Appendix - B
AC - 04/2025
Item No. - (v)

As per NEP 2020

SRDSP Mandal's

SHRI PANCHAM KHEMRAJ MAHAVIDYALAYA (AUTONOMOUS), SAWANTWADI

Affiliated to University of Mumbai

Title of the Program: Science

B.Sc. (Mathematics)

A: U. G. Certificate in **Mathematics: 2024-2025**

B: U. G. Diploma in **Mathematics: 2025-2026**

C: B.Sc. in **Mathematics: 2025-2027**

Syllabus for

Semester III & Semester IV

Ref: GR dated 20th April, 2023 for Credit structure of UG

Shri Pancham Khemraj Mahavidyalaya (Autonomous), Sawantwadi

(As per NEP 2020

Sr. No.	Heading	Particulars	
1.	**Title of the Program**	A	U.G. Certificate in **Mathematics**
		B	U.G. Diploma in **Mathematics**
		C	B.Sc. in **Mathematics**
2.	**Eligibility**	A	H. Sc. Science **OR** Passed Equivalent Academic Level 4.0
		B	Under Graduate Certificate in Mathematics & Allied Academic Level **OR** Passed Equivalent Academic Level 4.5
		C	Under Graduate Diploma in Mathematics & Allied Academic Level **OR** Passed Equivalent Academic Level 5.0
3.	**Duration of the program**	A	One Year
		B	Two Years
		C	Three Years
4.	**Intake capacity**		120/ division

5.	**Scheme of Examination**		NEP 40% Internal 60% External, Semester End examination, Individual passing in internal and External examination.
6.	**Standard of Passing**		40%
7.	**Credit Structure** **Sem. I** **Sem. II**		Attached herewith
	Sem. III **Sem. IV**		
	Sem. V **Sem. VI**		
8.	**Semesters**	A	Sem I & II
		B	Sem III & IV
		C	Sem V & VI
9.	**Program Academic Level**	A	4.5
		B	5.0
		C	5.5
10.	**Pattern**	Semester	
11.	**Status**	New (Revised)	
12.	**To be implemented from Academic Year progressively**	From Academic Year: 2025-26	

Sign of the BOS
Chairman
Dr. V. P. Sonalkar
BOS of Mathematics

Sign of

Sign of

Member of the Board of Studies of Mathematics

Sr. No.	Name of the Faculty	Category	Designation
01	Dr. Vishwas Pandurang Sonalkar	12.5 (1)	HoD/ Chairman
02	Miss. Tanvi Dilip Shinde	12.5 (2)	Member
03	Miss. Gayatri Rajesh Awate		Member
04	Dr. Kishor D. Kucche	12.5 (3)	Member
05	Dr. Jervin Zen Lobo		Member
06	Dr. Shridhar Krishna Pawar	12.5 (4)	Member
07	Asst. Prof. Sagar Balavant Patil	12.5 (5)	Member
08	Miss. Shreya Shripad Bhagwat	12.5 (6)	Member
09	Dr. Subhash Ishwar Unhale	12.5 (7)	Member

Preamble

1. Introduction:

Shri Pancham Khemraj Mahavidyalaya, Sawantwadi (Autonomous) believes in implementing several measures to bringequity, efficiency and excellence in higher education system in conformity to the guidelines laid down by the University Grants Commission (UGC). In order to achieve these goals, all efforts are made to ensure high standards of education by implementing several steps to enhance the teaching- learning process, examination and evaluation techniques and ensuring the all-round development of learners.

The institute has brought into force the revised syllabi as per the Choice Based Credit System (CBCS) for the Second year B. Sc. in Mathematics from the academic year 2025-2026. Mathematics has been fundamental to the development of science and technology. In recent decades, the extent of application of Mathematic s to real world problems has increased by leaps and bounds. Taking into consideration the rapid changes in science and technology and new approaches in different areas of mathematics and related subjects like Physics, Statistics and Computer Sciences, the board of studies in Mathematics with concern of teachers of Mathematics from different colleges affiliated to University of Mumbai has prepared the syllabus of S.Y.B. Sc. Mathematics. The present syllabi of S. Y. B. Sc. for Semester III and Semester IV has been designed as per NEP 2020 guidelines. Curriculum so that the students learn Mathematics needed for these branches, learn basic concepts of Mathematics and are exposed to rigorous methods gently and slowly. The syllabi of S. Y. B. Sc. Mathematics would consist of two semesters and each semester would comprise of Three course and Two practicals. These courses will provide essential skills and knowledge in mathematics, it's also vital to expand mathematical experiences for those with a natural affinity for the subject. The practical course has been designed to help the student have a firm grip on the theoretical concepts through relevant experiments in each course.

2. Aims and Objectives:

- Give the students a sufficient knowledge of fundamental principles, methods, and a clear perception of in numerous powers of mathematical ideas and tools and know how to use them by modelling, solving, and interpreting.
- Reflecting on the broad nature of the subject and developing mathematical tools for continuing further study in various fields of science.
- Enhancing students' overall development and to equip them with mathematical modelling abilities, problem solving skills, creative talent, and power of communication necessary for various kinds of employment.
- A student should get adequate exposure to global and local concerns that explore them many aspects of Mathematical Sciences.

3. Program Outcome:

After successful completion of this programme learners will be able to

- Develop the knowledge of basic concepts of different branches of science.
- Basic tricks in Mathematics can be helpful to learners in Competitive Examinations.
- Prepare Learners for prominent career in Industry, Banks and for further Academic

study.

- Learners can set up mathematical models of real-world problems and obtain solutions for the same.

4. Learning Outcomes:

- Students' knowledge and skills will get enhanced and they will get confidence and interest in mathematics, so that they can master mathematics effectively and will be able to formulate and solve problems from mathematical perspective.
- Students thinking ability and attitude will change towards learning mathematics and practicals will improve their logical and analytical thinking.

Credit Structure of the Programme (Sem III & IV)

Semester	Course Code	Title of the Course	Category of Course	No. of Credits
III (Level 5.0)	**USMTT301 (Major)**	Real Analysis and Linear Algebra I	**Major**	**2**
	USMTT302 (Major)	Indian Mathematics (IKS)	**Major**	**2**
	USMTP303	Practical -301 (Practical based on Real Analysis and Linear Algebra I)	**Major**	**2**
	USMTT304 (Minor)	Basics of Number Theory and Linear Programming	**Minor**	**2**
	USMTP305 (Minor)	Practical -401 (Practical based on Basics of Number Theory and Linear Programming)	**Minor**	**2**
	MTOE02 (OE)	Mathematics for Competitive Exams – II	**OE**	**2**
	MTOE03 (OE)	Vedic Mathematics – I	**OE**	**2**
	MTSEC03 (SEC)	Basics in Python Programming	**SEC**	**2**
	FP		**FP**	**2**
IV (Level 5.0)	**USMTT401 (Major)**	Multivariable Calculus and Ordinary Differential Equation	**Major**	**2**
	USMTT402 (Major)	Linear Algebra II	**Major**	**2**
	USMTP403	Practical - 501 (Practical based on Multivariable Calculus, Linear Algebra II and Ordinary Differential Equation)	**Major**	**2**
	USMTT404 (Minor)	Basic Mathematics in Real Life – II	**Minor**	**2**
	USMTP405 (Minor)	Practical - 601 (Practical based on Basic Mathematics in Real Life - II)	**Minor**	**2**
	MTOE04 (OE)	Vedic Mathematics – II	**OE**	**2**

	MTOE05 (OE)	Quantitative Aptitude	**OE**	**2**
	MTVSC03 (VSC)	Computing with Python	**VSC**	**2**
	FP		**FP**	**2**

SEMESTER - III
STRUCTURE OF THE COURSE

Semester	Course Code	Course title	No. of Credits	No. of Lectures
I	**USMTT301 (Major)**	**Real Analysis and Linear Algebra I**	**2**	**30**

SEMESTER – III

Course Title: - **Real Analysis and Linear Algebra I (Major)**

Course Code: **USMTT301**

Course Objectives:

- To give sufficient knowledge of fundamental principles, methods, and a clear perception of numerous powers of mathematical ideas and tools and the skills to use them by modelling, solving, and interpreting.
- To reflect the broad nature of the subject and develop mathematical tools for continuing further study in various fields of sciences.
- To enhance students' overall development, problem solving skills, creative talent, and power of communication are necessary for various kinds of employment.
- To give adequate exposure to global and local concerns that would help learners explore many aspects of Mathematical Sciences.

Course Outcomes: After completion of the course, students will be able to

- Explain the basic concepts of Real Analysis including Infinite series, Riemann integration.
- Explain the Formal proofs are given lot of emphasis in this course which also enhances understanding of the subject of Mathematics as a whole.
- Expositions to system of linear equations and matrices, Vector spaces, Basis and dimension, Linear Transformation, Inner product space, Eigen values and eigenvectors.
- Solve systems of linear equations by using Gaussian elimination method.

UNIT I) INFINITE SERIES, RIEMANN INTEGRATION **15 LECTURES**
(i) Infinite series in R. Definition of convergence and divergence. Basic examples including geometric series. Elementary results such as if $\sum_{n=1}^{\infty} a_n$ is convergent, then $a_n \to 0$, but converse not true. Cauchy Criterion. Algebra of convergent series. (ii) Tests for convergence: Comparison Test, Limit Comparison Test, Ratio Test (without proof), Root Test (without proof), Abel Test (without proof) and Dirichlet Test (without proof). Examples. The decimal expansion of

real numbers. Convergence of $\sum_{n=1}^{\infty}\frac{1}{n^p}$ (p > 1). Divergence of harmonic series $\sum_{n=1}^{\infty}\frac{1}{n}$.

