO10	1	1	1	2	2	1	2
PO11	1	1	1	2	2	1	2
PO12	2	2	3	3	3	2	3
PO13	1	1	1	2	2	1	2

Justification for the mapping

PO1: ***Comprehensive knowledge and understanding*** - Each CO contribute to a deeper understanding of vector spaces, transformations, inner product spaces, and advanced topics in linear algebra.

PO2: ***Practical, professional, and procedural knowledge*** - CO2, CO3, CO4, CO5, and CO7 involve applying linear algebra to solve real-world problems and understanding eigenvalues, eigenvectors, and transformations, making their mapping strong.

PO3: ***Entrepreneurial mindset and knowledge*** **-** Linear algebra provides a foundation for problem-solving in technology and business applications, but its direct entrepreneurial impact is moderate.

PO4: ***Specialized skills and competencies*** - The course outcomes develop specialized knowledge in vector spaces, eigenvalues, inner products, and matrix structures, which are essential in various fields.

PO5: ***Capacity for Application, Problem-Solving, and Analytical Reasoning*** - Problem-solving is at the core of linear algebra, whether in theoretical proofs or applied contexts.

PO6: ***Communication skills and collaboration*** - While linear algebra primarily focuses on mathematical problem-solving, some COs (like CO2 and CO5) involve collaboration and explanation of solutions.

PO7: ***Research-related skills*** - CO3, CO4, CO5, and CO7 involve higher-order thinking, which is crucial for research and deeper mathematical exploration.

PO8: ***Learning how to learn skills*** - The entire course fosters independent learning skills, making students capable of grasping advanced mathematical concepts.

PO9: ***Digital and technological skills*** - Some aspects of linear algebra (such as computational methods) involve technology, but not all COs directly contribute.

PO10: ***Multicultural competence, inclusive spirit, and empathy*** - Mathematics is universal, but its direct impact on multicultural competence is limited.

PO11: ***Value inculcation and environmental awareness*** - The ethical implications of mathematical research and its applications may contribute to value inculcation.

PO12: ***Autonomy, responsibility, and accountability*** - Higher-order mathematical thinking requires students to work independently and take responsibility for problem-solving.

PO13: ***Community engagement and service*** - While not directly related to social service, applications of linear algebra in engineering and data analysis can contribute indirectly.

CBCS Syllabus as per NEP 2020 for S.Y.B.Sc. Mathematics (2024 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** S.Y.B.Sc.
Semester	**:** III
Course Type	**:** Minor
Course Name	**:** Practical based on Differential Equations
Course Code	**:** MAT-207-MN
No. of Teaching Hours	**:** 60
No. of Credits	**:** 2

Course Objectives:

1. To introduce students to the fundamental concepts of differential equations and their solutions.
2. To develop skills in verifying solutions and forming differential equations from real-world problems.
3. To teach methods for solving first-order and second-order differential equations, both homogeneous and non-homogeneous.
4. To explore applications of differential equations in physics, engineering, and biological sciences.
5. To introduce the variation of parameters method and other techniques for solving differential equations.
6. To provide insights into systems of first-order differential equations and their real-world significance.
7. To introduce partial differential equations (PDEs) and their basic solution techniques.

Course Outcomes:

CO1: Students will be able to verify whether a given function is a solution to a differential equation.
CO2: Students will be able to formulate differential equations from real-world scenarios.
CO3: Students will be able to solve first-order and second-order differential equations using various methods.
CO4: Students will be able to apply differential equations to scientific and engineering problems.
CO5: Students will be able to use the variation of parameters method to solve higher-order equations.
CO6: Students will be able to analyze and solve systems of first-order differential equations.
CO7: Students will be able to solve simple first-order partial differential equations and understand their applications.

