AC – 27/12/2023
Item No. – 6.3 (N)

As Per NEP 2020

University of Mumbai

Title of the program

A- U.G. Certificate in Mathematics
B- U.G. Diploma in Mathematics
C- B.A./ B.Sc. (Mathematics)
D- B.A./ B.Sc. (Hons.) in Mathematics
E- B.A./ B.Sc. (Hons. with Research) in Mathematics

Syllabus for

Semester – Sem I & II (Scheme I)

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

(With effect from the academic year 2024-25 Progressively)

University of Mumbai

(As per NEP 2020)

Sr. No.	Heading	Particulars	
1	**Title of program** **O: _____A**	**A**	**U.G. Certificate in Mathematics**
	O: _____B	**B**	**U.G. Diploma in Mathematics**
	O: _____C	**C**	**B.A./ B.Sc. (Mathematics)**
	O: _____D	**D**	**B.A./ B.Sc. (Hons.) in Mathematics**
	O: _____E	**E**	**B.A./ B.Sc. (Hons. with Research) in Mathematics**
2	**Eligibility** **O: _____A**	**A**	XII Science/Arts with Mathematics OR Passed Equivalent Academic Level 4.0
	O: _____B	**B**	Under Graduate Certificate in Mathematics Academic Level 4.5
	O: _____C	**C**	Under Graduate Diploma in Mathematics Academic Level 5.0
	O: _____D	**D**	Bachelors of Mathematics with minimum CGPA of 7.5 Academic Level 5.5
	O: _____E	**E**	Bachelors of Mathematics with minimum CGPA of 7.5 Academic Level 5.5
3	**Duration of program** **R: _____**	**A**	One Year
		B	Two Years
		C	Three Years
		D	Four Years
		E	Four Years
4	**Intake Capacity** **R: _____**	**120**	

5	**Scheme of Examination** **R: _____**	NEP 40% Internal 60% External, Semester End Examination Individual Passing in Internal and External Examination	
6	**R: _____ Standards of Passing**	40%	
7	**Credit Structure** **Sem. I - R: _____A** **Sem. II - R: _____B**	Attached herewith	
	Credit Structure **Sem. III - R: _____C** **Sem. IV - R: _____D**		
	Credit Structure **Sem. V - R: _____E** **Sem. VI - R: _____F**		
8	**Semesters**	A	Sem I & II
		B	Sem III & IV
		C	Sem V & VI
		D	Sem VII & VIII
		E	Sem VII & VIII
9	**Program Academic Level**	A	4.5
		B	5.0
		C	5.5
		D	6.0
		E	6.0
10	**Pattern**	Semester	
11	**Status**	New	
12	**To be implemented from Academic Year Progressively**	From Academic Year: 2024-25	

Sign of the BOS Chairman
Dr. Bhausaheb S Desale
The Chairman, Board of Studies in Mathematics

Sign of the
Offg. Associate Dean
Dr. Madhav R. Rajwade
Faculty of Science & Technology

Sign of the
Offg. Dean
Prof. Shivram S. Garje
Faculty of Science & Technology

Preamble

1) Introduction

The University of Mumbai has brought into force the revised syllabi as per the National Education Policy (NEP 2020) for the First year B. Sc/ B. A. Programme (Certificate Course) in Mathematics from the academic year 2024-2025. Mathematics has been fundamental to the development of science and technology. In recent decades, the extent of application of Mathematics 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 F.Y.B. Sc. / F. Y. B. A. (certificate course) Mathematics. The present syllabi of F. Y. B. Sc. for Semester I and Semester II have been designed as per U. G. C. Model 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 F. Y. B. Sc. / F. Y. B. A. would consist of two semesters and each semester would comprise of three courses for F. Y. B. Sc. / F. Y. B. A. Mathematics. Course I is `Real Analysis I and Real Analysis II'. Real Analysis is applied and needed in every conceivable branch of science. Course II, `Algebra I and Discrete Mathematics' develops mathematical reasoning and logical thinking and has applications in science and technology. Course III contains practicals based on courses I and II. It helps to improve problem solving skills of students.

2) Aims and Objectives

1) 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.
2) Reacting the broad nature of the subject and developing mathematical tools for continuing further study in various fields of science.
3) 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.
4) A student should get adequate exposure to global and local concerns that explore them many aspects of Mathematical Sciences

3) Learning Outcomes

1. Real Analysis (Sem I & II): This course gives introduction to basic concepts of Analysis with rigor and prepares students to study further courses in Analysis. Formal proofs are given lot of emphasis in this course which also enhances understanding of the subject of Mathematics as a whole.
2. Algebra I (Sem I) & Discrete Mathematics (Sem II): This course gives expositions to number systems (Natural Numbers & Integers), like divisibility and prime numbers and their properties. These topics later find use in advanced subjects like cryptography and its uses in cyber security and such related fields.