(iii) Alternating series. Leibnitzs Test. Examples. Absolute convergence, absolute convergence implies convergence but not conversely. Conditional Convergence.

(iv) Idea of approximating the area under a curve by inscribed and circumscribed rectangles. Partitions of an interval. Refinement of a partition. Upper and Lower sums for a bounded real valued function on a closed and bounded interval. Riemann integrability and the Riemann integral Criterion for Riemann integrability. Characterization of the Riemann integral as the limit of a sum. Examples.

(v) Algebra of Riemann integrable functions. Also, basic results such as if f : [ab] $\rightarrow R$ is integrable, then

(a) $\int_a^b f(x)dx = \int_a^c f(x)dx + \int_c^b f(x)dx$

(b) $|f|$ is integrable and $\left|\int_a^b f(x)dx\right| \leq \int_a^b |f(x)|dx$

(c) If f(x) $\geq$ 0 for all x $\in$ [a, b] then $\int_a^b f(x)dx \geq 0$.

II) SYSTEM OF EQUATIONS, MATRICES AND VECTOR SPACES
15 LECTURES

(i) Systems of homogeneous and non-homogeneous linear equations, Simple examples of finding solutions of such systems. Geometric and algebraic understanding of the solutions. Matrices (with real entries), Matrix representation of system of homogeneous and non-homogeneous linear equations. Algebra of solutions of systems of homogeneous linear equations. A system of homogeneous linear equations with number of unknowns more than the number of equations has infinitely many solutions.

(ii) Elementary row and column operations. Row equivalent matrices. Row reduction (of a matrix to its row echelon form). Gaussian elimination. Applications to solving systems of linear equations. Examples.

(iii) Elementary matrices. Relation of elementary row operations with elementary matrices. Invertibility of elementary matrices. Consequences such as (i) a square matrix is invertible if and only if its row echelon form is invertible. (ii) invertible matrices are products of elementary matrices. Examples of the computation of the inverse of a matrix using Gauss elimination method.

(iv) Definition of a vector space over R. Subspaces; criterion for a nonempty subset to be a subspace of a vector space. Examples of vector spaces, including the Euclidean space R^n, lines, planes and hyperplanes in R^n passing through the origin, space of systems of homogeneous linear equations, space of polynomials, space of various types of matrices, space of real valued functions on a set.

(v) Intersections and sums of subspaces. Direct sums of vector spaces. Quotient space of a vector space by its subspace. Linear combination of vectors. Linear span of a subset of a vector space. Definition of a finitely generated vector space. Linear dependence and independence of subsets of a vector space.

Recommanded Books:

1. Sudhir Ghorpade and Balmohan Limaye, A course in Calculus and Real Analysis, Springer International Ltd, 2000.
2. R.R. Goldberg, Methods of Real Analysis; Oxford and IBH Pub. Co., New Delhi, reprint, 2019.
3. Serge Lang, Introduction to Linear Algebra, Springer International Edition, Second Edition, 2009.

Reference Books:

1. S Kumaresan, Linear Algebra- A Geometric Approach, PHI Learning Pvt. Ltd, Ninth Edition. 2009.
2. Sheldon Axler, Linear Algebra done right, Springer International Edition, 4th Edition, 2024.
3. Gareth Williams, Linear Algebra with Applications, Jones and Bartlett Publishers, 9th Edition,2019.
4. David W. Lewis, Matrix theory, World Scientific Publishing Co Pte Ltd, 1991.
5. Ajit Kumar, S. Kumaresan; A Basic Course in Real Analysis; CRC Press, 2014.
6. Calculus and Analytic Geometry (Ninth Edition); Thomas and Finney; Addison-Wesley, Reading Mass., 1998.
7. T. M. Apostol; Calculus Vol. 1, John Wiley Pvt. Ltd. 2th Edition, 2013.

8. D. Somasundaram and B. Choudhary; A First Course in Mathematical Analysis, Narosa, New Delhi, 1996.
9. J. E. Marsden, A.J. Tromba and A. Weinstein; Basic Multivariable Calculus; W. H. Freeman & Co Ltd; 3rd edition, 1993.
10. Howard Anton, Chris Rorres, Elementary Linear Algebra, Wiley Student Edition. Eleventh Edition, 2014.

Course Title: INDIAN MATHEMAT ICS (IKS) (Major)
Course Code: USMTT302

Course Objectives:

- To give knowledge of History of Indian Mathematics.
- To provide a glimpse of how various important mathematical ideas got evolved in India over several millennia.
- To give adequate exposure to Mathematics of the Vedic Age.
- To give knowledge of the Evolution of the Indian Decimal Place Value System.

Course Outcomes: After completion of the course, students will be able to

- Explain the basic concepts of History of Indian Mathematics.
- Understand various mathematical ideas got evolved in India over several millennia.
- Explain the Evolution of the Indian Decimal Place Value System.
- Understand the Work of Ancient mathematicians Aryabhata I and Brahmagupta.

UNIT I) INDIAN MATHEMATICS IN WORLD MATHEMATICS, THE HARAPPA- VEDIC NEXUS 15 LECTURES
(i) History of Indian Mathematics: Some outstanding Issues. Problems in Studying the History of Indian Mathematics. Differing Perspectives on Indian Mathematics and Astronomy. (ii) Indian Mathematics: Unravelling its Roots. Indian Mathematics in World Mathematics: Global Interactions. Ancient India: A Chronology to the Beginning of the Common Era. (iii) The Beginnings: The Harappan Story. 'Frozen' Mathematics of the Harappan Civilisation. Indus Writing: A Numerical Record? Mathematics of the Vedic Age.
UNIT II) MATHEMATICS IN JAIN AND BUDDHIST LITERATURE, HERALDING THE GOLDEN AGE 15 LECTURES

(i) Large Numbers: An Indian Obsession, The Evolution of the Indian Decimal Place Value System. *Sunyata* and the Emergence of the Mathematical Zero. The Infinity: The Jain Preoccupation.

(ii) Heralding the Golden Age: Aryabhata I, The Mathematics in *Aryabhatiya.* Brahmagupta, The Mathematics in the *Brahmasphutasiddhanta.*

Recommanded Books:

[1] George Gheverghese Joseph, Indian Mathematics: Engaging with The World from Ancient to Modern Times, World Scientific Publishing Europe Ltd, 2022.

[2] Partha Pratim Ray, The Great Mathematicians of Bharat, First Edition, Rajmangal Prakashan, Uttar Pradesh, India, 2023.

References Books:

[1] Gaurav Tekriwal, The Great Indian Mathematicians: 15 Pioneers Who put Indian Mathematics on the World Map, Puffin publisher, 2021.

[2] Gérard G. Emch, R. Sridharan, M. D. Srinivas, Contributions to The History of Indian Mathematics, 2005.

[3] T. S. Bhanumurthy, A Modern Introduction To Ancient Indian Mathematics, New Age International Private Limited, 2008.

[4] Gerard G. Emch, R. Sridharan, M. D. Srinivas, Contributions to The History of Indian Mathematics, Hindustan Book Agency, 2005.

[5] C. S. Seshadri, Studies in the History of Indian Mathematics, Hindustan Book Agency, New Delhi, India, 2010.

[6] L.V. Gurjar, Ancient Indian Mathematics and Vedha, Ideal book Service Poona, 1947.

[7] P. P. Divakaran, Mathematics of India: Concepts, methods, connections, Hindustan Book Agency, New Delhi, India, 2017.

EXAMINATION PATTERN FOR MAJOR SUBJECTS

Scheme of Examination for Each Semester:

Continuous Internal Evaluation (CIE): 20 Marks

Sr. No.	Particulars	Marks
01	One Unit Test	10 Marks
02	Home Assignment/ Book Review/ Presentation/Poster/Chart /Model Making.	05 Marks
03	Subject related activities.	05 Marks
	Total	**20 Marks**

Semester End Examination (SEE): 30 Marks

Duration: 1 Hour		**Marks: 30**
Q. 1 A)	Attempt Any Two: (a) Question on Unit I (b) Question on Unit I (c) Question on Unit I	10 Marks
Q. 2 A)	Attempt Any Two: (a) Question on Unit II (b) Question on Unit II (c) Question on Unit II	10 Marks
Q. 3 A)	Attempt Any Two: (a) Question on Unit I or Unit II (b) Question on Unit I or Unit II (c) Question on Unit I or Unit II	10 Marks
	Total	**30 Marks**

Course Title: Practical -301

(Practical based on Real Analysis and Linear Algebra I)

CREDIT STRUCTURE

Semester	Course Code	Title of the Course	Category of Course	Credits
III (Level 5.0)	**USMTP303**	**Practical – 301 (Practical based on Real Analysis and Linear Algebra I)**	**Practical**	**02**

Course Objectives (CO):

- To give sufficient knowledge of fundamental principles, methods, and a clear perception of numerous powers of mathematical ideas and tools and the skills to use them by modelling, solving and interpreting.
- To reflect the broad nature of the subject and develop mathematical tools for continuing further study in various fields of sciences.
- To give knowledge of History of Indian Mathematics.
- To give adequate exposure to Mathematics of the Vedic Age.