Topics and Learning Points

Teaching Hours

Theory: **12**

1. **Introduction to differential equations and first-order equations:** Definition, classification, formation and solving first-order differential equations
2. **Exact and higher-order differential equations:** Exact differential equations, integrating factors, second-order differential equations and applications
3. **Advanced methods and systems of equations:** Method of variation of parameters for non-homogeneous equations and coupled first-order differential equations
4. **Partial differential equations (PDEs) and their solutions:** Formation of PDEs by eliminating arbitrary functions and solving simple PDEs

List of practical: **48**

1. Verification of Solutions of Differential Equations
2. Formation of Differential Equations
3. Solving First-Order Linear Differential Equations
4. Applications of First-Order Differential Equations
5. Exact Differential Equations
6. Solving Second-Order Homogeneous Differential Equations
7. Solving Second-Order Non-Homogeneous Differential Equations
8. Applications of Second-Order Differential Equations
9. Solving Differential Equations Using Variation of Parameters
10. Solving a System of First-Order Differential Equations
11. Formation of Partial Differential Equations
12. Solving a Simple First-Order PDE

Text Book:

George F. Simmons, *Differential Equations with Applications and Historical Notes*, CRC Press, 2nd Edition.

Reference Books:

1. George F. Simmons and Steven G. Krantz, *Differential Equations: Theory,Technique and Practice*, McGraw-Hill Higher Education.
2. Steven G. Krantz, *Differential Equations: Theory,Technique and Practice with Boundary Value Problems*, CRC Press, 2015.
3. Earl A. Coddington, *An Introduction to Ordinary Differential Equations*, Dover.
4. M.D.Raisinghania, *Ordinary and Partial Differential Equations*, S. Chand Publishing.
5. Dennis G. Zill, *A First Course in Differential Equations with Modeling Applications*, Cengage Learning.

CO-PO Mapping

Weightage: 1 – weak or low relation, 2 – moderate or partial relation, 3 – strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO01	3	3	3	3	3	3	3
PO02	2	3	3	3	3	3	3
PO03	1	2	2	3	2	2	2
PO04	2	3	3	3	3	3	3
PO05	2	3	3	3	3	3	3
PO06	1	2	2	2	2	2	2
PO07	1	2	2	3	2	2	3
PO08	2	3	3	3	3	3	3
PO09	1	2	2	2	2	2	2
PO10	1	1	1	2	1	1	1
PO11	1	1	1	2	1	1	1
PO12	2	3	3	3	3	3	3
PO13	1	2	2	3	2	2	2

Justification for the mapping

PO1: ***Comprehensive knowledge and understanding*** - CO1 to CO7 are strongly related as the course cover fundamental and advanced concepts of differential equations. Students gain a deep theoretical understanding of solving and applying differential equations.

PO2: ***Practical, professional, and procedural knowledge*** - CO2 to CO7 have a strong relation as students formulate and solve differential equations in practical scenarios. CO1 has a moderate relation as it focuses more on verifying solutions rather than application.

PO3: ***Entrepreneurial mindset and knowledge*** **-** CO2, CO4, and CO7 have a moderate relation as differential equations are used in industrial applications and innovation. Other COs have a weak relation as they focus more on theoretical aspects.

PO4: ***Specialized skills and competencies*** - CO2 to CO7 have a strong relation since students develop problem-solving techniques and computational skills in solving differential equations. CO1 has a moderate relation as it helps in verifying solutions.

PO5: ***Capacity for Application, Problem-Solving, and Analytical Reasoning*** - CO2 to CO7 have a strong relation as students apply differential equations in engineering, physics, and real-world problems. CO1 has a moderate relation as it involves checking correctness rather than application.

PO6: ***Communication skills and collaboration*** - CO2 to CO7 have a moderate relation as students must explain solutions and collaborate in problem-solving. CO1 has a weak relation as it is mainly a verification step.

PO7: ***Research-related skills*** - CO2, CO4, and CO7 have a strong relation as they introduce advanced problem-solving techniques useful in research. CO1, CO3, CO5, and CO6 have a moderate relation as they contribute to mathematical research methodologies.

PO8: ***Learning how to learn skills*** - CO1 to CO7 have a strong relation as solving differential equations requires continuous learning, adapting new methods, and applying various techniques.

PO9: ***Digital and technological skills*** - CO2 to CO7 have a moderate relation as solving differential equations often involves computational tools. CO1 has a weak relation since verifying solutions does not necessarily require digital tools.

