Deccan Education Society's

Fergusson College (Autonomous), Pune

Learning Outcomes-Based Curriculum

for 3/4 years B. Sc. / B. Sc. (Honours) Programme

as per guidelines of

NEP-2020

for

F. Y. B. Sc. (Mathematics)

With effect from Academic Year

2023-2024

B. Sc. Major Mathematics

Program Outcomes (POs)

PO1	**Disciplinary Knowledge** Demonstrate comprehensive knowledge of the discipline that forms a part of a postgraduate programme. Execute strong theoretical and practical understanding generated from the specific programme in the area of work.
PO2	**Critical Thinking and Problem solving** Exhibittheskill of critical thinking and understand scientific texts and place scientific statements and themes in contexts and also evaluate them in terms of generic conventions.Identify the problem by observing the situation closely, take actions and apply lateral thinking and analytical skills to design the solutions.
PO3	**Social competence** Exhibit thoughts and ideas effectively in writing and orally; communicate with others using appropriate media, build effective interactive and presenting skills to meet global competencies. Elicit views of others, present complex information in a clearand concise way and help reach conclusions in group settings.
PO4	**Research-related skills and Scientific temper** Infer scientific literature, build a sense of enquiry and able to formulate, test, analyze, interpret and establish hypothesis and research questions; and to identify and consult relevant sources to find answers. Plan and write a research paper/project while emphasizingonacademics and research ethics, scientific conduct and creating awareness about intellectual property rights and issues of plagiarism.
PO5	**Trans-disciplinary knowledge** Create new conceptual, theoretical and methodological understanding that integrates and transcends beyond discipline-specific approaches to address a common problem.
PO6	**Personal and professional competence** Perform independently and also collaboratively as a part of a team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO7	**Effective Citizenship and Ethics** Demonstrate empathetic social concern and equity centred national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO8	**Environment and Sustainability** Understand the impact of thescientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
PO9	**Self-directed and Life-long learning** Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

Program Specific Outcomes (PSOs) of Department of Mathematics

PSO1	Bachelor's degree in mathematics is the culmination of in-depth knowledge of algebra, calculus, geometry, differential equations and several other branches of mathematics. This also leads to study of related areas like computer science and statistics. Thus, this programme helps learners in building a solid foundation for higher studies in mathematics.
PSO2	The skills and knowledge gained has intrinsic beauty, which also leads to proficiency in analytical reasoning. This can be utilised in modelling and solving real life problems.
PSO3	Students undergoing this programme learn to logically question assertions, to recognise patterns and to distinguish between essential and irrelevant aspects of problems. They also share ideas and insights while seeking and benefitting from knowledge and insight of others. This helps them to learn behave responsibly in a rapidly changing interdependent society.
PSO4	Students completing this programme will be able to present mathematics clearly and precisely, make vague ideas precise by formulating them in the language of mathematics, describe mathematical ideas from multiple perspectives and explain fundamental concepts of mathematics to non-mathematicians.
PSO5	Completion of this programme will also enable the learners to join teaching profession in primary and secondary schools.
PSO6	This programme will also help students to enhance their employability for government jobs, jobs in banking, insurance and investment sectors, data analyst jobs and jobs in various other public and private enterprises.

Fergusson College (Autonomous), Pune
Proposed First Year Curriculum as per NEP 2020

Department of Mathematics

B. Sc. Major Mathematics
Structure for Major / Minor

Semester	Paper Code	Paper Title	Type	Credits
I	**MTS-100 (Major)**	Practical Course on Algebra and Geometry	**Theory**	**2**
	MTS-101 (Major)	Algebra and Geometry	**Practical**	**4**
	MTS-120 (GE/OE)	Introduction to Business Mathematics	**Theory**	**2**
	MTS-121 (GE/OE)	Introduction to Quantitative and Logical Thinking-I	**Theory**	**2**
	MTS-130 (VSC)	Introduction to Python	**Voc. Skill**	**2**
	MTS-140 (SEC)	Foundation of Mathematics	**Skill**	**2**
	IKS-101 (IKS)	Indian Knowledge Systems	**IKS**	**2**
II	**MTS-150 (Major)**	Computational problems in Calculus	**Theory**	**2**
	MTS-151 (Major)	Calculus	**Practical**	**4**
	MTS-161 (Minor)	Calculus with Sequences and Series	**Theory**	**2**
	MTS-162(Minor)	Calculus and Differential Equations	**Theory**	**2**
	MTS-163(Minor)	Calculus with Applications	**Theory**	**2**
	MTS-165 (Minor) For CS	Mathematical Foundation for Computer Science	**Theory**	**2**
	MTS-166 (Minor) For CS	Mathematical Foundation for Data Science	**Theory**	**2**
	MTS-170 (GE/OE)	Introduction to Applied Mathematics	**Theory**	**2**
	MTS-171 (GE/OE)	Introduction to Quantitative and Logical Thinking-II	**Theory**	**2**
	MTS-180 (VSC)	Numerical Methods using Python	**Voc. Skill**	**2**
	MTS-190 (SEC)	Mathematical Writing, LATEX and Sage	**Skill**	**2**

Teaching and Evaluation (Only for FORMAL education courses)

Course Credits	No. of Hours per Semester Theory/Practical	No. of Hours per Week Theory/Practical	Maximum Marks	CE 40 %	ESE 60%
1	**15 / 30**	**1 / 2**	**25**	**10**	**15**
2	**30 / 60**	**2 / 4**	**50**	**20**	**30**
3	**45 / 90**	**3 / 6**	**75**	**30**	**45**
4	**60 / 120**	**4 / 8**	**100**	**40**	**60**

Eligibility: As per the rules and regulations of Savitribai Phule Pune University (SPPU)

MTS-100: Practical Course on Algebra and Geometry:

1. Permutations and combinations
2. Binomial theorem
3. Theory of Equations-I
4. Theory of Equations-II
5. Complex Numbers
6. Division algorithm and Euclidean algorithm
7. Congruences
8. Matrix Algebra
9. Eigen values, Eigenvectors and Cayley-Hamilton theorem
10. Planes
11. Straight lines
12. Sphere

F. Y. B.Sc. (Major) Semester I		
Title of the Course and Course Code	**Algebra and Geometry (MTS-101)**	**Number of Credits: 04**
Course Outcomes (COs) On completion of the course, the students will be able to:		Bloom's cognitive level
CO1	Understand basic countingprinciples. Understand the importance of roots of real and complex polynomials and learn various methods of obtaining roots.	1
CO2	Familiarize with basic number theoretic concepts such as Divisibility and congruences.	2
CO3	Employ De Moivre's theorem in a number of applications to solve numerical problems.	3
CO4	Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix, using rank.	4
CO5	Find eigenvalues and corresponding eigenvectors for a square matrix.	5
CO6	Explain the properties of three-dimensional shapes.	6

Suggested Pedagogical Processes

- Lecture method: Concepts and operations of sets, Matrix Algebra, Graphs, Trees on Blackboard with examples, problems on sets using Venn diagrams
- ICT supplemented teaching
- Experiential learning
- Case studies
- Problem based learning
- Student seminars
- Group discussions

MTS-101: Algebra and Geometry(Major)

Course Contents

Semester I

Unit No.	Title of Unit and Contents	No. of hours
I	**Basic Counting Methods** 1.1 Addition principle 1.2 Multiplication principle, 1.3 Permutations and combinations 1.4 Binomial theorem.	**5**
II	**Theory of Equations** 2.1 Elementary theorems on the roots of an equations 2.2 The remainder and factor theorems, Synthetic division, 2.3 Factored form of a polynomial. 2.4 The Fundamental theorem of algebra. (Without proof) 2.4 Relations between the roots and the coefficients of polynomial equations 2.5 Integral and rational roots.	**10**
III	**Complex Numbers** 3.1 Polar representation of complex numbers, 3.2 The *n*th roots of unity 3.3 De Moivre's theorem and its applications(integer and rational indices)	**5**
IV	**Basic Number Theory** 4.1 The division algorithm, 4.2 Divisibility and the Euclidean algorithm, 4.3 The fundamental theorem of arithmetic, 4.4 Modular arithmetic and basic properties of congruences.	**10**
V	**Row Echelon Form of Matrices and Applications** 5.1 Systems of linear equations 5.2 Row reduction and echelon forms 5.3 The rank of a matrix and applications; 5.4 Matrix operations, 5.5 Determinants, 5.6 The inverse of a matrix, 5.7 Characterizations of invertible matrices; 5.8 Eigen values and eigenvectors, 5.9 The characteristic equation and the Cayley-Hamilton theorem.	**15**
VI	**Planes, Straight Lines and Spheres** 6.1 Planes: Distance of a point from a plane, 6.2 Angle between two planes, 6.3 pair of planes, 6.4 Bisectors of angles between two planes; 6.5 Straight lines: Equations of straight lines, 6.6 Distance of a point from a straight line, 6.7 Distance between two straight lines, 6.8 Distance between a straight line and a plane; 6.9 Spheres: Different forms, 6.10 Intersection of two spheres, 6.11 Orthogonal intersection, 6.12 Tangents and normal.	**15**

Learning Resources:

Reference Books	1. Barbeau, Edward J, Polynomials, Springer, 1989. 2. Brown and Churchill, Complex Variables and Applications, 7th Edition, McGraw Hill, 2010. 3. Shantinarayan: Analytical Solid Geometry, S. Chand and Company Ltd, New Delhi, 1998. 4. P.K.Jain and Khalil Ahmad, A Textbook of Analytical Geometry of Three Dimensions, Wiley Estern Ltd. 1999. 5. Askwyth, E. H: The Analytical Geometry of the Conic Sections. 6. David M. Burton, Elementary number theory, Seventh Edition, Tata McGraw Hill, 2012. 7. W. S. Bunside and A. R. Panton:The Theory of Equations: With an Introduction to the Theory of Binary Algebraic Forms, Dover Phoenix Editions, 2005. 8. Alan Tucker, Applied Combinatorics, Wiley, 1995. 9. Serge Lang: Introduction to Linear Algebra, Second Edition, 1986. 10. Howard Anton, Chris Rorres, Elementary Linear Algebra: Applications Version, Wiley (11th Edition). 11. S. Kumaresan, Linear Algebra: A Geometric Approach, Prentice Hall of India, New Delhi, 1999. 12. K. Hoffmann and R. Kunze Linear Algebra, Second Ed. Prentice Hall of India New Delhi, (1998). 13. G.B. Thomas, R. Finney, Calculus and Analytic Geometry, Addison-Wesley, 1995. 14. Titu Andreescu, & Dorin Andrica (2014). *Complex Numbers from A to...Z*. (2nd edition). Birkhäuser. 15. Robert J. T. Bell (1994). *An Elementary Treatise on Coordinate Geometry of Three Dimensions*. Macmillan India Ltd. 16. 13. D. Chatterjee (2009). *Analytical Geometry: Two and Three Dimensions*. Narosa Publishing House. 17. 14. Leonard Eugene Dickson (2009). *First Course in the Theory of Equations*. The Project Gutenberg EBook (http://www.gutenberg.org/ebooks/29785) 18. Bernard Kolman & David R. Hill (2003). *Introductory Linear Algebra with Applications* (7th edition). Pearson Education Pvt. Ltd. India. 19. David C. Lay, Steven R. Lay & Judi J. McDonald (2016). *Linear Algebra and its Applications* (5th edition). Pearson Education Pvt. Ltd. India.