Course Outcomes: After the completion of the course, students will be able:

- Explain the basic concepts of Real Analysis including Infinite series, Riemann integration.
- Expositions to system of linear equations and matrices, Vector spaces, Basis and dimension, Linear Transformation, Inner product space, Eigen values and eigenvectors.
- Solve systems of linear equations by using Gaussian elimination method.
- Explain the basic concepts of History of Indian Mathematics.
- Understand various mathematical ideas got evolved in India over several millennia.
- Explain the Evolution of the Indian Decimal Place Value System.

LIST OF PRACTICALS

1.	Elementary results on Infinite series.
2.	Examples on Root Test, Abel Test and Dirichlet Test.
3.	Examples on Comparison Test, Limit Comparison Test, Ratio Test.
4.	Convergence of $\sum_{n=1}^{\infty} \frac{1}{n^p}$ (p > 1), Divergence of harmonic series $\sum_{n=1}^{\infty} \frac{1}{n}$.
5.	Alternating series. Leibnitzs Test.
6.	Absolute convergence and Conditional Convergence.
7.	Upper and Lower sums for a bounded real valued function.

8.	Idea of approximating the area under a curve by inscribed and circumscribed rectangles.
9.	Riemann integrability and Criterion for Riemann integrability.
10.	Algebra of Riemann integrable functions, Basic Results.
11.	Systems of homogeneous and non-homogeneous linear equations.
12.	Geometric interpretation of the solutions.
13.	Row equivalent matrices. Row reduction of a matrix to its row echelon form.
14.	Gaussian elimination method.
15.	Properties of Elementary matrices and Invertibility of elementary matrices.
16.	Computation of the inverse of a matrix using Gauss elimination method.
17.	Subspaces, properties.
18.	Intersections and sums of subspaces. Direct sums of vector spaces.
19.	Examples of vector spaces.
20.	Basis of a vector space. Basic results on vector space.

Recommanded Books:

1. Sudhir Ghorpade and Balmohan Limaye, A course in Calculus and Real Analysis, Springer International Ltd, 2000.
2. R.R. Goldberg, Methods of Real Analysis; Oxford and IBH Pub. Co., New Delhi, reprint, 2019.
3. Howard Anton, Chris Rorres, Elementary Linear Algebra, Wiley Student Edition. Eleventh Edition, 2014.
4. Serge Lang, Introduction to Linear Algebra, Springer International Edition, Second Edition, 2009.

Reference Books:

1. S Kumaresan, Linear Algebra- A Geometric Approach, PHI Learning Pvt. Ltd, Ninth Edition. 2009.
2. Sheldon Axler, Linear Algebra done right, Springer International Edition, 4th Edition, 2024.
3. Gareth Williams, Linear Algebra with Applications, Jones and Bartlett Publishers, 9th Edition,2019.
4. David W. Lewis, Matrix theory, World Scientific Publishing Co Pte Ltd, 1991.
5. Ajit Kumar, S. Kumaresan; A Basic Course in Real Analysis; CRC Press, 2014.
6. Calculus and Analytic Geometry (Ninth Edition); Thomas and Finney; Addison-Wesley, Reading Mass., 1998.
7. T. M. Apostol; Calculus Vol. 1, John Wiley Pvt. Ltd. 2th Edition, 2013.
8. D. Somasundaram and B. Choudhary; A First Course in Mathematical Analysis, Narosa, New Delhi, 1996.
9. J. E. Marsden, A.J. Tromba and A. Weinstein; Basic Multivariable Calculus; W. H. Freeman & Co Ltd; 3rd edition, 1993.

SEMESTER – III

Course Title: **BASICS OF NUMBER THEORY AND LINEAR PROGRAMMING (Minor)**

Course Code: **USMTT304**

Course Objectives:

- To understand the properties and relationships of numbers, particularly integers, including concepts like divisibility, prime numbers, and factorization.
- To develop Number Sense and Problem-Solving Skills.
- To provide a scientific, analytical approach to solving complex problems.
- To make informed decisions by optimizing resource allocation and improving system performance.

Course Outcomes: After completion of the course, students will be able to

- Develop Problem-Solving Skills.
- Explain the properties and relationships of numbers.
- Use quantitative methods to help organizations make better decisions and optimize their processes.
- Use quantitative methodologies to obtain the optimum performance under specifi c circumstances.

UNIT I) UNDERSTAN-DING INTEGERS	**15 LECTURES**

(i) Statement and simple problems on First Principle of Mathematical Induction. Statement of Division algorithm; G. C. D. of two positive integers, Expression of G. C. D. of two integers x, y in the form px + qy (p, q are integers),

(Euclidean Algorithm without proof).

(ii) Representation of a positive integer in Binary and decimal mode. Linear Diophantine equation in two variables: Statement of condition on the existence of integral solution, General / particular solution, Simple real-life applications.

(iii) Prime Integers. Some elementary properties of prime Integers (only statement), Fundamental theorem of Arithmetic (only statement), Algorithm for Primality test. Congruence of Integers: Meaning of $a \equiv b \pmod{m}$, Statements of elementary properties of congruence;

If $a \equiv b \pmod m$ then for any integer c, $(a + c) \equiv (b + c) \pmod m$, $(a – c) \equiv (b – c) \pmod m$, $ac \equiv bc \pmod m$, $a^n \equiv b^n \pmod m$ for natural numbers n. Application of congruence of integers: Divisibility tests by 2, 3, 4, 5, 7, 9, 11, 13 (Statements of relevant results and problems only).
UNIT II) Basics of Operations Research 15 LECTURES
(i) Idea of Linear Programming Problems: Objective function, decision variables, constraints. Formulation of daily life problems as an LPP (e.g. Carpenter problem, preparation of mixtures of chemicals, diet problems etc.). (ii) Solution of an LPP by graphical method (only Bounded region). Definition of Game, Examples from daily life Two-person zero sum game, Strategy, Payoff, Saddle point, Solution of a game problem with saddle point (only elementary problems).

References Books:

[1] Richard Courant and Herbert Robbins; What is Mathematics? Oxford University Press, 1995.

[2] David M. Burton; Elementary Number Theory, Universal Book Stall, 1989.

[3] Kenneth H. Rosen, Elementary Number Theory and its Applications; Addison-Wesley Publishing Company, 1984.

[4] M. K. Sen and B. C. Chakraborty; Introduction to Discrete Mathematics, Books and Allied (P) Ltd, 2019.

[5] Elliott Mendelson; Introduction to Mathematical Logic; Chapman & Hall; London, 1997.

[6] M. Chakraborty; Lecture note: A journey through the logic wonderland, IIEST Shibpur, 2016.

[7] Paul R. Thie and G. E. Keough, An Introduction to Linear Programming and Game Theory; John Wiley & Sons, INC., Third Edition, 2008.

[8] Richard Bronson and Govindasami Naadimuthu, Schaum's Outline of Operations Research; McGraw Hill, 1997.

[9] J. G. Chakraborty and P.R. Ghosh, Linear Programming and Game Theory, Moulik Library, 2009.

[10] Petr Zima and Robert L. Brown, Mathematics of Finance, Schaum's Outline Series, McGraw-Hill, 2nd edition, 1996.

[11] P. Chandra, Investment Analysis and Portfolio Management; McGraw Hill (2008).
[12] Bonnie Averbach and Orin Chein, Problem Solving Through Recreational Mathematics, Dover Publications, 1980.

EXAMINATION PATTERN FOR MINOR SUBJECTS

Scheme of Examination for Each Semester:

Continuous Internal Evaluation (CIE): 20 Marks

Sr. No.	Particulars	Marks
01	One Unit Test	10 Marks
02	Home Assignment/ Book Review/ Presentation/Poster/Chart /Model Making.	05 Marks
03	Subject related activities.	05 Marks
	Total	**20 Marks**

Semester End Examination (SEE): 30 Marks

Duration: 1 Hour		**Marks: 30**
Q. 1 A)	Attempt Any Two: (d) Question on Unit I (e) Question on Unit I (f) Question on Unit I	10 Marks
Q. 2 A)	Attempt Any Two: (d) Question on Unit II (e) Question on Unit II (f) Question on Unit II	10 Marks
Q. 3 A)	Attempt Any Two: (d) Question on Unit I or Unit II (e) Question on Unit I or Unit II (f) Question on Unit I or Unit II	10 Marks
	Total	**30 Marks**

Course Title: Practical - 401 (PRACTICAL BASED ON BASICS OF NUMBER THEORY AND LINEAR PROGRAMMING)

CREDIT STRUCTURE

Semester	Course Code	Title of the Course	Category of Course	Credits
III (Level 5.0)	**USMTP305**	**Practical - 401 (PRACTICAL BASED ON BASICS OF NUMBER THEORY AND LINEAR PROGRAMMING)**	**Practical (Minor)**	**02**

Course Objectives:

- To understand the properties and relationships of numbers, particularly integers, including concepts like divisibility, prime numbers, and factorization.
- To develop Number Sense and Problem-Solving Skills.
- To provide a scientific, analytical approach to solving complex problems.
- To make informed decisions by optimizing resource allocation and improving system performance.

Course Outcomes: After completion of the course, students will be able to

- Develop Problem-Solving Skills.
- Explain the properties and relationships of numbers.
- Use quantitative methods to help organizations make better decisions and optimize their processes.
- Use quantitative methodologies to obtain the optimum performance under specific circumstances.
- Solve the examples in Competitive exams in less time.