PO10: ***Multicultural competence, inclusive spirit, and empathy*** **-** CO4 has a moderate relation as differential equations are applied in diverse scientific fields, affecting various communities. Other COs have a weak relation as they focus on mathematical theory rather than social aspects.
PO11: ***Value inculcation and environmental awareness*** **-** CO4 has a moderate relation since differential equations are used in environmental modeling (e.g., pollution modeling, climate change analysis). Other COs have a weak relation as they do not directly address environmental issues.
PO12: ***Autonomy, responsibility, and accountability*** **-** CO2 to CO7 have a strong relation as students are expected to solve complex problems independently, ensuring accuracy and responsibility in their work. CO1 has a moderate relation as verifying solutions requires logical reasoning but not as much autonomy.
PO13: ***Community engagement and service*** **-** CO4 has a strong relation as differential equations contribute to solving community-related problems in engineering, healthcare, and ecology. CO2, CO3, CO5, CO6, and CO7 have a moderate relation since they provide the foundational knowledge required for such applications.

CBCS Syllabus as per NEP 2020 for S.Y.B.Sc. Mathematics (2024 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** Second Year
Semester	**:** III
Course Type	**:** Open Elective
Course Name	**:** Fundamentals of Higher Mathematics
Course Code	**:** MAT-208-OE
No. of Teaching Hours	**:** 30
No. of Credits	**:** 2

Course Objectives:

1. To provide fundamental knowledge of the number system, arithmetic operations, and algebraic expressions.
2. To develop problem-solving skills using laws of exponents, surds, and algebraic factorization.
3. To introduce and strengthen the understanding of linear and quadratic equations.
4. To equip students with commercial mathematics concepts like percentage, profit & loss, interest calculations, and ratio-proportion.
5. To enhance geometrical understanding by covering basic properties of angles, triangles, circles, and the Pythagoras theorem.
6. To introduce students to trigonometric ratios, identities, and their real-life applications.
7. To familiarize students with basic statistical concepts, including measures of central tendency, dispersion, and elementary probability.

Course Outcomes:

CO1: Student will be able to identify and classify different types of numbers in the number system.
CO2: Student will be able to perform fundamental arithmetic operations and simplify algebraic expressions using laws of exponents and surds.
CO3: Student will be able to solve and analyze linear and quadratic equations in real-life contexts.
CO4: Student will be able to apply commercial mathematics concepts like percentage, profit & loss, simple and compound interest in problem-solving.
CO5: Student will be able to demonstrate a clear understanding of basic geometric principles, including triangle properties, circles, and Pythagoras theorem applications.
CO6: Student will be able to utilize trigonometric ratios and identities to solve mathematical and real-world problems.
CO7: Student will be able to analyze data using statistical measures such as mean, median, mode, standard deviation, and apply basic probability concepts.

Topics and Learning Points

Teaching Hours

Unit 1: Basic Arithmetic and Algebra **08**

1.1 Number System: Natural, Whole, Integers, Rational, Irrational and Real numbers
1.2 Fundamental Operations: Addition, Subtraction, Multiplication and Division
1.3 Laws of Exponents and Surds
1.4 Factorization and Simplification of Algebraic Expressions
1.5 Introduction to Linear Equations and Quadratic Equations

Unit 2: Commercial Mathematics **07**

2.1 Percentage, Profit and Loss
2.2 Simple Interest and Compound Interest
2.3 Ration and Proportion

Unit 3: Basic Geometry and Trigonometry **07**

3.1 Types of Angles, Properties of Triangle, Circle
3.2 Pythagoras Theorem and its Applications
3.3 Introduction to Trigonometric Ratios
3.4 Trigonometric Identities and Simple Applications

Unit 4: Elementary Statistics **08**

4.1 Measures of Central Tendency: Mean, Median, Mode
4.2 Measures of Dispersion: Range, Variance, Standard Deviation
4.3 Basics of Probability: Concepts and Simple Examples

Text Book:

Haym Kruglak, John T. Moore and Ramon A. Mata-Toledo, *Theory and Problems of Basic Mathematics with Applications to Science and Technology*, Schaum's Outline Series, 2nd Edition.