Credit Structure of the Program (Sem I, II, III & IV)

Under Graduate Certificate in Mathematics

	R:_____A								
Level	**Semester**	**Major**		**Minor**	**OE**	**VSC, SEC (VSEC)**	**AEC, VEC, IKS**	**OJT, FP, CEP, CC,RP**	**Cum. Cr. / Sem.**	**Degree/ Cum. Cr.**
		Mandatory	**Electives**							
4.5	I	Real Analysis – I (Th) (2) Algebra – I (Th) (2) Practical I (Practical based on above two papers) (2)		-	2 + 2	VSC:2 Basics in Python Programming, SEC:2 Data Analytics- I	AEC:2, VEC:2, IKS:2	CC:2	22	**UG Certificate 44**
	R:_____B									
	II	Real Analysis – II (Th) (2) Discrete Mathematics (Th) (2) Practical II (Practical based on above two papers) (2)		2	2 + 2	VSC:2 Computing with Python, SEC:2 Data Analytics - II	AEC:2, VEC:2	CC:2	22	
	Cum Cr.	12	-	2	8	4+4	4+4+2	4	44	

Exit option: Award of UG Certificate in Major with 40-44 credits and an additional 4 credits core NSQF course/ Internship OR Continue with Majorand Minor

Under Graduate Diploma in Mathematics

	R:_____C								
Level	**Semester**	**Major**		**Minor**	**OE**	**VSC, SEC (VSEC)**	**AEC, VEC, IKS**	**OJT, FP, CEP, CC,RP**	**Cum. Cr. / Sem.**	**Degree/ Cum. Cr.**
		Mandatory	**Electives**							
5.0	III	Real Analysis – III (Th) (2) Linear Algebra - I (Th) (2) Ordinary Differential Equations (Th) (2) Practical based on the three papers (2)		2 (Th) +2 (Pr)	2	VSC:2 Introduction to Sage-Math / Introduction to SCILAB / Introduction to WS-Maxima	AEC:2	FP: 2 CC:2	22	**UG Diploma 88**
	R:_____D									
	IV	Multivariable Calculus-I (Th) (2), Linear Algebra - II (Th) (2), Numerical Methods/Statistics (Th) (2), Practical based on the three papers (Pr) (2)		2 (Th) +2 (Pr)	2	SEC:2 Introduction to GeoGebra/ JAVA Programming	AEC:2	CEP: 2 CC:2	22	
	Cum Cr.	28		10	12	6+6	8+4+2	8+4	88	

Exit option; Award of UG Diploma in Major and Minor with 80-88 credits and an additional 4 credits core NSQF course/ Internship OR Continuewith Major and Minor

B.A./ B.Sc. (Mathematics)

	R:_____E									
Level	**Semester**	**Major**		**Minor**	**OE**	**VSC, SEC (VSEC)**	**AEC, VEC, IKS**	**OJT, FP, CEP, CC,RP**	**Cum. Cr. / Sem.**	**Degree/ Cum. Cr.**
		Mandatory	**Electives**							
5.5	V	Multivariable Calculus-II (Th) (2) Group Theory (Th) (2) Topology of Metric Spaces-I (Th) (2) Practical – I (Based on Multivariable Calculus II and Group Theory) (2) Practical – II (Based on Multivariable Calculus II and Topology of Metric Spaces-I) (2)	4 Partial Differential Equations (Th) / Number Theory and Its Applications -I (Th) / / Operation Research -I (Th) / Graph Theory- I (Th) / Concepts of Probability & Random Variables (Th) Practical – III (Based on the Elective)	4		VSC: 2 R-Programming / Advance Excel / Cryptography/ Applications of Integral Calculus (Practical)		FP/CEP:2	22	**UG Degree 132**
	R:_____F									
	VI	Basic Complex Analysis (Th) (2) Ring Theory (Th) (2) Topology of Metric Spaces-II (Th) (2) Practical – I (Based on Basic Complex Analysis and Ring Theory) (2) Practical – II (Based on Basic Complex Analysis and Topology of Metric Spaces-II) (2)	4 Integral Transforms (Th) / Number Theory and Its Applications – II (Th) / Operation Research -II(Th)/ Graph -II (Th) Practical – III (Based on the Elective)	4				OJT :4	22	

	Cum Cr.	48	8	18	12	8+6	8+4+2	8+6+4	132	
Exit option: Award of UG Degree in Major with 132 credits OR Continue with Major and Minor										