LIST OF PRACTICALS

1.	Problems on First Principle of Mathematical Induction.
2.	Division algorithm Theorem, G. C. D. of two positive integers.
3.	Representation of a positive integer in Binary and decimal mode.
4.	Existence of integral solution.
5.	General / particular solution of Linear Diophantine equation.
6.	Real-life applications on Linear Diophantine equation.
7.	Prime Integers. Elementary properties of prime Integers, Fundamental theorem of Arithmetic.
8.	Elementary properties of congruence.
9.	Application of congruence of integers.
10.	Divisibility tests by 2, 3, 4 and 5.
11.	Divisibility tests by 7, 9, 11 and 13.
12.	Examples on divisibility of integers.

13.	Linear Programming Problems: Objective function, decision variables, constraints.
14.	Formulation of daily life problems as an LPP – I.
15.	Formulation of daily life problems as an LPP – II.
16.	Solution of an LPP by graphical method.
17.	Game, Examples from daily life, Two-person zero sum game.
18.	Strategy, Payoff, Saddle point.
19.	Solution of a game problem with saddle point.
20.	Duality in LPP.

References Books:

[1] Richard Courant and Herbert Robbins; What is Mathematics? Oxford University Press, 1995.

[2] David M. Burton; Elementary Number Theory, Universal Book Stall, 1989.

[3] Kenneth H. Rosen, Elementary Number Theory and its Applications; Addison-Wesley Publishing Company, 1984.

[4] M. K. Sen and B. C. Chakraborty; Introduction to Discrete Mathematics, Books and Allied (P) Ltd, 2019.

[5] Elliott Mendelson; Introduction to Mathematical Logic; Chapman & Hall; London, 1997.

[6] M. Chakraborty; Lecture note: A journey through the logic wonderland, IIEST Shibpur, 2016.

[7] Paul R. Thie and G. E. Keough, An Introduction to Linear Programming and Game Theory; John Wiley & Sons, INC., Third Edition, 2008.

[8] Richard Bronson and Govindasami Naadimuthu, Schaum's Outline of Operations Research; McGraw Hill, 1997.

[9] J. G. Chakraborty and P.R. Ghosh, Linear Programming and Game Theory, Moulik Library, 2009.

[10] Petr Zima and Robert L. Brown, Mathematics of Finance, Schaum's Outline Series, McGraw-Hill, 2nd edition, 1996.

[11] P. Chandra, Investment Analysis and Portfolio Management; McGraw Hill (2008).

[12] Bonnie Averbach and Orin Chein, Problem Solving Through Recreational Mathematics, Dover Publications, 1980.

EXAMINATION PATTERN FOR

PRACTICAL - 301, PRACTICAL - 401, PRACTICAL - 501, PRACTICAL - 601

Scheme of Examination for Each Semester:

Continuous Internal Evaluation (CIE): 20 Marks

Sr. No.	Particulars	Marks
01	One Unit Test	10
02	Quiz/ Seminar	05
03	Viva	05
	Total	**20 Marks**

Semester End Practical Examination: 30 Marks

Duration: 2 Hour		**Marks: 25**
Q. 1 A)	Attempt Any Three: (Out of Five)	15
Q. 2 A)	Attempt Any Two: (Out of Four)	10
	Total	**25 Marks**

Marks for Journal: **05.**

CREDIT STRUCTURE

Semester	Course Code	Title of the Course	Type	Credits
III (Level 5.0)	**MTOE02 (OE)**	**MATHEMATICS FOR COMPETITIVE EXAMS - II**	**Theory**	**02**

Course Objectives:

- To understand the Basic concepts in Mathematics.
- To use different tricks to solve the problems of Mathematics in Competitive Examinations.
- To strengthen the ability to draw logical conclusions.

Course Outcomes: After completion of the course, students will be able to

- Provide a platform to the learners for building the fundamentals of basic mathematics for competitive examinations preparation strategy.
- Establish a framework to help learners acquire knowledge and expertise necessary to secure employment opportunities in the Government sector.

UNIT I) INTEREST AND ANNUNITY **10 Lectures**
Simple Interest, Compound Interest (Nominal & Effective Rate of Interest), Calculations involving upto 4 time periods. Annuity Immediate and its Present value, Future value. Equated Monthly Instalments (EMI) using reducing balance method & amortization of loans. Related Examples.
UNIT II) PERMUTATION AND COMBINATION 10 Lectures
Factorial Notation, Fundamental principle of counting, Permutation as arrangement, Simple examples, combination as selection, Simple examples, Relation between ${}^{n}Cr$ and ${}^{n}Pr$. Examples on commercial application of permutation and combination.
UNIT III) ARITHMETIC 10 LECTURES
Banker's Discount, Binomial theorem, Boat and 10 Streams, Calendar, Chain rule, clock, Odd Man Out and Series. Problems Trains and Age. Present value, Future value, true discount. Related examples.

References Books:

1) Mathematics for Economics and Finance Methods and Modelling by Martin Anthony and Norman Biggs, Cambridge University Press, Cambridge low-priced edition, 2000, Chapters 1, 2, 4, 6 to 9 & 10.

2) Business Mathematics by D. C. Sancheti and V. K. Kapoor, Sultan Chand & Sons, 2006, Chapter 1, 5, 7, 9 &10.
3) Fundamentals of Mathematical Statistics, Gupta S. C., Kapoor V. K., Sultan Chand & Sons, 12th Edition, 2020.
4) Statistics - Theory, Method & Applications, D. C. Sancheti & V. K. Kapoor, Sultan Chand and Sons, 2010.
5) Mathematical Statistical Techniques (F. Y. B. Com.), R. J. Shah, Sheth publishers Pvt. Ltd. Mumbai, 3rd Edition, 2009.
6) Quantitative Methods – I (BBI First year: First Semester), A. V. Deshpande, A. P. Kumtha, Vipul Prakashan, Mumbai, 1st Edition 2016.
7) Quantitative Methods – II (BBI First year: Second Semester), A. P. Kumtha, Vipul Prakashan, Mumbai, 1st Edition 2016.

CREDIT STRUCTURE

Semester	Course Code	Title of the Course	Type	Credits
III (Level 5.0)	**MTOE03 (OE)**	**VEDIC MATHEMATICS – I**	**Theory**	**02**

Course Objectives:

- To reduce the fear of Mathematics and increase the confidence.
- To provide an insight into ancient Indian Mathematics.
- To crack scholarship and entrance exams.

Course Outcomes: After completion of the course, students will be able to

- Crack basic tricks in Vedic Maths which can be helpful in Competitive Examinations.
- learn the Contribution of ancient Indian Mathematicians to Mathematics.

UNIT I) INTRODUCTION OF VEDIC MATHS 10 LECTURES
Tirthaji and the discovery of Vedic Mathematics. Development of further material. Maharishi School. Calculating Prodigies. The Sutras of Vedic Maths. Origin of Vedas. Authenticity. Nature of the Sutras. Pythagoras and the Cosmology of number.
UNIT II) MULTIPLICATION AND DIVISION 10 LECTURES
Multiplication**:** 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. Nikhilam Navtashchramam Dashtaha (Multiplication of two numbers of three digits). Division: 1. Nikhilam Navtashchramam Dashtaha (two digits divisor) 2. Paravartya Yojyet method (three digits divisor).

UNIT II) DIVISIBILITY, POWER AND CUBE ROOT 10 LECTURES
Divisibility: 1. Ekadhikenpurven method (two digits divisor) 2. Eknunenpurven method (two digits divisor). Power: 1. Square (two-digit numbers), 2. Cube (two- digit numbers). Cube Root: 1. Four-digit number. 2. Six-digit number. 3. Seven-digit number.

Reference Books:

1) Sri Bharati Krisna Tirthaji, V. S. Agarwala, Vedic Mathematics or Sixteen Simple Mathematical Formulae from the Vedas, Indological Publishers Delhi, 1981.
2) Gaurav Tekriwal, Maths Sutra: The Art of Vedic Speed Calculation., ISBN 13: 9780143425021, 2015.
3) William Q., Vedic Mathematics Secrets Fun Applications of Vedic Math In Your Everyday Life, 2007.
4) Dhaval Bathia, Vedic Mathematics Made Easy, Jaico Publishing House, 2021.
5) Vedic Mathematics, Motilal Banarsi Das, New Delhi.
6) Vedic Ganita: Vihangama Drishti-1, Siksha Sanskriti Uthana Nyasa, New Delhi.
7) Vedic Ganita Praneta, Siksha Sanskriti Uthana Nyasa, New Delhi.
8) Vedic Mathematics: Past, Present and Future, Siksha Sanskriti Uthana Nyasa, New Delhi.
9) Leelavati, Chokhambba Vidya Bhavan, Varanasi.

SKILL ENHANCEMENT COURSE (SEC)
TITLE OF THE COURSE: BASICS IN PYTHON PROGRAMMING
CREDIT STRUCTURE

Semester	Course Code	Title of the Course	Type	Credits
III (Level 5.0)	MTSEC03	BASICS IN PYTHON PROGRAMMING	Practical	02

Course Objectives (CO):

- To learn and understand algorithms.
- To define the structure and components of algorithm and python program.
- To learn and understand python looping and control statements manipulations.
- To learn about inbuilt input/output operations and compound data types in Python.
- To learn about searching, sorting and recursion with python programming.