Reference Books:

1. R. K. Ghosh and S. Saha, *Business Mathematics and Statistics*, New Central Book Agency Pvt. Ltd.
2. R. S. Aggarwal, *Quantitative Aptitude for Competitive Examinations*, S. Chand.
3. Trevor Johnson and Hugh Neill, *Mathematics: A complete introduction*, Teach Yourself Books
4. Haym Kruglak and John T. Moore, *Basic Mathematics with Applications to Science and Technology*, Schaum's Outline.
5. Hugh Neill and Trevor Johnson, *Mathematics: A Complete Introduction*, Mobius.

CO-PO Mapping

Weightage: 1 – weak or low relation, 2 – moderate or partial relation, 3 – strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO01	3	3	3	3	3	3	3
PO02	2	3	3	3	2	3	3
PO03	1	2	2	3	1	2	2
PO04	1	2	3	3	2	3	3
PO05	2	3	3	3	2	3	3
PO06	1	1	2	2	1	2	2
PO07	1	2	2	2	1	2	3
PO08	2	2	3	3	2	3	3
PO09	1	2	2	2	1	2	2
PO10	1	1	1	2	1	1	1
PO11	1	1	1	1	1	1	1
PO12	1	2	2	2	1	2	2
PO13	1	1	2	2	1	2	2

Justification for the mapping

PO1: ***Comprehensive knowledge and understanding*** - Strongly related to all COs as students gain fundamental mathematical knowledge, including numbers, algebra, equations, geometry, trigonometry, and statistics.

PO2: ***Practical, professional, and procedural knowledge*** - Strongly related to CO2, CO3, CO4, CO6, and CO7, as these involve applying mathematical concepts in real-world situations and moderately related to CO1 and CO5 since understanding classifications and geometry also supports professional applications.

PO3: ***Entrepreneurial mindset and knowledge*** **-** Moderately related to CO2, CO3, CO4, CO6, and CO7 as mathematical skills aid in problem-solving, financial calculations, and data analysis useful in entrepreneurship and weakly related to CO1 and CO5, as these have indirect entrepreneurial applications.

PO4: ***Specialized skills and competencies*** - Strongly related to CO3, CO4, CO6, and CO7, as these outcomes involve analytical and applied skills essential in problem-solving and moderately related to CO2 and CO5, as algebraic operations and geometric principles contribute to specialized skills.

PO5: ***Capacity for Application, Problem-Solving, and Analytical Reasoning*** - Strongly related to CO2, CO3, CO4, CO6, and CO7, as these focus on mathematical problem-solving in various contexts and moderately related to CO1 and CO5, as classification of numbers and geometric principles also support logical reasoning.

PO6: ***Communication skills and collaboration*** - Moderately related to CO3, CO4, CO6, and CO7, as these involve real-world applications requiring clear explanation and collaboration and weakly related to CO1, CO2, and CO5, as these involve individual learning rather than direct communication or teamwork.

PO7: ***Research-related skills*** - Strongly related to CO7 as statistical analysis is crucial in research, moderately related to CO2, CO3, CO4, and CO6, as algebra, equations, and trigonometry aid in problem-solving research and weakly related to CO1 and CO5, as these provide foundational knowledge but have limited direct research applications.

PO8: ***Learning how to learn skills*** - Strongly related to CO3, CO4, CO6, and CO7, as these require analytical thinking and adaptability and moderately related to CO1, CO2, and CO5, as understanding number systems, algebra, and geometry aids continuous learning.
PO9: ***Digital and technological skills*** - Moderately related to CO2, CO3, CO4, CO6, and CO7, as mathematical knowledge supports data analysis and computational applications and weakly related to CO1 and CO5, as these have minimal direct technology integration.
PO10: ***Multicultural competence, inclusive spirit, and empathy*** - Moderately related to CO4 as commercial mathematics applies universally and weakly related to all other COs since mathematics generally does not directly address multicultural competence.
PO11: ***Value inculcation and environmental awareness*** - Weakly related to all COs as basic mathematics does not have direct links to value inculcation or environmental awareness.
PO12: ***Autonomy, responsibility, and accountability*** - Moderately related to CO2, CO3, CO4, CO6, and CO7, as problem-solving fosters independent learning and decision-making and weakly related to CO1 and CO5, as these provide foundational understanding but do not strongly emphasize independent learning.
PO13: ***Community engagement and service*** - Moderately related to CO3, CO4, CO6, and CO7, as mathematical knowledge helps in community-based problem-solving like financial literacy and data interpretation and weakly related to CO1, CO2, and CO5, as these have less direct impact on community engagement.