[Abbreviation - OE – Open Electives, VSC – Vocation Skill Course, SEC – Skill Enhancement Course, (VSEC), AEC – Ability Enhancement Course, VEC – Value Education Course, IKS – Indian Knowledge System, OJT – on Job Training, FP – Field Project, CEP – Continuing Education Program, CC – Co-Curricular, RP – Research Project]

Sem. - I

Syllabus
B.A./ B.Sc. (Mathematics)
(Sem.- I)
Name of the Course: Real Analysis - I

Sr. No.	Heading	Particulars
1	**Description the course:** **Including but not limited to:**	Calculus has a wide range of applications in Science and Technology, like Physics, Chemistry, Biotechnology, Engineering etc. The Mathematical Analysis provides rigorous foundation to Calculus, and so the course aims to make learners gain the insight of Analysis, by learning various properties of Real Numbers, concepts like Sequences, limits and continuity of functions, and the derivatives. In order that the learner gets a feel of the variety of applications of the knowledge gained, the course also includes the applications of differentiation.
2	**Vertical:**	Major
3	**Type:**	Theory
4	**Credits:**	2 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)
5	**Hours Allotted:**	30 Hours
6	**Marks Allotted:**	50 Marks
7	**Course Objectives (CO):** This course gives introduction to basic concepts of Analysis with rigor and prepares students to study further courses in Analysis. In this course, importance is given to formal proofs which also enhances understanding of the subject of Mathematics as a whole. CO1. 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. CO2. To reflect the broad nature of the subject and develop mathematical tools for continuing further study in various fields of sciences. CO3. To enhance students' overall development, problem solving skills, creative talent, and power of communication are necessary for various kinds of employment. CO4. To give adequate exposure to global and local concerns that would help learners explore many aspects of Mathematical Sciences.	
8	**Course Outcomes (OC):** After completion of the course, students will be able to OC1: understand the real number system and differential equations.	

	OC2: learn the concepts of modulus, infimum, supremum. OC3: have a different (better) perspective of mathematics, as an aid to analytic and abstract thinking. OC4: understand the concepts related to sequences, like bounded, convergent, divergent, Cauchy, etc. OC5: evaluate the limits of convergent sequences and find solutions of differential equations. OC6: construct counter examples related to bounded sets, bounded sequence, Cauchy sequence and convergent sequence. OC7: apply differential equations to solve problems related to population growth and finding the current at a given time.
9	**Modules: -** **Module 1: Real Number System and Sequences (15 Hours)**
	(1) Real number system $\mathbb{R}$ and order properties of $\mathbb{R}$, absolute value and its properties. AM-GM inequality, Cauchy-Schwarz inequality, Intervals and neighborhoods, interior points, limit point, Hausdorff property. (2) Bounded sets, supremum and infimum, maximum and minimum, statement of lub axiom and its consequences, Archimedean property and its applications, density of rationals. (3) Definition of a sequence and examples, convergence of sequences, limit of a convergent sequence and uniqueness of limit, bounded sequence, divergent sequences, Convergence (without proof) of standard sequences like $\left(\frac{1}{1+na}\right)$, (b^n) with $0 < b$, $\left(c^{\frac{1}{n}}\right)$ $\forall c > 0$ and $\left(n^{\frac{1}{n}}\right)$. (4) Algebra of convergent sequences, Sandwich theorem, monotone sequences, monotone convergence theorem and consequences such as convergence of $\left(1+\frac{1}{n}\right)^n$. (5) Definition of subsequence, subsequence of a convergent sequence is convergent and converges to the same limit, Cauchy sequence, every convergent sequence is a Cauchy sequence and converse.
	Module 2: First Order First Degree Differential Equations (15 Hours)
	(1) Order and degree of ordinary differential equation, linear and non-linear ODE. Solution of homogeneous and non-homogeneous differential equations of first order and first degree. Notion of partial derivatives. (2) Exact Equations: General solution of Exact equations of first order and first degree. Necessary and sufficient condition for $Mdx + Ndy = 0$ to be exact. Non-exact equations: Rules for nding integrating factors (without proof) for non exact equations, such as: i) $\frac{1}{Mx+Ny}$ is an I.F. if $Mx + Ny \neq 0$ and $Mdx + Ndy = 0$ is homogeneous. ii) $\frac{1}{Mx-Ny}$ is an I.F. if $Mx - Ny \neq 0$ and $Mdx + Ndy = 0$ is of the form $f_1(x,y)\, y\, dx + f_2(x,y)\, xdy = 0$. iii) $e^{\int f(x)dx}$ (resp $e^{\int g(y)dy}$) is an I.F. if $N \neq 0$ (resp $M \neq 0$) and $\frac{1}{N}\left(\frac{\partial M}{\partial y} -$