Course Outcomes: After completion of the course, students will be able to

- Learn the fundamental concepts of algorithm and python.
- Understand the implementation of basic syntax, Input / Output operations, Loop controls and decision making with algorithms and Python.
- Apply basic programming techniques for solving problems in mathematics.
- Verify elementary mathematical results using Python.
- Evaluate the solutions of complex mathematical problems using Python.
- Create different algorithms/programs for searching sorting and recursion-Based problem.

LIST OF PRACTICALS

1.	Algorithm, characteristics of an algorithm. Elementary algorithmic vocabulary, Algorithm on assigning value to a variable and performing basic mathematical operations on the same and printing the final result.
2.	Exchange of values of two variables, using dummy variable.
3.	Exchange of values of two variables, without using dummy variable.
4.	Conditional Structure (if-then-else).
5.	Algorithm on accepting a positive integer from the user and writing all of its divisors and obtaining the sum of $1+2+\cdots+n$, $1^2+2^2+\cdots+n^2$, etc.
6.	Loop Structure with pre-unknown number of iterations (while loop).
7.	Checking whether the given (finite) sequence is monotone or not.
8.	Convergence of the sequences $\frac{1}{n}$ and $\frac{1}{n^2}$.
9.	Algorithm on Searching and sorting.
10.	Recursion: Algorithm of Tower of Hanoi and Fibonacci sequence.
11.	Running Code in the Interactive Shell, IDLE. Input, Processing, and Output.
12.	Data types and expressions.
13.	Boolean expressions and Conditional Structure (if-then-else-elif).

14.	Math Directory and the built-in functions and values – I.
15.	Math Directory and the built-in functions and values – II.
16.	Loop Structure with pre-known number of iterations (for loop).
17.	Getting positive integral roots of Brahmagupta's equation and verifying Goldbach conjecture.
18.	Divergence of the sequence 1, $1 + \frac{1}{2}$, $1 + \frac{1}{2} + \frac{1}{3}$, ……
19.	Program on integral roots of a given polynomial and getting square root of a positive integer.
20.	Program on accepting a positive real number from the user, say epsilon, and getting value of E.

Recommanded Books:

1. Downey, A. et al., How to think like a Computer Scientist: Learning with Python, John Wiley, 2015.
2. Goel, A., Computer Fundamentals, Pearson Education.
3. Lambert K. A., Fundamentals of Python - First Programs, Cengage Learning India, 2015.

Reference Books:

1. Barry, P., Head First Python, O Reilly Publishers.
2. Dromy, R. G., How to solve it by Computer, Pearson India.
3. Guzdial, M. J., Introduction to Computing and Programming in Python, Pearson India.
4. Perkovic, L., Introduction to Computing Using Python, 2/e, John Wiley, 2015.
5. Sprankle, M., Problem Solving & Programming Concepts, Pearson India.
6. Venit, S. and Drake, E., Prelude to Programming: Concepts & Design, Pearson India.
7. Zelle, J., Python Programming, An Introduction to Computer Science, Franklin, Beedle & Associates Inc.
8. Rajaraman, V., Computer Basics and C Programming, Prentice-Hall India.
9. E Balagurusamy, Introduction to Computing and Problem-Solving Using Python, McGraw Hill Education (India) Private Limited.

EXAMINATION PATTERN FOR

SKILL ENHANCEMENT COURSE AND VOCATIONAL SKILL COURSE

Scheme of Examination for Each Semester:

Internal Evaluation (CIE): 20 Marks

Sr. No.	Particulars	Marks
01	One Unit Test	10
02	Quiz/ Seminar	05
03	Viva	05
	Total	**20 Marks**

Semester End Practical Examination: 30 Marks

Duration: 2 Hour		**Marks: 25**
Q. 1 A)	Attempt Any Three: (Out of Five)	15
Q. 2 A)	Attempt Any Two: (Out of Four)	10
	Total	**25 Marks**

Marks for Journal: **05.**

SEMESTER - IV

STRUCTURE OF THE COURSE

Semester	Course Code	Course title	No. of Credits	No. of Lectures
IV	**USMTT401 (Major)**	**MULTIVARIABLE CALCULUS AND ORDINARY DIFFERENTIAL EQUATION**	**2**	**30**

SEMESTER – IV

Course Title: - **MULTIVARIABLE CALCULUS AND ORDINARY DIFFERENTIAL EQUATION (MAJOR)**

Course Code: **USMTT401.**

Course Objectives:

- To give the students a sufficient knowledge of fundamental principles, methods and a clear perception of innumerous power of mathematical ideas and tools and know how to use them by modeling, solving and interpreting.
- To get adequate exposure to global and local concerns that explore them many aspects of Mathematical Sciences.
- To enhance students' overall development, problem solving skills, creative talent, and power of communication are necessary for various kinds of employment.

Course Outcomes: After completion of the course, students will be able to

- Introduce the basic concepts of Calculus with rigor and prepares students to study further courses in Calculus.
- Solve higher order homogeneous linear differential equations with constant coefficients.
- Prepare themselves to get solutions of so many kinds of problems in all subjects of science and also prepares learner for further studies of differential equations and related fields.

UNIT I) FUNCTIONS OF SEVERAL VARIABLES AND DIFFERENTIAT-ION OF SCALAR FIELDS 15 LECTURES

(i) Review of vectors in R^n [with emphasis on R^2 and R^3] and basic notions such as addition and scalar multiplication, inner product, length (norm), and distance between two points. Real-valued functions of several variables (Scalar fields). Graph of a function. Level sets (Level curves, level surfaces, etc). Examples.

(ii) Vector valued functions of several variables (Vector fields). Component functions. Examples. Sequences, Limits and Continuity: Sequence in R^n [with emphasis on R^2 and R^3] and their limits. Neighbourhoods in R^n. Limits and

continuity of scalar elds. Composition of continuous functions. Sequential characterizations. Algebra of limits and continuity (Results with proofs). Iterated limits. Limits and continuity of vector fields. Algebra of limits and continuity vector fields. (without proofs).

(iii) Partial and Directional Derivatives of scalar fields: Definitions of partial derivative and directional derivative of scalar elds (with emphasis on R^2 and R^3). Mean Value Theorem of scalar fields.

(iv) Differentiability of scalar elds (in terms of Linear transformation). The concept of (total) derivative. Uniqueness of total derivative of a differentiable function at a point. Examples of functions of two or three variables. Increment Theorem. Basic properties including

(a) continuity at a point of differentiability,

(b) existence of partial derivatives at a point of differentiability, and

(c) differentiability when the partial derivatives exist and are continuous.

UNIT 2) HIGHER ORDER LINEAR DIFFERENTIAL EQUATIONS AND SYSTEMS OF FIRST ORDER LINEAR DIFFERENTIAL EQUATIONS 15 LECTURES

(i) The general n^{th} order linear differential equations, Linear independence, An existence and uniqueness theorem, the Wronskian, Classification: homogeneous and non-homogeneous, General solution of homogeneous and non-homogeneous LDE, The Differential operator and its properties. Higher order homogeneous linear differential equations with constant coefficients, the auxiliary equations, Roots of the auxiliary equations: real and distinct, real and repeated, complex and complex repeated.

(ii) Higher order homogeneous linear differential Equations with constant coefficients, the method of undermined coefficients, method of variation of parameters. The inverse differential operator and particular integral, Evaluation of $\frac{1}{f(D)}$ for the functions like, e^{ax}, sinax, cosax, x^m, x^msinax, x^mcosax, e^{ax}V and xV, where V is any function of x. Higher order linear Differential equations with variable coefficients:

The Cauchys equation:

$$x^3\frac{d^3y}{dx^3} + x^2\frac{d^2y}{dx^2} + x\frac{dy}{dx} + y = f(x)$$

and The Legendre's equation: $(ax+b)^3\frac{d^3y}{dx^3} + (ax+b)^2\frac{d^2y}{dx^2} + (ax+b)\frac{dy}{dx} + y = f(x)$.

(iii) Existence and uniqueness theorem for the solutions of initial value problems for a system of two first order linear differential equations in two unknown functions x, y of a single independent variable t, of the form

$$\frac{dx}{dt} = F(t,x,y),\ \frac{dy}{dt} = G(t,x,y)$$

(statement only).

Homogeneous linear system of two first order Differential equations in two unknowns functions of a single independent variable t, of the form

$$\frac{dx}{dt} = a_1(t)x + b_1(t)y$$
$$\frac{dy}{dt} = a_2(t)x + b_2(t)y.$$

(iv) Wronskian for a homogeneous linear system of first order linear differential equations in two functions x, y of a single independent variable t. Vanishing properties of the Wronskian. Relation with linear independence of solutions. Homogeneous linear systems with constant coefficients in two unknowns functions x, y of a single independent variable t. Auxiliary equation associated to a homo. system of equations with constant coefficients.

Recommanded books:

1) T. Apostol; Calculus, Vol. 2 (Second Edition); John Wiley.
2) Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariable Calculus and Analysis (Second Edition); Springer.
3) E. D. Rainville and P.E. Bedient, Elementary Differential Equations, Macmillan Publisher,7th Edition, 1989.
4) M. D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand Publishing Company, Twentieth Edition, 2024.