CBCS Syllabus as per NEP 2020 for S.Y.B.Sc. Mathematics (2024 Pattern)

Name of the Programme	**:** B.Sc. Mathematics
Program Code	**:** USMT
Class	**:** S.Y.B.Sc.
Semester	**:** III
Course Type	**:** Indian Knowledge System
Course Name	**:** Vedic Mathematics
Course Code	**:** MAT-209-IKS
No. of Teaching Hours	**:** 30
No. of Credits	**:** 2

Course Objectives:

1. To introduce students to the historical background and fundamental concepts of Vedic Mathematics.
2. To familiarize students with the 16 Sutras and 13 Sub-Sutras used in fast mental calculations.
3. To enhance students' arithmetic skills using Vedic techniques for addition, subtraction, multiplication, and division.
4. To develop students' ability to solve algebraic equations efficiently using Vedic methods.
5. To improve problem-solving speed and accuracy using Vedic Mathematics in competitive exams.
6. To enable students to apply Vedic techniques for computing squares, cubes, square roots, and cube roots.
7. To encourage analytical thinking and mental agility through advanced Vedic methods in arithmetic and algebra.

Course Outcomes:

CO1: Students will be able to explain the origin, history, and significance of Vedic Mathematics.

CO2: Students will be able to apply Vedic Sutras for rapid addition, subtraction, multiplication, and division.

CO3: Students will be able to solve quadratic and simultaneous equations using Vedic methods.

CO4: Students will be able to factorize algebraic expressions efficiently using Vedic techniques.

CO5: Students will be able to compute squares, cubes, square roots, and cube roots using mental calculations.

CO6: Students will be able to apply Vedic mathematical techniques in solving competitive exam problems.

CO7: Students will be able to demonstrate improved speed, accuracy, and confidence in numerical problem-solving.

Topics and Learning Points

	Teaching Hours
Unit 1: Introduction to Vedic Mathematics	**05**
1.1 History and Origin of Vedic Mathematics	
1.2 Introduction to the 16 Sutras and 13 Sub-Sutras	
1.3 Concept of Mental Calculation and Speed Enhancement	
Unit 2: Fast Arithmetic Using Vedic Sutras	**09**
2.1 Addition and Subtraction using Vedic Methods	
2.2 Nikhilam Sutra (Base Multiplication)	
2.3 Urdhva-Tiryagbhyam Sutra (Vertical and Crosswise Method)	
2.4 Paravartya Yojayet Sutra (Base Division)	
2.5 Direct and Short Division Methods	
Unit 3: Algebraic Applications of Vedic Mathematics	**09**
3.1 Factorization of Algebraic Expressions using Vedic Sutras	
3.2 Solving Quadratic Equations using Vedic Methods	
3.3 Simultaneous Equations using Anurupye Sutra	
3.4 Square and Cube Roots using Vedic Techniques	
Unit 4: Advanced Vedic Techniques and Applications	**07**
4.1 Square and Cube Calculation using Ekadhikena Purvena Sutra	
4.2 Calculating Reciprocals and Fractions using Vedic Methods	
4.3 Applications in Competitive Exams	

Text Book:

Bharati Krishna Tirtha, *Vedic Mathematics*, Motilal Banarsidass Publishers

Reference Books:

1. Vandana Singhal, *Vedic Mathematics for All Ages: A Beginners' Guide*, Motilal Banarsidass Publishers
2. Pandit Ramnandan Shashtri, *Vedic Mathematics: Made Easy*, Arihant Prakashan.
3. V. S. Agrawala, *Vedic Mthematics for Students*, Motilal Banarsidass Publishers
4. Rajesh Kumar Thakur, *The Essentials of Vedic Mathematics*, Rupa Publishers.
5. *Vedic Mathematics: The Problem Solver*, Maple Press Pvt. Ltd.