Semester I		
Title of the Course and Course Code	**Introduction to Business Mathematics (OE-I) (MTS-120)**	**Number of Credits : 02**
Course Outcomes (COs) On completion of the course, the students will be able to:		Bloom's cognitive level
CO1	Understand basic concepts of simple and compound interest.	1
CO2	Familiarize basic concepts ofShares and mutual funds.	2
CO3	Applications like dividend, NAV, SIP etc.	3
CO4	Relation between Nominal and Effective rate of interest	4
CO5	Find amount and present value of an ordinary certain	5
CO6	Explain the linear equation and inequalities.	6

Course Contents
MTS-120: Introduction to Business Mathematics (OE- I)
Semester - I

Unit No.	Title of Unit and Contents	No. of hours
I	**Financial mathematics – series, time and investment** 1.1 Discrete and continuous growth 1.2 Interest 1.3 Part year investment and the annual equivalent rate 1.4 Time periods, initial amounts and interest rates 1.5 Investment appraisal: net present value 1.6 The internal rate of return 1.7 Geometric series and annuities 1.8 Perpetual annuities 1.9 Pension pots, annuity income and drawdown pensions 1.10 Drawdown pension income 1.11 Loan repayments and mortgages 1.12 Savings schemes 1.13 Sinking fund savings schemes 1.14 Other applications of growth and decline 1.15 asset valuation 1.16 Valuation of bonds 1.17 Valuation of shares	**17**
II	**Mutual Funds:** 2.1 Calculation of Net income after considering entry load. 2.2 Dividend 2.3 Change in Net Asset Value(N.A.V.) and exit load	**4**

	2.4 Averaging price under the Systematic Investment Plan(S.I.P.)	
III	**Functions:** 3.1 Functions 3.2 Graphs, Slopeand Intercepts 3.3 Graphs of Non-linear Functions 3.4 Linear equations and inequalities.	**9**

Learning Resources:

Reference Books	1. Edward Dowling (1992), Introduction to Mathematical Economics, Schaum's Outline Series. 2. Christopher J. Stocker, Michael R. Ziegler, Karl E. Byleen (2019), Raymond A. BarnettCollege Mathematics for Business, Economics, Life Sciences, and Social Sciences, Fourteenth edition Pearson. 3. Alpha C. Chiang (2005), Kevin Wainwright Fundamental Methods of Mathematical Economics, Fourth Edition,McGraw Hill 4. Mike Rosses and Piotr Lis (2016), Basic Mathematics for Economists, Third edition, Routledge 5. Frank Ayres (1983), Mathematics of Finance, Schaum's Outline Series 6. Carl P. Simon, Lawrence Blume Mathematics for Economists. 7. Knut Sydsaester and Peter Hammond with Arne Strom Essential Mathematics for Economic Analysis, Pearson. 8. Ronald Shone, Economic Dynamics Phase Diagrams and Their Economic Application, Cambridge University Press.

Semester I		
Title of the Course and Course Code	**Introduction to Quantitative and Logical Thinking (OE-II) (MTS-121)**	**Number of Credits: 02**
Course Outcomes (COs) On completion of the course, the students will be able to:		Bloom's cognitive level
CO1	Understand basic concepts Integers, Rational and Irrational numbers.	1
CO2	Familiarize basic concepts of Permutation and Combinations.	2
CO3	Interpret the concepts of LOGICAL REASONING Skills	3
CO4	Solve the problems easily by using short-cut method with time management which will be helpful to them to clear the competitive exams for better job opportunity.	4
CO5	Analyze the problems logically and approach the problems in a different manner like Probability	5
CO6	Construct the problems based on Ages.	6

Course Contents
MTS-121: Introduction to Quantitative and Logical Thinking-I(OE-II)
Semester I

Unit No.	Title of Unit and Contents	No. of hours
I	1.1 Whole numbers 1.2 Integers 1.3 Rational and irrational numbers 1.4 Fractions 1.5 Square roots and Cube roots 1.6 Surds and Indices 1.7 Problems on Numbers 1.8 Divisibility	**8**
II	2.1 HCF and LCM 2.2 Ratio and Proportion 2.3 Percentage 2.4 Average 2.5 Problems Based on Ages 2.6 Profit and Loss 2.7 Squares and Square Roots 2.8 Cubes and Cube Roots.	**10**
III	3.1 Series 3.2 Progression and Sequence	**6**

	3.3 Fractions	
IV	4.1 Permutation and Combination 4.2 Probability	**6**

Learning Resources:

Reference Books	1. R. V. Praveen Quantitative Aptitude and Reasoning, PHI Learning Pvt Ltd 2. Dinesh Khattar Quantitative Aptitude for Competitive Examinations, Pearson 3. R.S. Aggarwal Quantitative Aptitude

F. Y. B.Sc. (Vocational Skill Course) Semester I		
Title of the Course and Course Code	**Introduction to Python (MTS130)**	**Number of Credits : 02**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		Bloom's cognitive level
CO1	Understand why Python is a useful scripting language for developers.	1
CO2	Familiarize and learn how to use lists, tuples, and dictionaries in Python programs..	2
CO3	Acquire programming skills in core Python and implement object oriented concepts.	3
CO4	Recognize basic principles of Python programming language.	4
CO5	Creating different functions in Python	6

Course Contents
MTS-130: Introduction to Python(VSC-I)
Semester-I

Unit No.	Title of Unit and Contents	No. of hours
I	**Basics of Python Programming** 1.1 Feature, History and Future of Python 1.2 Writing and executing first Python program 1.3 Literal Constants 1.4 Variable and Identifiers 1.5 Data types 1.6 Input Operations 1.7 Comment, Reserve Words and Indentation 1.8 Operators and Expressions 1.9 Operations on Strings	**6**
II	**Decision Control Statements** 2.1 Introduction to Decision Control statements 2.2 Selection/Conditional Branching Statements 2.3 Basic Loop Structure/Iterative Statements 2.4 Nested Loops 2.5 The Break and Continue Statements 2.6 The Pass Statement	**8**