References books:

1) J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus; Springer.
2) D. Somasundaram and B. Choudhary; A First Course in Mathematical Analysis, Narosa, New Delhi, 1996.
6) K. Stewart; Calculus; Booke/Cole Publishing Co, 1994.
7) Calculus and Analytic Geometry, G.B. Thomas and R. L. Finney, (Ninth Edition); Addison Wesley, 1998.
8) Howard Anton; Calculus- A new Horizon, (Sixth Edition); John Wiley and Sons Inc, 1999.
9) S L. Gupta and Nisha Rani; Principles of Real Analysis; Vikas Publishing house PVT LTD.
10) Shabanov, Sergei; Concepts in Calculus, III: Multivariable Calculus; University Press of Florida, 2012.
11) S. C. Malik and Savita Arora; Mathematical Analysis; New Age International Publishers.

12) G.F. Simmons; Differential Equations with Applications and Historical Notes; Taylors and Francis.
13) S. S. Sastry, Introductory Methods of Numerical Analysis, Prentice Hall India Learning Private Limited; Fifth Edition, 2012.
14) K. Atkinson, W. Han and D Stewart, Numerical Solution of Ordinary Differential Equations, Wiley.

STRUCTURE OF THE COURSE

Semester	Course Code	Course title	No. of Credits	No. of Lectures (Hrs)
IV	**USMTT402 (Major)**	**LINEAR ALGEBRA-II**	**2**	**30**

SEMESTER – IV

Course Title: - **LINEAR ALGEBRA II (MAJOR)**

Course Code: **USMTT402**

Course Objectives:

- To emphasis in this course which also enhances understanding of the subject of Mathematics as a whole.
- To give sufficient knowledge of Linear Transformations, Inner Products and Orthogonality of vectors.
- To enhance students' overall development, problem solving skills, creative talent, and power of communication are necessary for various kinds of employment.

Course Outcomes: After completion of the course, students will be able to

- Explain properties of inner product space.
- Gives expositions to Linear Transformations and Orthogonality of vectors.
- Explain the Eigenvalues, Eigenvectors of a linear transformation of a vector space and Diagonalisation.

UNIT I) I) LINEAR TRANSFORMA-TIONS AND INNER PRODUCTS AND ORTHOGONALITY 15 LECTURES
(i) Definition of a linear transformation of vector spaces; elementary properties. Examples. Sums and scalar multiples of linear transformations. Composites of linear transformations. A Linear transformation of $V \rightarrow W$, where V, W are vector spaces over R and V is a finite-dimensional vector space is completely determined by its action on an ordered basis of V. Null-space (kernel) and the image (range) of a linear transformation. Nullity and rank of a linear transformation. Rank-Nullity Theorem (Fundamental Theorem of Homomorphisms). (ii) Matrix associated with linear transformation of $V \rightarrow W$, where V and W are finite dimensional vector spaces over R. Matrix of the composite of two linear transformations. Invertible linear transformations (isomorphisms), Linear operator, Effect of change of bases on matrices of linear operator. Equivalence of the rank of a matrix and the rank of the associated linear transformation. Similar matrices.

(iii) Inner product spaces (over R). Examples, including the Euclidean space R^n and the space of real valued continuous functions on a closed and bounded interval. Norm associated to an inner product. Cauchy-Schwarz inequality. Triangle inequality. Angle between two vectors. Orthogonality of vectors. Pythagoras theorem and some geometric applications in R^2. Orthogonal sets, Orthonormal sets. Gram-Schmidt orthogonalizaton process. Orthogonal basis and orthonormal basis for a finite-dimensional inner product space.

(iv) Orthogonal complement of any set of vectors in an inner product space. Orthogonal complement of a set is a Vector subspace of the inner product space. Orthogonal decomposition of an inner product space with respect to its subspace. Orthogonal projection of a vector onto a line (one dimensional subspace). Orthogonal projection of an inner product space onto its subspace.

UNIT II) EIGENVALUES, EIGENVECTORS AND DIAGONALIZATION 15 LECTURES

(i) Eigenvalues and eigenvectors of a linear transformation of a vector space into itself and of square matrices. The eigenvectors corresponding to distinct eigenvalues of a linear trans formation are linearly independent. Eigen spaces. Algebraic and geometric multiplicity of an eigenvalue.

Characteristic polynomial. Properties of characteristic polynomials (only statements). Examples.

(ii) Cayley-Hamilton Theorem. Applications. Invariance of the characteristic polynomial and eigenvalues of similar matrices. Diagonalisable matrix. A real square matrix A is diagonalisable if and only if there is a basis of R^n consisting of eigenvectors of A. (Statement only- A_{nxn} is diagonalisable if and only if sum of algebraic multiplicities is equal to sum of geometric multiplicities of all the eigenvalues of A = n).

(iii) Procedure for diagonalising a matrix. Spectral Theorem for Real Symmetric Matrices (Statement only). Examples of orthogonal diagonalisation of real symmetric matrices. Applications to quadratic forms and classification of conic Sections.

Reference books:

1) Howard Anton, Chris Rorres; Elementary Linear Algebra; Wiley Student Edition, Eleventh Edition, 2014.
2) Serge Lang, Introduction to Linear Algebra, Springer International Edition, Second Edition, 2009.
3) S. Kumaresan, Linear Algebra- A Geometric Approach, PHI Learning Pvt. Ltd, Ninth Edition. 2009.
4) Sheldon Axler, Linear Algebra done right, Springer International Edition, 4th Edition, 2024.
5) Gareth Williams, Linear Algebra with Applications, Jones and Bartlett Publishers, 9th Edition, 2019.
6) David W. Lewis, Matrix theory, World Scientific Publishing Co Pte Ltd, 1991.
7) M. Artin: Algebra, Prentice Hall of India Private Limited, Second Edition, 2010.
8) K. Hoffman and R. Kunze: Linear Algebra, Prentice Hall of India, New Delhi, 1971.
9) Gilbert Strang: Linear Algebra and its applications, International Student Edition.
10) L. Smith: Linear Algebra, Springer Verlag. Springer-Verlag New York, Third Edition, 1998.
11) A. Ramachandra Rao and P. Bhima Sankaran: Linear Algebra, Tata Mc Graw Hill, New Delhi.
12) T. Banchoff and J. Wermer: Linear Algebra through Geometry, Springer Verlag New York, Second Edition, 1992.
13) Klaus Janich, Linear Algebra, Springer-Verlag Berlin and Heidelberg GmbH & Co. K publisher, 1997.
14) 11. Otto Bretcher: Linear Algebra with Applications, Pearson Education.

Course Title: Practical - 501 (Practical based on Multivariable Calculus, Linear Algebra II and Ordinary Differential Equation)

CREDIT STRUCTURE

Semester	Course Code	Title of the Course	Category of Course	Credits
IV (Level 5.0)	**USMTP403**	**Practical - 501 (Practical based on Multivariable Calculus, Linear Algebra II and Ordinary Differential Equation)**	**Practical**	**02**

Course Objectives (CO):

- To get adequate exposure to global and local concerns that explore them many aspects of Mathematical Sciences.
- To reflect the broad nature of the subject and develop mathematical tools for continuing further study in various fields of science.
- To give sufficient knowledge of Linear Transformations, Inner Products and Orthogonality of vectors.

Course Outcomes: After the completion of the course, students will be able:

- Solve higher order homogeneous linear differential equations with constant coefficients.
- Prepare themselves to get solutions of so many kinds of problems in all subjects of science and also prepares learner for further studies of differential equations and related fields.
- Gives expositions to Linear Transformations and Orthogonality of vectors.
- Explain the Eigenvalues, Eigenvectors of a linear transformation of a vector space and Diagonalisation.

LIST OF PRACTICALS

1.	Real-valued functions of several variables (Scalar fields). Graph of a function. Level sets. Examples.
2.	Iterated limits. Limits and continuity of vector fields.
3.	Partial derivative and directional derivative of scalar elds (with emphasis on R^2 and R^3). Mean Value Theorem of scalar fields.
4.	Differentiability of scalar fields (in terms of linear transformation). The concept of (total) derivative.
5.	Increment Theorem. Basic properties.

6.	Gradient. Relation between total derivative and gradient of a function. Chain rule. Geometric properties of gradient.
7.	Solution of Higher order homogeneous linear differential equations with constant coefficients.
8.	The method of undermined coefficients, method of variation of parameters.
9.	Examples of initial value problems for a system of two first order linear differential equations in two unknown functions.
10.	Non-homogeneous linear system of linear system of two first order differential equations in two unknown functions of a single independent variable t.
11.	Linear transformation of vector spaces, Elementary properties. Examples.
12.	Nullity and rank of a linear transformation. Rank-Nullity Theorem.
13.	Invertible linear transformations, Linear operator, Effect of change of bases on matrices of linear operator.
14.	Algebraic and geometric multiplicity of an eigenvalue.
15.	Examples of Inner product spaces (over R). Cauchy-Schwarz inequality. Triangle inequality.
16.	Cayley-Hamilton Theorem. Applications.
17.	Examples of Gram-Schmidt orthogonalizaton process.
18.	Diagonalisable matrix. Properties of Diagonalisable matrix.
19.	Spectral Theorem for Real Symmetric Matrices. Examples of orthogonal diagonalisation of real symmetric matrices.
20.	Applications to quadratic forms and classification of conic Sections.