CO-PO Mapping

Weightage: 1 – weak or low relation, 2 – moderate or partial relation, 3 – strong or direct relation

Programme Outcomes	Course Outcomes						
	CO1	CO2	CO3	CO4	CO5	CO6	CO7
PO01	3	2	2	2	2	3	3
PO02	2	3	3	3	3	3	3
PO03	1	2	2	2	2	3	3
PO04	1	3	3	3	3	3	3
PO05	2	3	3	3	3	3	3
PO06	2	1	1	1	1	2	2
PO07	2	2	2	2	2	2	2
PO08	3	3	3	3	3	3	3
PO09	1	2	2	2	2	2	2
PO10	2	1	1	1	1	2	2
PO11	2	1	1	1	1	2	2
PO12	2	2	2	2	2	3	3
PO13	2	1	1	1	1	2	2

Justification for the mapping

PO1: ***Comprehensive knowledge and understanding*** - CO1 has a strong relation as it directly deals with understanding the origin, history, and significance of Vedic Mathematics, CO2 to CO5 have a moderate relation since they involve applying Vedic Mathematics concepts rather than just theoretical understanding and CO6 and CO7 have a strong relation as they enhance overall numerical abilities and conceptual clarity.

PO2: ***Practical, professional, and procedural knowledge*** - CO2 to CO7 have a strong relation since they focus on practical application of Vedic Mathematics for faster calculations, problem-solving, and competitive exams and CO1 has a moderate relation as it provides background knowledge but does not directly involve procedural applications.

PO3: ***Entrepreneurial mindset and knowledge*** **-** CO6 and CO7 have a strong relation as they help develop numerical efficiency, which is useful for entrepreneurship, finance, and business calculations, CO2 to CO5 have a moderate relation as they contribute to innovative problem-solving techniques useful in entrepreneurial tasks and CO1 has a weak relation since historical knowledge does not directly impact entrepreneurship.

PO4: ***Specialized skills and competencies*** **-** CO2 to CO7 have a strong relation as they develop specialized skills in mathematical calculations and mental arithmetic and CO1 has a weak relation as it is more theoretical than skill-based.

PO5: ***Capacity for Application, Problem-Solving, and Analytical Reasoning*** - CO2 to CO7 have a strong relation since they enhance problem-solving ability using Vedic techniques and CO1 has a moderate relation as understanding the history of Vedic Mathematics may contribute to an analytical perspective.

PO6: ***Communication skills and collaboration*** - CO6 and CO7 have a moderate relation as applying Vedic Mathematics in competitive exams may require clear explanation and presentation of solutions and CO1 to CO5 have a weak relation since they primarily focus on individual problem-solving rather than communication or collaboration.

PO7: ***Research-related skills*** - All COs have a moderate relation as they encourage analytical thinking, exploration of mathematical techniques, and deeper understanding of problem-solving approaches.

PO8: ***Learning how to learn skills*** - All COs have a strong relation as Vedic Mathematics fosters independent learning, critical thinking, and innovative approaches to solving mathematical problems.
PO9: ***Digital and technological skills*** - CO2 to CO7 have a moderate relation as they can be applied to digital learning platforms and technological tools for mathematical computations and CO1 has a weak relation as historical knowledge does not involve technology.
PO10: ***Multicultural competence, inclusive spirit, and empathy*** - CO6 and CO7 have a moderate relation as they enhance confidence and encourage a positive attitude toward learning and CO1 to CO5 have a weak relation as they are primarily mathematical concepts with limited cultural impact.
PO11: ***Value inculcation and environmental awareness*** - CO6 and CO7 have a moderate relation as the discipline and efficiency gained from Vedic Mathematics contribute to personal growth and CO1 to CO5 have a weak relation as they do not directly promote value inculcation or environmental awareness.
PO12: ***Autonomy, responsibility, and accountability*** - CO6 and CO7 have a strong relation as they develop self-reliance in mathematical problem-solving and decision-making and CO1 to CO5 have a moderate relation as they encourage independent thinking and skill-building.
PO13: ***Community engagement and service*** - CO6 and CO7 have a moderate relation as numerical efficiency can be shared through teaching and community engagement and CO1 to CO5 have a weak relation as they focus more on individual learning rather than community-based activities.