	$\frac{\partial N}{\partial x}\Big)\left(\frac{1}{M}\left(\frac{\partial M}{\partial y}-\frac{\partial N}{\partial x}\right)\right)$ is a function of x (resp y) alone, say $f(x)$ (resp $g(y)$). (3) Linear and reducible linear equations of first order and finding their solutions (4) Applications to orthogonal trajectories, population growth, and finding the current at a given time.
10	**Text Books:** 1. R. R. Goldberg, Methods of Real Analysis, Oxford and IBH, 1964. 2. K. G. Binmore, Mathematical Analysis, Cambridge University Press, 1982. 3. R. G. Bartle-D. R. Sherbert, Introduction to Real Analysis, John Wiley & Sons, 1994. 4. Sudhir Ghorpade and Balmohan Limaye, A course in Calculus and Real Analysis,Springer International Ltd, 2000. 5. George F. Simmons, Differential Equations with Applications and Historical Notes, Taylor's and Francis, Third Edition, 2017.
11	**Reference Books** 1. T. M. Apostol, Calculus Volume I, Wiley & Sons (Asia) Pte, Ltd. 2. Richard Courant-Fritz John, An Introduction to Calculus and Analysis, Volume I,Springer. 3. Ajit Kumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, 2014. 4. James Stewart, Calculus, Third Edition, Brooks/ cole Publishing Company, 1994.
	<u>Scheme of the Examination</u>
	The performance of the learners shall be evaluated in two parts. • Internal Continuous Assessment of 20 marks. • Semester End Examination of 30 marks. • A separate head of passing is required for internal and semester-end examinations.
12	**Internal Continuous Assessment: 40%** — **Semester End Examination: 60%**
13	**Continuous Evaluation through:** Quizzes, Class Tests, presentations, projects, role play, creative writing, assignments etc. (at least 3)

Sr. No.	Particulars	Marks
1	A class test of 10 marks is to be conducted during each semester in an Offline mode.	10

2	Project on any one topic related to the syllabus or a quiz (offline/online) on one of the modules.	05
3	Seminar/ group presentation on any one topic related to the syllabus.	05

Paper pattern of the Test (Offline Mode with One hour duration):
Q1: Definitions/Fill in the blanks/ True or False with Justification.
(04 Marks: 4 x 1).
Q2: Attempt any 2 from 3 descriptive questions. (06 marks: 2 × 3)

14 **Format of Question Paper:**
The semester-end examination will be of 30 marks of one hour duration covering the entiresyllabus of the semester.

Note: Attempt any TWO questions out of THREE.			
Q.No.1	Module 1 and 2	Attempt any **THREE** out of **FOUR**. (Each question of 5 marks) (a) Question based on OC1/OC2 (b) Question based on OC3 (c) Question based on OC4 (d) Question based on OC5/OC6/OC7	15 Marks
Q.No.2	Module 1 and 2	Attempt any **THREE** out of **FOUR**. (Each question of 5 marks) (a) Question based on OC1/OC2 (b) Question based on OC3 (c) Question based on OC4 (d) Question based on OC5/OC6/OC7	15 Marks
Q.No.3	Module 1 and 2	Attempt any **THREE** out of **FOUR**. (Each question of 5 marks) (a) Question based on OC1/OC2 (b) Question based on OC3 (c) Question based on OC4 (d) Question based on OC5/OC6/OC7	15 Marks

Name of the Course: Algebra - I

Sr. No.	Heading	Particulars
1	**Description of the course: Including but not limited to:**	Algebra has a wide range of applications in Computer science, search engines, cryptography and many more. Learning algebra helps us to use illustrations to increase our thinking skills. Topics like Integers and functions help us to understand the elementary and fundamental aspects of mathematics and numbers. The entire world revolves around algebraic applications and algebra is a big part of many businesses because these businesses use algebraic operations in finance
2	**Vertical:**	Major
3	**Type:**	Theory
4	**Credits:**	2 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)
5	**Hours Allotted:**	30 Hours
6	**Marks Allotted:**	50 Marks
7	**Course Objectives (CO):** This course introduces basic concepts of Algebra with rigour and prepares students to study further courses in linear and abstract algebra. Formal proofs are emphasized which also enhance understanding of the subject of Mathematics as a whole. CO1. 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. CO2. To reflect the broad nature of the subject and develop mathematical tools for continuing further study in various fields of sciences. CO3. To enhance students' overall development, problem-solving skills, creative talent and power of communication are necessary for various kinds of employment. CO4. To give adequate exposure to global and local concerns that would help learners explore many aspects of Mathematical Sciences.	
8	**Course Outcomes (OC):** After completion of the course, students will be able to OC1: understand the integer and rational number system and illustrate examples of polynomials in $F[x]$, where $F = \mathbb{Z}, \mathbb{Q}, \mathbb{R}, \mathbb{C}$. OC2: explain the properties and theorems of polynomials with suitable examples. OC3: verify the statements of theorems by applying them in problem-solving.	