Reference books:

1) T. Apostol; Calculus, Vol. 2 (Second Edition); John Wiley.
2) Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariable Calculus and Analysis Second Edition, Springer.
3) E. D. Rainville and P.E. Bedient, Elementary Differential Equations, Macmillan Publisher, 7th Edition, 1989.
4) M. D. Raisinghania, Ordinary and Partial Differential Equations, S. Chand Publishing Company, Twentieth Edition, 2024.
5) J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus; Springer.
6) D. Somasundaram and B. Choudhary; A First Course in Mathematical Analysis, Narosa, New Delhi, 1996.
7) K. Stewart; Calculus; Booke/Cole Publishing Co, 1994.
8) G.F. Simmons; Differential Equations with Applications and Historical Notes; Taylors and Francis.
9) S. S. Sastry, Introductory Methods of Numerical Analysis, Prentice Hall India Learning Private Limited; Fifth Edition, 2012.
10) K. Atkinson, W. Han and D Stewart, Numerical Solution of Ordinary Differential Equations, Wiley.
11) Howard Anton, Chris Rorres; Elementary Linear Algebra; Wiley Student Edition, Eleventh Edition, 2014.

12) Serge Lang, Introduction to Linear Algebra, Springer International Edition, Second Edition, 2009.
13) S. Kumaresan, Linear Algebra- A Geometric Approach, PHI Learning Pvt. Ltd, Ninth Edition. 2009.
14) Sheldon Axler, Linear Algebra done right, Springer International Edition, 4th Edition, 2024.
15) Gareth Williams, Linear Algebra with Applications, Jones and Bartlett Publishers, 9th Edition, 2019.
16) David W. Lewis, Matrix theory, World Scientific Publishing Co Pte Ltd, 1991.
17) M. Artin: Algebra, Prentice Hall of India Private Limited, Second Edition, 2010.
18) K. Hoffman and R. Kunze: Linear Algebra, Prentice Hall of India, New Delhi, 1971.
19) Gilbert Strang: Linear Algebra and its applications, International Student Edition.
20) L. Smith: Linear Algebra, Springer Verlag. Springer-Verlag New York, Third Edition, 1998.

Course Title: - **BASIC MATHEMATICS IN REAL LIFE (Minor)**

Course Code: **USMTT404**

Course Objectives:

- To introduce the basic Mathematical concepts that are used in different aspects of our daily life.
- To perform basic calculations and measurement.
- To understand about ratios and proportions.

Course Outcomes: After completion of the course, students will be able to

- Understand everyday banking transactions, identify patterns and relationships.
- Perform basic calculations and measurement.
- Understand about ratios and proportions.

UNIT I) I) TIME VALUE OF MONEY **15 LECTURES**
(i) Time value of money: - Simple interest and Compound interest (Fundamental Formulae); Interest payable monthly, quarterly, annually; (Only problems). Ordinary Simple Annuities – Accumulated value and Discounted Value of an ordinary simple annuity – Idea of repayment of loans, Simple problems. (No formula derivation). (ii) Problems on Dividend calculation and Calculation of income tax on taxable income (old and new regime). Equated Monthly Instalments (EMI) by Interest of Reducing Balance and Flat Interest methods – examples and problems.
UNIT II) ARITHMETICAL ABILITY AND DATA INTERPRETATION **15 LECTURES**
(i) Percentage; Ratio and Proportion; Time and Distance; Allegations or Mixture; Area, Volume, Surface Areas; Trigonometric ratios; Height and Distance in our everyday life. (ii) Probability, Classification of data – Frequency distribution, Tabulation; Graphical representation of data - Bar Graphs, Pie Charts, Line Graphs; Calendar and Clocks**.**

References Books

[1] Richard Courant and Herbert Robbins; What is Mathematics? Oxford University Press, 1995.

[2] David M. Burton; Elementary Number Theory, Universal Book Stall, 1989.

[3] Kenneth H. Rosen, Elementary Number Theory and its Applications; Addison-Wesley Publishing Company, 1984.

[4] M. K. Sen and B. C. Chakraborty; Introduction to Discrete Mathematics, Books and Allied (P) Ltd, 2019.

[5] Elliott Mendelson; Introduction to Mathematical Logic; Chapman & Hall; London, 1997.

[6] M. Chakraborty; Lecture note: A journey through the logic wonderland, IIEST Shibpur, 2016.

[7] Paul R. Thie and G. E. Keough, An Introduction to Linear Programming and Game Theory; John Wiley & Sons, INC., Third Edition, 2008.

[8] Richard Bronson and Govindasami Naadimuthu, Schaum's Outline of Operations Research; McGraw Hill, 1997.

[9] J. G. Chakraborty and P. R. Ghosh, Linear Programming and Game Theory, Moulik Library, 2009.

[10] Petr Zima and Robert L. Brown, Mathematics of Finance, Schaum's Outline Series, McGraw-Hill, 2nd edition, 1996.

[11] P. Chandra, Investment Analysis and Portfolio Management; McGraw Hill, 2008.

[12] Bonnie Averbach and Orin Chein, Problem Solving Through Recreational Mathematics, Dover Publications, 1980.

[13] Quantitative Aptitude, R.S. Aggarwal, S. Chand Publishing 2022.

[14] Fundamentals of Business Mathematics, M.K. Bhowal, Asian Books, 2009.

[15] Fundamentals of Mathematical Statistics, S.C. Gupta, V.K. Kapoor, Sultan Chand and Sons, 2020.

[16] The Mathematics of Everyday Life, A.S. Posamentier, C. Spreitzer, Prometheus Books, Illustrated Edition, 2018.

Course Title: Practical - 601

(Practical based on Basic Mathematics in Real Life)

CREDIT STRUCTURE

Semester	Course Code	Title of the Course	Category of Course	Credits
IV (Level 5.0)	**USMTP405**	**Practical - 601 (Practical based on Basic Mathematics in Real Life)**	**Practical (Minor)**	**02**

Course Objectives:

- To introduce the basic Mathematical concepts that are used in different aspects of our daily life.
- To perform basic calculations and measurement.
- To understand about ratios and proportions.

Course Outcomes: After completion of the course, students will be able to

- Understand everyday banking transactions, identify patterns and relationships.
- Perform basic calculations and measurement.
- Understand about ratios and proportions.

LIST OF PRACTICALS

1.	Time value of money: Simple interest and Compound interest.
2.	Interest payable at different intervals.
3.	Accumulated value of an ordinary simple annuity.
4.	Discounted Value of an ordinary simple annuity.
5.	Idea of repayment of loans, Simple problems.
6.	Problems on Dividend calculation.
7.	Calculation of income tax on taxable income.
8.	Equated Monthly Instalments (EMI) by Interest of Reducing Balance method. Examples.
9.	Equated Monthly Instalments (EMI) by Interest of Flat Interest method. Examples.
10.	Percentage; Ratio and Proportion.
11.	Example on Time and Distance an Allegations or Mixture.
12.	Examples on Area, Volume.
13.	Surface Areas, Trigonometric ratios.
14.	Height and Distance problems in our everyday life.
15.	Probability, examples.
16.	Classification of data - Frequency distribution.

17.	Tabulation; Graphical representation of data.
18.	Bar Graphs, Pie Charts.
19.	Line Graphs; Calendar and Clocks**.**
20.	Examples in our everyday life.

References Books

[1] Richard Courant and Herbert Robbins; What is Mathematics? Oxford University Press, 1995.

[2] David M. Burton; Elementary Number Theory, Universal Book Stall, 1989.

[3] Kenneth H. Rosen, Elementary Number Theory and its Applications; Addison-Wesley Publishing Company, 1984.

[4] M. K. Sen and B. C. Chakraborty; Introduction to Discrete Mathematics, Books and Allied (P) Ltd, 2019.

[5] Elliott Mendelson; Introduction to Mathematical Logic; Chapman & Hall; London, 1997.

[6] M. Chakraborty; Lecture note: A journey through the logic wonderland, IIEST Shibpur, 2016.

[7] Paul R. Thie and G. E. Keough, An Introduction to Linear Programming and Game Theory; John Wiley & Sons, INC., Third Edition, 2008.

[8] Richard Bronson and Govindasami Naadimuthu, Schaum's Outline of Operations Research; McGraw Hill, 1997.

[9] J. G. Chakraborty and P. R. Ghosh, Linear Programming and Game Theory, Moulik Library, 2009.

[10] Petr Zima and Robert L. Brown, Mathematics of Finance, Schaum's Outline Series, McGraw-Hill, 2nd edition, 1996.

[11] P. Chandra, Investment Analysis and Portfolio Management; McGraw Hill, 2008.

[12] Bonnie Averbach and Orin Chein, Problem Solving Through Recreational Mathematics, Dover Publications, 1980.

[13] Quantitative Aptitude, R.S. Aggarwal, S. Chand Publishing 2022.

[14] Fundamentals of Business Mathematics, M.K. Bhowal, Asian Books, 2009.

[15] Fundamentals of Mathematical Statistics, S.C. Gupta, V.K. Kapoor, Sultan Chand and Sons, 2020.

[16] The Mathematics of Everyday Life, A.S. Posamentier, C. Spreitzer, Prometheus Books, Illustrated Edition, 2018.

CREDIT STRUCTURE

Semester	Course Code	Title of the Course	Type	Credits
IV (Level 5.0)	MTOE04 (OE)	VEDIC MATHEMATICS – II	Theory	02

Course Objectives:

- To understand the Basic concepts in Mathematics.
- To use different tricks to solve the problems of Mathematics in Competitive Examinations.
- To strengthen the ability to draw logical conclusions.