	2.7 The Else Statement Used with Loops	
III	**Python Strings** 3.1 Concatenating, appending and Multiplying Strings 3.2 Strings Are Immutable 3.3 String Formatting Operators 3.4 Built-in String Method and Functions 3.5 Slice Operations 3.6 Ord() and Char() Functions 3.7 In and Not in Operators 3.8 Comparing and Iterating String	**4**
IV	**Data Structure** 4.1 Sequences 4.2 List 4.3 Tuple 4.4 Sets 4.5 Dictionaries	**4**
V	**Function and Modules** 5.1 Function Definition 5.2 Function Call 5.3 Variable Scope and Lifetime 5.4 The Return Statement 5.5 More on Defining Function 5.6 Lambda Functions 5.7 Recursive Functions 5.8 Module 5.9 Packages in Python	**8**

Learning Resources:

Reference Books	1. Reema Thareja, Python Programming Using Problem Solving Approach, Oxford University Press, 2015 2. Allen Downey,Think Python, How to Think Like a Computer Scientist, Green Tea Press Needham, Massachusetts, 2015. 3. Robert Johansson, Introduction to Scientific Computing in Python, SMTEBOOKS, Apress, 2016. 4. Hans-PetterHalvorsen,Python for Scientific engineering, 2020.
E-resources	https://tinyurl.com/yu4bdsnn Programming, Data Structures And Algorithms Using Python - Course (nptel.ac.in)-Swayam Course on Python by Madhavan Mukund

F. Y. B. Sc. (Skills Enhancement Course-I) Semester I		
Title of the Course and Course Code	**Foundation of Mathematics (MTS-140)**	**Number of Credits: 02**
Course Outcomes (COs) On completion of the course, the students will be able to:		Bloom's cognitive level
CO1	Describe fundamentals of set theory, relations, functions, equivalence classes.	1
CO2	Explain mathematical statements logically	2
CO3	Apply techniques of proof to prove the statement in different ways.	3
CO4	Analyze statements logically and write it using quantifiers	4
CO5	Evaluate the images and inverse images of elements under functions.	5
CO6	Generate statements from quantifiers	6

Suggested Pedagogical Processes

- Lecture method: Concepts and operations of sets, Matrix Algebra, Graphs, Trees on Blackboard with examples, problems on sets using Venn diagrams
- ICT supplemented teaching
- Experiential learning
- Case studies
- Problem based learning
- Student seminars
- Group discussions

Course Contents
MTS-140: Foundation of Mathematics(SEC-I)
Semester-I

Unit No.	Title of Unit and Contents	No. of hours
I	**Statements and Logic** 1.1 Statements 1.2 Statements with quantifiers 1.3 Compound Statements 1.4 Implications 1.5 Proofs in Mathematics	**8**

II	**Sets, Relations, and Functions** 2.1 Sets: Operations on sets, Family of sets, Power set, Cartesian product of sets 2.2 Functions: Bijective function, Composition of functions, Inverse of function, Inverse Image of sets 2.3 Relation: Types of relation, Equivalence relations, Equivalence classes and partition of set.	**15**
III	**Induction Principle** 3.1 The induction principle 3.2 The strong induction principle 3.3 Well-ordering principle	**7**

Learning Resources:

Reference Books	1. Ajit Kumar, S. Kumaresan and B. K. Sarma, A Foundation Course in Mathematics, Narosa 2. Robert Bartle and Donald Sherbert, Introduction to real Analysis (Fourth Edition), John Wiley and Sons Inc. 3. Kenneth Rosen, Discrete Mathematics and its Applications (Seventh Edition), Mc Graw Hill.
E-resources	1. E-Books: https://sites.google.com/site/vvacharyanew/ 2. https://studio.youtube.com/channel/UChCsGynvfLk4g0DpgvXXvJA/videos

F. Y. B. Sc. Semester I		
Title of the Course and Course Code	**Indian Knowledge Systems (IKS-101)**	**Number of Credits: 02**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		Bloom's cognitive level
CO1	An overview of the Development of Mathematics in India	
CO2	Mathematics contained in the Sulbasutra	
CO3	Weaving Mathematics into Beautiful Poetry	
CO4	The Evolution of Sine Function in India	

Course Contents
MTS-141: Mathematics in Ancient India
Semester-I

Unit No.	Title of Unit and Contents	No. of hours
I	Geometry in the Sulvasutras	**8**
II	Development of Decimal System in India	**8**
III	Ganitpad of Aryabhatta	**8**
IV	Work of Bhaskaracharya	**6**

Learning Resources:

Reference Books	1. Studies in the History of Indian Mathematics**,** C.S. Seshadri (Editor),Hindustan Book Agency, 2010. 2. AryabhattachaGanitapadvatyachaMarathi anuvad, S. K. Abhyankar, BhaskaracharyaPratishthana, 1979.

	3. The Mathematics of India Concepts, Methods, Connections, P. P. Divakaran, Hindustan Book Agency, 2018.

MTS-150: Computational problems in Calculus

1. **Real Numbers**
2. **Sequences of Real Numbers and convergence**
3. **Types of sequences and applications**
4. **Convergent series of real Numbers**
5. **Tests for convergence of series and Applications**
6. **Limit of a functions**
7. **Continuity of functions**
8. **Continuous functions on Interval**
9. **Differentiability of functions**
10. **Mean Value theorems and applications**
11. **L'Hospital's rule**
12. **Successive differentiation and applications**

F. Y. B. Sc. (Major) Semester II		
Title of the Course and Course Code	**Calculus (MTS-151)**	**Number of Credits : 04**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		Bloom's cognitive level
CO1	Assimilate the notions of limit of a sequence and convergence of a series of real numbers.	1
CO2	Calculate the limit and examine the continuity of a function at a point.	5
CO3	Understand the consequences of various mean value theorems for differentiable functions.	2
CO4	Sketch graphs of functions using limit, continuity and differentiability	3
CO5	Apply derivative tests in optimization problems appearing in social sciences, physical sciences, life sciences and a other disciplines.	4
CO6	Create functions satisfying certain geometrical properties.	6