	OC4: analyze the problem and apply the theorems accordingly. OC5: generalize statements of theorems and interpret the proof. OC6: develop skills to note the minute and relevant details in the concepts and develop an understanding of the abstract part of algebra required for higher-order thinking in pure mathematics in the higher classes.
9	**Modules: -** **Module 1: Relations, Functions and Integers (15 Hours)**
	(1) Definition of relation and function, domain, co-domain and range of a function, composition of functions, image $f(A)$, inverse image $f^{-1}(B)$ for a function $f: X \to Y$, injective, surjective, bijective functions, examples of functions including constant, identity, polynomial, projection, inclusion, binary operation. Finite and infinite sets. (2) Equivalence relation, Equivalence classes, properties such as two equivalences classes are either identical or disjoint, definition of partition, every partition gives an equivalence relation and vice versa. (3) Statement of well-ordering property of non-negative integers, Principle of finite induction (first and second) because of Well-Ordering Principle. (4) Divisibility in integers, division algorithm, greatest common divisor (g.c.d.) and least common multiple (l.c.m.) of two non-zero integers, basic properties of g.c.d. such as existence and uniqueness of g.c.d. of two non-zero integers a & b and that the g.c.d. can be expressed as $ma + nb$ for some $m, n \in \mathbb{Z}$, Euclidean algorithm. Primes, Euclid's lemma, Fundamental Theorem of arithmetic (Statement only), the set of primes is infinite. (5) Congruence, definition and elementary properties, congruence is an equivalence relation on $\mathbb{Z}$, residue classes and partition of $\mathbb{Z}$, addition modulo, multiplication modulo n, examples. linear congruence equations. Examples.
	Module 2: Polynomials (15 Hours)
	(1) Definition of a polynomial, polynomials over F where $F = \mathbb{Q}, \mathbb{R}$ or $\mathbb{C}$, Algebra of polynomials, degree of polynomial, basic properties. (2) Division algorithm in $F[X]$ (without proof), and g.c.d of two polynomials and its basic properties, Euclidean algorithm (proof of the above results may be given only in the case of $\mathbb{Q}[X]$ with a remark that the results as well as the proofs remain valid in the case of $\mathbb{R}[X]$ or $\mathbb{C}[X]$). (3) Roots of a polynomial function, relation between roots and coefficients, multiplicity of a root. Elementary consequences such as, Remainder theorem, Factor theorem, A polynomial function of degree n has at most n roots. Complex and non-real roots of polynomials in $\mathbb{R}[X]$ occur in conjugate pairs. (Emphasis on examples and problems in polynomials with real coefficients). (4) Necessary condition for a rational number $\frac{p}{q}$ to be a root of a polynomial with integer coefficients (viz. p divides the constant coefficient and q divides the leading coefficient), the corollary for monic polynomials (viz. a rational root of a monic

	polynomial with integer coefficients is necessarily an integer). Simple consequence such as irrationality is necessary of $\sqrt{p}$ for any prime number p.
10	**Text Books** (1) David M. Burton, Elementary Number Theory, Seventh Edition, McGraw Hill Education (India) Private Ltd. (2) Norman L. Biggs, Discrete Mathematics, Revised Edition, Clarendon Press, Oxford 1989.
11	**Reference Books** (1) I. Niven and S. Zuckerman, Introduction to the theory of numbers, Third Edition, Wiley Eastern, New Delhi, 1972. (2) G. Birkoff and S. Maclane, A Survey of Modern Algebra, Third Edition, Mac Millan, New York, 1965. (3) N. S. Gopalkrishnan, University Algebra, Ne Age International Ltd, Reprint 2013. (4) I. N. Herstein, Topics in Algebra, John Wiley, 2006. (5) P. B. Bhattacharya S. K. Jain and S. R. Nagpaul, Basic Abstract Algebra, New Age International, 1994. (6) Kenneth Rosen, Discrete Mathematics and its Applications, McGraw Hill, International Edition, Mathematics Series.
	<u>Scheme of the Examination</u>
	The performance of the learners shall be evaluated in two parts. • Internal Continuous Assessment of 20 marks. • Semester End Examination of 30 marks. • A separate head of passing is required for internal and semester-end examinations.
12	**Internal Continuous Assessment: 40%** — **Semester End Examination: 60%**
13	**Continuous Evaluation through:** Quizzes, Class Tests, presentations, projects, role play, creative writing, assignments etc. (at least 3)