Course Outcomes: After completion of the course, students will be able to

- Provide a platform for building the fundamentals of basic mathematics for competitive examinations preparation strategy.
- Establish a framework to acquire knowledge and expertise necessary to secure employment opportunities in the Government sector.

UNIT I) FACTORISATION AND DIVISION 10 LECTURES
1. Factorisation (of simple quadratics). 2. Factorisation (of harder quadratics). 3. Factorisation of Cubics. **4.** Argumental Division.
UNIT II) Contribution of Indian Mathematicians 10 LECTURES
Contribution of Indian Mathematicians (In light of Arithmetic): 1. Aryabhatt. 2. Brahmagupt. 3. Mahaveeracharya. 4. Bharti Krishna Tirtha.

UNIT III) LCM and HCF	10 LECTURES
(i) Least Common Multiple, Highest Common Factor. Examples. Quadratic Equations, Some basic Problems with Vedic Methods. (ii) Use of Various Vedic Techniques for Competitive Exams.	

Reference Books:

1) Sri Bharati Krisna Tirthaji, V. S. Agarwala, Vedic Mathematics or Sixteen Simple Mathematical Formulae from the Vedas, Indological Publishers Delhi, 1981.
2) Gaurav Tekriwal, Maths Sutra: The Art of Vedic Speed Calculation., ISBN 13: 9780143425021, 2015.
3) William Q., Vedic Mathematics Secrets Fun Applications of Vedic Math In Your Everyday Life, 2007.
4) Dhaval Bathia, Vedic Mathematics Made Easy, Jaico Publishing House, 2021.
5) Vedic Mathematics, Motilal Banarsi Das, New Delhi.
6) Vedic Ganita: Vihangama Drishti-1, Siksha Sanskriti Uthana Nyasa, New Delhi.
7) Vedic Ganita Praneta, Siksha Sanskriti Uthana Nyasa, New Delhi.
8) Vedic Mathematics: Past, Present and Future, Siksha Sanskriti Uthana Nyasa, New Delhi.
9) Leelavati, Chokhambba Vidya Bhavan, Varanasi.

CREDIT STRUCTURE

Semester	Course Code	Title of the Course	Type	Credits
IV (Level 5.0)	MTOE05 (OE)	QUANTITATIVE APTITUDE	Theory	02

Course Objectives:

- To understand the fundamental properties of numbers.
- To use different tricks to solve the problems of Mathematics in Competitive Examinations.
- To understand the concept of Mensuration and Geometry.

Learning Outcomes: After the completion of this course, learners will be able to:

- Understand the fundamental properties of numbers.
- Establish a framework to acquire knowledge and expertise necessary to secure employment opportunities in the Government sector.
- Apply shortcut methods and tricks in competitive examinations.

UNIT I) NUMBER SYSTEM **10 LECTURES**
Real Number System, Properties of Real Numbers, Euclid's division lemma, examples, Decimal representation of rational numbers in terms of terminating/ non-terminating recurring 10 II) Probability decimals. Calculating square roots, cube roots etc. Simplifications, Inequality.
UNIT II) PROBABILITY **10 LECTURES**
Sample space, Events, Types of events, Probability of an event, Examples, Complementary events, Addition theorem of probability conditional probability, independent events. Examples. Random variable.
UNIT III) MENSURATION AND GEOMETRY **10 LECTURES**
Mensuration, Basic of Geometry, Segments & Angles, Parallel and Perpendicular Lines. Triangle Relationships, Congruent Triangles, Quadrilaterals, Similarity, Polygons and Area, Surface Area and Volume.

Reference Books:

1) R. S. Aggarwal, Quantitative Aptitude for Competitive Exams, S. Chand Publication, Delhi, 2017.
2) Oswaal Editorial Board, Objective Quantitative Aptitude for All Competitive Examinations Chapter-wise & Topic-wise, 2023.
3) Dinesh Khattar, The Pearson Guide to Quantitative Aptitude for Competitive Examinations, 2013.
4) Arun Sharma, Teach Yourself Quantitative Aptitude for Competitive Exams, Second Edition, Mc-Graw Hill Publication, 2019.
5) Arun Sharma, How to Prepare for Quantitative Aptitude for CAT, Mc-Graw Hill Publication, 2022.
6) S. A. Bari, Practical Business Mathematics, New Literature Publishing Company Bombay, 1971.
6) K. Selva kumar, Mathematics for Commerce Notion Press Chennai, 1st Edition 2014.
8) Dinesh Khattar & S. R. Arora, Business Mathematics with Applications, S. Chand Publishing New Delhi, 2001.
9) Operations Research P. K. Gupta & D. S. Hira S. Chand Publishing New Delhi, 2015.

VOCATIONAL SKILL COURSE (VSC)

TITLE OF THE COURSE: COMPUTING WITH PYTHON

CREDIT STRUCTURE

Semester	Course Code	Title of the Course	Type	Credits
IV (Level 5.0)	MTVSC03	COMPUTING WITH PYTHON	Practical	02

Course Objectives (CO):

- To understand why Python is a useful scripting language for developers.
- To learn how to use lists, tuples, and dictionaries in Python programs.
- To learn how to use indexing and slicing to access data in Python programs.
- To develop the skill of designing Mathematical user Interfaces with SymPy package in Python.
- To develop SymPy code for different areas of mathematical concepts including calculus, plotting graphs, derivatives and solving simultaneous equations.

Course Outcomes: After completion of the course, students will be able to

- Learn operations on strings, list, dictionaries and SymPy package.
- Understand how to use functions with arguments in Python.
- Apply basic programming techniques for solving problems in mathematics using SymPy Python.
- Verify implementation of basic mathematical results of calculus and algebra by using SymPy package.
- Evaluate the solutions of complex mathematical problems using Python.
- Create programs that plot graphs of trigonometric functions, linear, multiple and pretty printing with SymPy package in python.

LIST OF PRACTICALS

1.	String, Assigning value from user, Operators like +, == and *.
2.	Subscript Operator, such as accessing elements at a particular index, slicing a substring.
3.	Testing of substring (made up of single letter or multiple letters).
4.	String methods, such as center, count, endswith, startswith, find, isalpha, isdigit, join, lower, upper, replace, split, strip.
5.	Concept of List, Assigning value from user, Operators like +, == and *, Subscript operator and its various functions, len function.

6.	List methods, such as append, extend, insert and pop (with and without index).
7.	Sorting a list in ascending/descending order.
8.	Dictionary, Assigning key-value from user. Defining new dictionary, assigning, or adding key values to an empty dictionary. Adding keys and replacing values.
9.	Accessing values and removing keys. Dictionary operations using keywords like len, get, pop, list, clear etc.
10.	Basic operations on numbers (integers and fractions), Getting complex numbers,
11.	Doing basic operations on complex numbers. Defining new functions.
12.	Defining symbols and symbolic operations using sympy.
13.	Working with expressions such as factorizing and expanding, substituting in values, pprint (pretty printing) function.
14.	Solving equations of first degree and higher degree, solving simultaneous equations.
15.	Plotting graphs in Python using sympy, Basic commands in plotting a graph, range of x.
16.	Plotting graphs of functions such as sin, cos, exp, log and plotting multiple functions.
17.	Doing Calculus with Python using sympy.
18.	Use of sympy instead of importing math directory, assumptions with sympy, limit of a function.
19.	Instantaneous rate of change and derivative using sympy.
20.	Applications of derivatives such as maxima/minima, increasing/decreasing functions.

Text Books:

1. Downey, A. et al., How to think like a Computer Scientist: Learning with Python, John Wiley, 2015.
2. Goel, A., Computer Fundamentals, Pearson Education.
3. Lambert K. A., Fundamentals of Python - First Programs, Cengage Learning India, 2015.
4. Rajaraman, V., Computer Basics and C Programming, Prentice-Hall India.
5. E Balagurusamy, Introduction to Computing and Problem-Solving Using Python, McGraw Hill Education (India) Private Limited.
6. Amit Saha, Doing Math with Python, No Starch Press, Inc.

Reference Books:

1. Barry, P., Head First Python, O Reilly Publishers.
2. Dromy, R. G., How to solve it by Computer, Pearson India.
3. Guzdial, M. J., Introduction to Computing and Programming in Python, Pearson India.
4. Perkovic, L., Introduction to Computing Using Python, 2/e, John Wiley,

2015.
5. Sprankle, M., Problem Solving & Programming Concepts, Pearson India.
6. Venit, S. and Drake, E., Prelude to Programming: Concepts & Design, Pearson India.
7. Zelle, J., Python Programming, An Introduction to Computer Science, Franklin, Beedle & Associates Inc.

EXAMINATION PATTERN FOR OPEN ELECTIVE COURSES

Scheme of Examination for Each Semester:

Continuous Internal Evaluation (CIE): 20 Marks

Sr. No.	Particulars	Marks
01	One Unit Test	10
02	Assignment	05
03	Subject Related Activities	05
	Total	**20 Marks**

Semester End Examination:

Duration: 1 Hour		Unit No.	Marks
Q. 1 A)	Attempt Ant Two: (Out of Three)	1	10
Q. 2 A)	Attempt Ant Two: (Out of Three)	2	10
Q. 3 A)	Attempt Ant Two: (Out of Three)	3	10
		Total	**30 Marks**