Suggested Pedagogical Processes

- Lecture method: Concepts and operations of sets, Matrix Algebra, Graphs, Trees on Blackboard with examples, problems on sets using Venn diagrams
- ICT supplemented teaching
- Experiential learning
- Case studies
- Problem based learning
- Student seminars
- Group discussions

MTS-151: Calculus (Major)
Course Contents
Semester II

Unit No.	Title of Unit and Contents	No. of hours
I	**Sequences and Series of Real Numbers** 1.1 Introduction of real numbers, well ordering property, lub axiom, density of rational numbers 1.2 Sequences of real numbers and convergence of sequences 1.3 Monotone and bounded sequences 1.4 Subsequences, Bolzano-Weierstrass Theorem, Cauchy sequences 1.5 Convergence of series of real numbers	**10**
II	**Limit And Continuity** 2.1 Definition of limit of a real-valued function 2.2 Algebra of limits 2.3 Limit at infinity and infinite limits 2.4 Sequential criteria for limit 2.5 Continuity of a real valued function 2.6 Properties of continuous functions 2.7 Boundedness theorem, Maximum-Minimum theorem for continuous functions (statements only), 2.8 Intermediate value theorem 2.9 Types of continuity: Piecewise continuity, Uniform continuity.	**20**
III	**Differentiability** 3.1 Differentiability of a real-valued function, Geometrical interpretation of differentiability 3.2 Relation between differentiability and continuity 3.3 Differentiability and monotonicity 3.4 Chain rule of differentiation 3.5 Darboux's theorem 3.6 Mean Value theorems: Rolle's theorem, Lagrange's mean value theorem, Cauchy's mean value theorem, Geometrical interpretation of mean value theorems 3.7 Successive differentiation, Leibnitz's theorem, L'Hospital's Rule	**20**
IV	**Expansions of Functions** 4.1 Maclaurin's and Taylor's theorems 4.2 Taylor's theorem in finite form with Lagrange, Cauchy forms of remainder 4.3 Maxima and minima.	**10**

Learning Resources:

Reference Books	1. Robert Bartle, Donald Sherbert, Introduction to Real Analysis (Fourth Edition), John Wiley and Sons Inc. 2. Michael Spivak, Calculus, Cambridge University Press. 3. Thomas' Calculus (14^{th} edition), Pearson Education. 4. Howard Anton, I. Bivens& Stephan Davis (2016). Calculus (10^{th} edition). Wiley India. 5. Gabriel Klambauer (1986). Aspects of Calculus. Springer-Verlag. 6. Wieslaw Krawcewicz & Bindhyachal Rai (2003). Calculus with Maple Labs. Narosa.

	7. Gorakh Prasad (2016). Differential Calculus (19th edition). Pothishala Pvt. Ltd.
E-resources	1. E-Books: https://sites.google.com/site/vvacharyanew/ 2. https://studio.youtube.com/channel/UChCsGynvfLk4g0DpgvXXvJA/videos

F. Y. B. Sc. Semester I		
Title of the Course and Course Code	**Calculus with Sequences and Series (MTS-161)**	**Number of Credits : 02**
Course Outcomes (COs) **On completion of the course, the students will be able to:**		Bloom's cognitive level
CO1	Assimilate the notions of limit of a sequence and convergence of a series of real numbers.	1
CO2	Calculate the limit and examine the continuity of a function at a point.	2
CO3	Understand the consequences of various mean value theorems for differentiable functions.	3
CO4	Sketch curves in Cartesian and polar coordinate systems.	4
CO5	Apply derivative tests in optimization problems appearing in social sciences, physical sciences, life sciences and many other disciplines.	5
CO6	Explain the properties of limits, continuity, and differentiability.	6

MTS-161: Calculus with Sequences and Series

Course Contents

Semester II

Unit No.	Title of Unit and Contents	No. of hours
I	**Sequences and series of Real Numbers:** 1.1 Definition of a sequence, limit of a sequence, 1.2 Uniqueness of limit, Bounded sequence, Tail of a sequence, 1.3 Algebra of limits of sequences, Squeeze theorem for sequences, 1.4 Ratio test for sequences, Monotone sequence, Monotone convergence theorem (Statement only), 1.5 Subsequence's, Divergence Criteria, 1.6 Monotone subsequence theorem (statement only), 1.7 Bolzano-Weierstrass theorem (statement only), 1.8 Series: Definition, Sequence of partial sums, 1.9 Convergent series and Divergent series, n-thtem test, 1.10 Ratio test and root tests for convergence of series (statements and examples only).	**7**
II	**Limits and continuity of functions:** 2.1 Definition of limit, 2.2 Limits of some standard functions, 2.3 Sequential criteria for limits, Uniqueness of limit,	

	2.4 Divergence criteria, Algebra of limits, 2.5 Squeeze theorem for limit, 2.6 Sequential criteria, 2.7 Composition of continuous functions, 2.8 Continuous functions on intervals, Boundedness theorem (statement only), Maximum-Minimum theorem (statement only), Location of roots theorem (statement only), 2.9 Intermediate value theorem, Fixed point theorem, Preservation of intervals theorem.	**8**
III	**Derivative:** 3.1 Definition, Differentiability imply continuity, 3.2 Non differentiable functions, 3.3 Algebra of differentiable functions, 3.4 Caratheodory's theorem, 3.5 Chain rule for derivative of composite function, 3.6 Derivative of inverse function. 3.7 Mean value theorems: Vanishing of the derivative at interior extremum, Rolle's Theorem, Lagrange's mean value theorem, Cauchy's mean value theorem 3.8 Applications of mean value theorems to geometric properties of functions, First derivative test for extrema, Second derivative test for extrema, Derivative test for convexity, Intermediate value property for derivative, Darboux's theorem 3.9 Successive differentiation: n-th derivative of some standard functions, Leibnitz's theorem for n-th derivative, Applications of Leibnitz's theorem. 3.10 Indeterminate forms, L' Hospital's Rule 3.11 Taylor's theorem, Maclaurin's theorem, Applications of Taylor's Theorem.	**15**