Sr. No.	Particulars	Marks
1	A class test of 10 marks is to be conducted during each semester in an Offline mode.	10
2	Project on any one topic related to the syllabus or a quiz (offline / online) on one of the modules.	05
3	Seminar/group presentation on any one topic related to the syllabus.	05

	Paper pattern of the Test (Offline Mode with One hour duration): Q1: Definitions/Fill in the blanks/ True or False with Justification (04 Marks). Q2: Attempt any 2 from 3 descriptive questions. (06 marks: 2 × 3)	

14 **Format of Question Paper:**

The semester-end examination will be of 30 marks of one hour duration covering the entiresyllabus of the semester.

Note: Attempt any TWO questions out of THREE.			
Q.No.1	Module 1 and 2	Attempt any **THREE** out of **FOUR**. (Each question of 5 marks) (a) Question based on OC1/OC2 (b) Question based on OC3 (c) Question based on OC4 (d) Question based on OC5/OC6	15 Marks
Q.No.2	Module 1 and 2	Attempt any **THREE** out of **FOUR**. (Each question of 5 marks) (a) Question based on OC1/OC2 (b) Question based on OC3 (c) Question based on OC4 (d) Question based on OC5/OC6	15 Marks
Q.No.3	Module 1 and 2	Attempt any **THREE** out of **FOUR**. (Each question of 5 marks) (a) Question based on OC1/OC2 (b) Question based on OC3 (c) Question based on OC4 (d) Question based on OC5/OC6	15 Marks

Name of the Course: Practical - I

Sr. No.	Heading	Particulars
1	**Description the course: Including but not limited to:**	Problem solving forms one of the basic aspects of any course in Mathematics. Higher courses in Mathematics focus mainly on the theoretical nature of the subject, nevertheless, the problem- solving activity strengthens the concepts and helps the learners develop their ability to think over the existing problems in the subject, and also to create and crack new problems! This way a learner is not just motivated, but elevated also, to formulate new results, suggest new postulates (usually known as conjectures), and design new theories.
2	**Vertical:**	Major
3	**Type:**	Practical
4	**Credits:**	2 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)
5	**Hours Allotted:**	60 Hours
6	**Marks Allotted:**	50 Marks
7	**Course Objectives (CO):** This course introduces basic concepts of Algebra and Analysis with rigour and prepares students to study further courses. Formal proofs are emphasized which also enhance understanding of the subject of Mathematics as a whole. CO1. 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. CO2. To reflect the broad nature of the subject and develop mathematical tools for continuing further study in various fields of sciences. CO3. To enhance students' overall development, problem solving skills, creative talent, and power of communication are necessary for various kinds of employment. CO4. To give adequate exposure to global and local concerns that would help learners explore many aspects of Mathematical Sciences.	
8	**Course Outcomes (OC):** After completion of the course, students will be able to OC1: understand and practice the problems based on fundamental concepts. OC2: equip with skills to analyze problems and recognize bounded sets, bounded sequence, convergent and divergent sequences, monotone and Cauchy sequences, bijective functions, equivalence classes, exact and non-exact differential equation. OC3: apply order completeness axiom, well ordering principle, induction principle. OC4: evaluate limits of sequences, GCD, LCM, solutions of congruence, solution of first order and first degree homogeneous/ non-homogeneous and linear differential equation. OC5: formulate and validate results related to properties of integers / real numbers and differential equations.	

9 **Modules: -**

Module 1: Practical for Real Analysis I (30 Hours)

1.	Algebraic, order and absolute properties of real numbers.
2.	Inequalities, Archimedean Property, Hausdorff Property LUB axiom of $\mathbb{R}$.
3.	Convergent and divergent Sequences.
4.	Bounded Sequence, Monotone Sequence and Sandwich theorem.
5.	Cauchy Sequence, Subsequence and problems based on applications of properties of real numbers and sequences.
6.	Homogeneous and non-homogeneous differential equations.
7.	Solving exact and non-exact differential equations.
8.	Linear differential equations.
9.	Reduction of order of differential Equations.
10.	Applications of differential equations.