Learning Resources:

Reference Books	1. Howard Anton, I. Bivens& Stephan Davis (2016). *Calculus* (10th edition), Wiley India. 2. *Thomas*' *Calculus* (14th edition). Pearson Education. 3. Gabriel Klambauer (1986). *Aspects of Calculus*, Springer-Verlag. 4. WieslawKrawcewicz&Bindhyachal Rai (2003). *Calculus with Maple Labs*. Narosa. 5. Gorakh Prasad (2016). *Differential Calculus* (19th edition). Pothishala Pvt. Ltd. 6. Robert G. Bartle, Donald R. Sherbert, *Introduction to Real Analysis*, John Wiley &Sons, Fourth Edition, 2011.

F. Y. B. Sc. (Minor) Semester I		
Title of the Course and Course Code	**Calculus and Differential Equations (MTS 162)**	**Number of Credits: 02**
Course Outcomes (COs) On completion of the course, the students will be able to:		Bloom's cognitive level
CO1	Understand and learn functions and their properties.	1
CO2	Familiarize and learn to evaluate limit of function and study continuity.	2
CO3	Employ the rules of derivatives	3
CO4	Recognize basic applications of derivatives.	4
CO5	Evaluating differential equations.	6

MTS-162: Calculus and Differential Equations (Physical Sciences)

Course Contents

Semester II

Unit No.	Title of Unit and Contents	No. of hours
I	**Functions** 1.1 Functions and their graphs 1.2 Combining functions 1.3 Shifting and scaling graphs 1.4 Trigonometric functions	**4**
II	**Limit and Continuity** 2.1 Rates of change and tangents lines to curves 2.2 Limit of functions 2.3 Limit laws 2.4 The precise definition of limit 2.5 One-sided limits 2.6 Continuity 2.7 Limits involving infinity 2.8 Asymptotes of graph	**6**
III	**Derivatives** 3.1 Tangent lines and derivative at a point 3.2 The derivative as a function 3.3 Differentiation rules 3.4 The derivative as rate of change 3.5 The derivative of trigonometric functions 3.6 The chain rule 3.7 Implicit differentiation 3.8 Linearization and differentials	**6**
III	**Application of Derivatives** 4.1 Extreme values of a function on closed interval 4.2 The Mean Value Theorem 4.3 Monotonic Functions and First Derivative Test	**6**

	4.4 Concavity and Curve sketching 4.5 Applied Optimization 4.6 Newton's Method 4.7 Antiderivatives	
V	**First Order Differential Equations** 5.1 Solutions, Slope Fields and Euler's Method 5.2 First Order Linear Equations 5.3 Orthogonal Trajectories 5.4 Autonomous Equations 5.5 Graphical Solutions of Autonomous Equations	**8**

Learning Resources:

Reference Books	1. George B Thomas Jr., Joel Hass, Christofer Heil & Maurice D. Weir (2018), Thomas's Calculus (14th Edition), Pearson Education. 2. Howard Anton, Irl Bivens, Stephen Davis, Calculus, John Wiley & Sons, inc. 3. James Stewart, Calculus, Cengage Learning 4. W. W. Sawyer, What is Calculus about? The Mathematical Association of America, New Mathematical Library.

F. Y. B. Sc. (Minor) Semester I		
Title of the Course and Course Code	**Calculus with Applications (MTS 163)**	**Number of Credits : 02**
Course Outcomes (COs) On completion of the course, the students will be able to:		Bloom's cognitive level
CO1	Understand and learn the co-ordinate system.	1
CO2	Familiarize and learn functions and their properties.	2
CO3	Employ the rules of derivatives	3
CO4	Recognize basic applications of integral.	4
CO5	Evaluating differential equations.	6

MTS-163: Calculus with Applications (Chemistry& Geology)

Course Contents

Semester II

Unit No.	Title of Unit and Contents	No. of hours
I	**Coordinate System** 1.1 Cartesian Coordinates 1.2 Plane Polar Coordinates 1.3 Spherical Polar Coordinates 1.4 The Complex Plane	**3**
II	**Functions** 2.1 Exponential and Logarithmic Functions 2.2 Graphical Representation of Function 2.3 Roots of a Polynomial Functions 2.4 General Properties of General Logarithms and Natural Logarithms	**3**
III	**Differential Calculus** 3.1 Limit and Continuity 3.2 Differentiation of Function of Single Variable. 3.3 Differentiation of Function of Several Variables (Partial Derivative) 3.4 Total Differentiation 3.5 Geometric Properties of Derivatives 3.6 Constrained Maxima and Minima	**8**
IV	**Integral Calculus** 4.1 Introduction 4.2 General Methods of Integration 4.3 Integration Using Algebraic Substitution, Trigonometric Transformation, Partial Fractions, Integration by Parts, Reduction Formulae 4.4 Line Integral 4.5 Double and Triple Integral	**8**
V	**Differential Equations** 5.1 Linear Combinations Solutions of Differential Equations 5.2 First Order Differential Equations 5.3 Second Ordered Differential Equations with Constant Coefficients	

	5.4 Laguerre's Differential Equation 5.5 Legendre's Equation 5.6 Exact and Non Exact Differentials 5.7 Integrating Factor 5.8 Solving Non Exact Differential Equations	**8**

Learning Resources:

Reference Books	1. James R. Barrante, Applied Mathematics For Physical Chemistry (3rd Edition), Prentice Hall, 1974. 2. Erich Steiner, The Chemistry Maths Book, Oxford University Press.

MTS165: Mathematical Foundation for Computer Science

Course Contents

Semester-II

Unit No.	Title of Unit and Contents	No. of hours
I	**Statements and Logic** 1.1 Statements 1.2 Statements with quantifiers 1.3 Compound Statements 1.4 Implications 1.5 Proofs in Mathematics	**4**
II	**Sets, Relations and Functions** 2.1 Sets, Operations on Sets, Power Set, Cartesian product of Sets, Graphical representation of sets 2.2 Relations, types of Relations. 2.3 Equivalence relations. 2.4 Partition of a set and equivalence classes. 2.5 Digraphs of relations, matrix representation and composition of Relations. 2.6 Transitive closure and Warshall's Algorithm. 2.7 Types of functions (One - One, Onto, Bijective).	**8**
III	**Lattice and Boolean Algebra** 3.1 Partial ordering relations 3.2 Poset, Hasse diagram. 3.3 Lattices, Complemented lattice, Bounded lattice and Distributive Lattice. 3.4 Boolean variable, Boolean Function of degree n, Boolean identities, Definition of Boolean Algebra. 3.5 Disjunctive Normal form, Conjunctive Normal form.	**7**
IV	**Counting Principles** 4.1 Cardinality of a finite set. 4.2 The Sum Rule, the Product Rule, the Inclusion-Exclusion Principle. 4.3 Statement of Pigeonhole Principle, Its Applications.	**3**
V	**Recurrence Relation** 5.1 Introduction to Recurrence Relations, Formation. 5.2 Linear Recurrence Relations with constant coefficients. 5.3 Homogeneous Solutions. 5.4 Particular Solutions. 5.5 Total Solutions.	**8**

Learning Resources:

Reference Books	2 Kenneth Rosen, 'Discrete Mathematics and its applications', Seventh Edition by Tata McGraw Hill. 3 Kolman, Busby, Ross, Rehman, 'Discrete Mathematical Structures', Sixth edition, by Prentice Hall. 4 C. L. Liu, 'Elements of Discrete Mathematics', Fourth edition, by Tata McGraw Hill.

MTS166: Mathematical Foundation for Data Science

Course Contents

Semester-II

Unit No.	Title of Unit and Contents	No. of hours
I	**Statements and Logic** 1.1 Statements 1.2 Statements with quantifiers 1.3 Compound Statements 1.4 Implications 1.5 Proofs in Mathematics	**4**
II	**Matrices** 2.1 Matrix Operations. 2.2 The Inverse of a Matrix. 2.3 Characterization of invertible matrices.	**4**
III	**System of Linear Equations** 3.1 System of Linear equations. 3.2 Elementary Row operations and echelon forms. 3.3 Solution set of linear systems. 3.4 Matrix factorization [LU decomposition]	**6**
IV	**Permutation and Combinations** 4.1 Cardinality of a finite set. 4.2 The Product Rule, the Sum Rule, the Inclusion- Exclusion Principle. 4.3 Statement of Pigeonhole Principle, Its Applications. 4.4 Introduction to Permutations and Combinations. 4.5 Permutation and Combination with Repetitions.	**8**
V	**Basics of Probability** 5.1 Sample space, Discrete sample space: finite and countably infinite. 5.2 Concept of occurrence of an event. Algebra of events. 5.3 Definition of conditional probability of an event. 5.4 Definition of independence of two events. 5.5 Multiplication theorem. 5.6 Application of Bayes' Theorem	**8**

Learning Resources:

Reference Books	1. Howard Anton and Chris Rorres, 'Elementary Linear Algebra with Supplemental Applications', eleventh edition, Wiley Student Edition. 2. Kanti Bhushan Datta, 'Matrix and Linear Algebra (aided with MATLAB)', Third Edition, Eastern Economic Edition. 3. S. C. Gupta and V. K. Kapoor, 'Fundamentals of Mathematical Statistics', Eighth Edition, Sultan Chand and Sons Publishers, New Delhi.

Semester II		
Title of the Course and Course Code	**Introduction to Applied Mathematics (OE-III) (MTS-170)**	**Number of Credits: 02**
Course Outcomes (COs) On completion of the course, the students will be able to:		Bloom's cognitive level
CO1	Recall the graphs and equation of the line.	1
CO2	Study graphical representation of the lines and their solution.	2
CO3	Compute the addition and multiplication of matrices.	3
CO4	Solve the system of linear equations.	4
CO5	Discuss the solution of the system of linear equations.	5
CO6	Decide linear programming problem is optimized or not using graphical method.	6

MTS-170: Introduction to Applied Mathematics (OE-III)
Course Contents
Semester II

Unit No.	Title of Unit and Contents	No. of hours
I	**The Fundamentals of Linear Algebra:** 1.1 The role of linear algebra, 1.2 Addition and subtraction of matrices, 1.3 Scalar multiplication, vector multiplication, 1.4 Multiplication of matrices, 1.5 Commutative, associative and distributive laws in matrix algebra, 1.6 Identity and Null matrices, 1.7 Matrix expression of a system of linear equations, 1.8 Row operations, 1.9 Augmented matrix, 1.10 Gaussian method of solving linear equations	**10**
II	**Matrix Inversion:** 2.1 Determinants and Non-singularity 2.2 Third-order Determinants 2.3 Minors and Cofactors 2.4 Laplace Expansion and Higher-order Determinants 2.5 Properties of a Determinant 2.6 Cofactor and Adjoint Matrices 2.7 Inverse Matrices 2.8 Solving Linear Equations with the inverse 2.9 Cramer's Rule for Matrix Solutions and The Gaussian Method of Inverting a Matrix.	**10**
III	**Modelling with Linear Programming** 3.1 Two variable LP Model 3.2 Graphical LP solution,	**10**

	3.3 Selected LP Applications, 3.4 Graphical Sensitivity analysis	

Learning Resources:

Reference Books	1. Christopher J. Stocker, Michael R. Ziegler, Karl E. Byleen, Raymond A. BarnettCollege Mathematics for Business, Economics, Life Sciences, and Social Sciences, Pearson 2. Edward Dowling, Introduction to Mathematical Economics, Schaum's Outline Series. 3. Alpha C. Chiang, Kevin Wainwright Fundamental Methods of Mathematical Economics 4. Frank Ayres, Mathematics of Finance, Schaum's Outline Series. 5. Carl P. Simon, Lawrence Blume Mathematics for Economists. 6. Knut Sydsaester and Peter Hammond with Arne Strom Essential Mathematics for Economic Analysis, Pearson. 7. J. K. Sharma, Operations Research (Theory and Applications, second edition,2006),Macmillan India Ltd. 8. Hira and Gupta, Operations Research.