Module 2: Practical for Algebra I (30 Hours)

1.	Examples based on Functions.
2.	Equivalence relations.
3.	Principles of finite induction and Polynomials.
4.	GCD and LCM in $\mathbb{Z}$ using the Division Algorithm and Euclidean Algorithm and prime numbers and Fundamental Theorem of Arithmetic.
5.	Congruence and its properties.
6.	Linear congruence equations.
7.	Algebra of polynomials.
8.	GCD and LCM in $\mathbb{R}[x]$ using Division Algorithm and Euclidean Algorithm in $F[x]$.
9.	Roots of the polynomials.
10.	Rational root theorem.

10 **Text Books**

1. R. R. Goldberg, Methods of Real Analysis, Oxford and IBH, 1964.

2. K. G. Binmore, Mathematical Analysis, Cambridge University Press, 1982.

3. R. G. Bartle-D. R. Sherbert, Introduction to Real Analysis, John Wiley & Sons, 1994.

4. Sudhir Ghorpade and Balmohan Limaye, A course in Calculus and Real Analysis,Springer International Ltd, 2000.\

5. David M. Burton, Elementary Number Theory, Seventh Edition, McGraw Hill Education (India) Private Ltd.

6. Norman L. Biggs, Discrete Mathematics, Revised Edition, Clarendon Press, Oxford 1989

<table>
<tr><td></td><td colspan="2">7. George F. Simmons, Differential Equations with Applications and Historical Notes, Taylor's and Francis, Third Edition, 2017.</td></tr>
<tr><td>11</td><td colspan="2">Reference Books
(1) T. M. Apostol, Calculus Volume I, Wiley & Sons (Asia) Pte, Ltd.
(2) Richard Courant-Fritz John, A Introduction to Calculus and Analysis, Volume I,Springer.
(3) Ajit Kumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, 2014.
(4) James Stewart, Calculus, Third Edition, Brooks/ Cole Publishing Company, 1994.
(5) I. Niven and S. Zuckerman, Introduction to the theory of numbers, Third Edition, Wiley Eastern, New Delhi, 1972
(6) G. Birkoff and S. Maclane, A Survey of Modern Algebra, Third Edition, Mac Millan, New York, 1965
(7) N. S. Gopalkrishnan, University Algebra, Ne Age International Ltd, Reprint 2013
(8) I. N. Herstein, Topics in Algebra, John Wiley, 2006
(9) P. B. Bhattacharya S. K. Jain and S. R. Nagpaul, Basic Abstract Algebra, New Age International, 1994
(10 Kenneth Rosen, Discrete Mathematics and its Applications, McGraw Hill, International Edition, Mathematics Series</td></tr>
<tr><td></td><td colspan="2"><u>Scheme of the Examination</u></td></tr>
<tr><td>12</td><td>Internal Continuous Assessment: 40%</td><td>Semester End Examination: 60%</td></tr>
<tr><td>13</td><td>Continuous Evaluation through:
Quizzes, Class Tests, presentations, projects, role play, creative writing, assignments etc.
(at least 3)

<table>
<tr><td>Sr. No.</td><td>Particulars</td><td>Marks</td></tr>
<tr><td>1</td><td>Objective question test</td><td>10</td></tr>
<tr><td>2</td><td>Overall performance</td><td>05</td></tr>
<tr><td>3</td><td>Viva</td><td>05</td></tr>
</table>
Paper pattern of the Test (Offline Mode):
Q1: (Attempt any 5 from 8) Multiple choice questions. (10 marks: 5 × 2)

Duration: 1Hrs
While setting question paper four MCQ on module 1 and</td><td></td></tr>
</table>

	four MCQ on module 2 both.	
14	**Format of Question Paper:** **Scheme of examination:** At the end of the Semester I, Practical examinations of three hours duration and 30 marks shall be conducted based on both the modules. Paper pattern: The question paper shall have two questions. **Marks for Journals:** For both Module 1 and Module 2 1. Journal: 5 marks (2.5 marks for each module 1 & module 2) The students are required to perform 75% of the Practical for the journal to be duly certified. The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.	

Q. No. 1	Five out of Eight multiple choice questions (four from module 1 and four from module 2) (OC1 to OC4)	Marks ($3 \times 5 = 15$ Marks)
Q. No.2	Attempt any Two out of Four (two from module 1 and two from module 2). (OC4 and OC5)	($5 \times 2 = 10$ Marks)

Name of the Course: Basics in Python Programming (VSC I)