Semester II		
Title of the Course and Course Code	**Introduction to Quantitative and Logical Thinking-II (OE-IV) (MTS-171)**	**Number of Credits: 02**
Course Outcomes (COs) On completion of the course, the students will be able to:		Bloom's cognitive level
CO1	Understand basic concepts Polynomials, Quadratic equations	1
CO2	Familiarize basic concepts of simple and compound interest.	2
CO3	Interpret the Venn diagram	3
CO4	Solve the problems on Clock Train and Calendar.	4
CO5	Analyze the problems on Heights and Distances	5
CO6	Construct the Venn diagram.	6

MTS-171: Introduction to Quantitative and Logical Thinking-II (OE-IV)

Course Contents

Semester II

Unit No.	Title of Unit and Contents	No. of hours
I	1.1 Algebra of Polynomials 1.2 Quadratic Equations 1.3 Partnership 1.4 Simple Interest. 1.5 Compound Interest	**10**
II	2.1 Time and Work 2.2 Work and Wages 2.3 Pipes and Cistern 2.4 Allegation 2.5 Problems on Trains	**10**
III	3.1 Problems on Clock 3.2 Problems on Calendar 3.3 Time and Distances 3.4 Heights and Distances 3.5 Set and Venn Diagram	**10**

Learning Resources:

Reference Books	1. R. V. Praveen,Quantitative Aptitude and Reasoning **2.** Dinesh Khattar, Quantitative Aptitude for Competitive Examinations-Pearson Education (2020) 3. R.S. Aggarwal Quantitative AptitudePHI Learning Pvt. Ltd.

F. Y. B. Sc. (Vocational Skill Course) Semester II		
Title of the Course and Course Code	**Numerical Methods using Python (MTS180)**	**Number of Credits : 02**
Course Outcomes (COs) On completion of the course, the students will be able to:		Bloom's cognitive level
CO1	Recall and understand the decision control statements.	1
CO2	Familiarize and learn how to use lists, tuples, and dictionaries in Python programs..	2
CO3	Acquire programming skills in core Python and implement object oriented concepts.	3
CO4	Recognize basic principles of Python programming language.	4
CO5	Creating different functions in Python	6

MTS-180: Numerical Methods using Python

Course Contents

Semester II

Unit No.	Title of Unit and Contents	No. of hours
I	**Decision Control Statements Revised** 1.1 Conditional and alternative statements 1.2 Chained and Nested if, if-else, if-elif-else, nested if, nested if-else	**4**
II	**Recursive Functions** 2.1 Factorial of a number 2.2 Greatest Common Divisor 2.3 Finding Exponents 2.4 The Fibonacci Series	**2**
III	**Linear Algebra** 3.1 Matrix Construction 3.2 Addition, Subtraction, Multiplication of Matrices 3.3 Power and Inverse of Matrix 3.4 Accessing rows and columns 3.5 Deleting and Inserting Rows of Matrix 3.6 Determinant, Row Echelon Form 3.7 Null Space, Column Space, Rank 3.8 Solving Systems of Linear Equations 3.9 Gauss-Jordan Method 3.10 Gauss-Eliminations Method 3.11 LU-Decomposition Method 3.12 Eigenvalues, Eigenvector's and Diagonalization	**10**
IV	**Numerical Methods in Python** 4.1 Roots of Equations 4.2 Newton-Rapson Method 4.3 False Position Method 4.4 Numerical Integration 4.5 Trapezoidal Rule 4.6 Simpson's $1/3^{rd}$ Rule	**6**

	4.7 Simpson's $3/8^{th}$ Rule	
V	**Some Sorting and searching Algorithms** 5.1 Merge sort, quick sort, bubble sort 5.2 Breadth first search algorithm, Depth first search algorithm	**8**

Learning Resources:

Reference Books	1. Reema Thareja, Python Programming Using Problem Solving Approach, Oxford University Press, 2015 2. Allen Downey, Think Python, How to Think Like a Computer Scientist, Green Tea Press Needham, Massachusetts, 2015 3. Robert Johansson, Introduction to Scientific Computing in Python, SMTEBOOKS, Apress, 2016 4. M. Goodrich, R. Tamassia, M. Goldwasser, Data Structure and Algorithms in Python, Wiley, 2013. 5. Basant Agarwal and Benjamin Baka, Data Structures and Algorithms with Python, Packt Publishing Ltd, 2018.
E-Resources	https://tinyurl.com/yu4bdsnn Programming, Data Structures And Algorithms Using Python - Course (nptel.ac.in)- Swayam Course on Python by Madhavan Mukund

MTS-190: Mathematical Writing, LATEX and Sage

Course Contents

Semester II

Unit No.	Title of Unit and Contents	No. of hours
I	**Mathematical Writing**	**6**
II	**Latex** **1.** Basics of Latex 2. The document 3. Bibliography 4. Type setting Mathematics 5. Type setting theorems	**12**
III	**Sage** **1.** Introduction 2. Graphing 3. Programming with sage 4. Matrix algebra with sage 5. Calculus with sage	**12**

Learning Resources:

Reference Books	1. Latex Tutorials: A primer. Indian Latex group, Trivandrum, India 2003. 2. Tutorial release 9.8, the sage development team, 2003.
E-Resources	1. https://ajitmathsoft.wordpress.com/sagemath/