Sr. No.	Heading	Particulars
1	**Description the course: Including but not limited to:**	Algorithm and Basic Python Programming are foundational components in the world of computer science and software development. Algorithms provide a systematic approach to problem-solving, while Python offers a versatile and easy-to-learn language for implementing these solutions. Algorithms are essential for creating efficient and optimized solutions to computational problems, enhancing the overall performance of software. Python, with its simplicity and readability, serves as a powerful tool for implementing algorithms and developing a wide range of applications. Algorithms are applied across diverse areas, including sorting, searching, graph theory, machine learning, and cryptography. Python finds application in web development, data science, artificial intelligence, and automation, showcasing its versatility. Understanding algorithms can be intellectually stimulating for those who enjoy logical and strategic thinking. Python, with its user-friendly syntax, often captures the interest of learners and developers alike. A combination of algorithmic skills and Python proficiency opens up various job prospects. Individuals with these skills can pursue roles such as software engineer/developer, data scientist/analyst, algorithm engineer, machine learning engineer/scientist, and research scientist. So, mastering algorithm design and Basic Python Programming is a powerful combination that equips individuals for success in the dynamic and ever-evolving field of computer science and technology. It not only enhances problem-solving capabilities but also provides a strong foundation for diverse career paths within the industry
2	**Vertical:**	Vocational Skill Course
3	**Type:**	Practical
4	**Credits:**	2 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)
5	**Hours Allotted:**	60 Hours
6	**Marks Allotted:**	50 Marks

7	**Course Objectives (CO):** CO1. To learn and understand algorithms. CO2. To define the structure and components of algorithm and python program. CO3. To learn and understand python looping and control statements manipulations. CO4. To learn about inbuilt input/output operations and compound data types in Python CO5. To learn about searching, sorting and recursion with python programming.	
8	**Course Outcomes (OC):** After completion of the course, students will be able to OC1. learn the fundamental concepts of algorithm and python. OC2. understand the implementation of basic syntax, Input / Output operations, loop controls and decision making with algorithms and Python. OC3. apply basic programming techniques for solving problems in mathematics. OC4. verify elementary mathematical results using Python. OC5. evaluate the solutions of complex mathematical problems using Python. OC6. create different algorithms/programs for searching sorting and recursion-based problem.	
9	**Modules: -** **Module 1: Algorithm (30 Hours)**	

1.	Definition of an algorithm, characteristics of an algorithm. Elementary algorithmic vocabulary (input or read, output or print), elementary mathematical operators (+, -, *, /, **, mod, div mod or %), logical operators (or, and, not). • Practical based on assigning value to a variable and performing basic mathematical operations on the same and printing the final result.
2.	Exchange of values of variables. • Practical based on exchange of values of two variables, using dummy variable. • Practical based on exchange of values of two variables, without using dummy variable. • Practical based on circular exchange of values of several variables.
3.	Conditional Structure (if-then-else) • Practical based on accepting and assigning value/s to variable/s and checking whether the variable is even/odd, multiple of 3/4/5 etc. • Practical based on accepting marks from the user and providing appropriate grade to the user.
4.	Loop Structure with pre-known number of iterations (for loop) • Practical based on accepting a positive integer from the user and writing all of its divisors (Application to divisibility)

	• Practical based on accepting a positive integer n from the user, obtaining the sum of $1 + 2 + \cdots + n$, $1^2 + 2^2 + \cdots + n^2$, $1^3 + 2^3 + \cdots + n^3$, and finally verifying that these sums equal $\frac{n(n+1)}{2}$, $\frac{n(n+1)(2n+1)}{6}$, $\frac{n^2(n+1)^2}{4}$
5.	Loop Structure with pre-unknown number of iterations (while loop) • Practical based on accepting two positive integers from the user and getting the GCD and LCM of the two numbers. • Practical based on accepting a positive integer from the user and checking whether it is prime or composite or neither.
6.	• Practical based on checking whether the given (finite) sequence is monotone or not. (Application to understanding monotone sequence) • Practical based on accepting a positive real number from the user, say epsilon, and getting value of n, such that $\frac{1}{n}$ or $\frac{1}{n^2}$ will be within epsilon distance from zero. (This suggests that the sequences like $\frac{1}{n}$ or $\frac{1}{n^2}$ could be convergent sequences)
7.	Searching and sorting: • Practical based on finding maximum and/or minimum element in a finite sequence of integers, • Practical based on the linear search and binary search algorithms of an integer x in a finite sequence of distinct integers, • Practical based on sorting of a finite sequence of integers in ascending order, selection sort.
8.	Recursion: • Practical based on Tower of Hanoi • Practical based on Fibonacci sequence

Module 2: Elementary Python Programming (30 Hours)

1.	Introduction, Installing Python. Running Code in the Interactive Shell, IDLE. Input, Processing, and Output. Editing, Saving, and Running a Script. • Practical based on directly assigning values to variables and printing their values. (The values will be numbers as well as strings) - The purpose of this practical is to make the learner comfortable with the python environment.
2.	Data types and expressions: Variables and the Assignment Statement, Program Comments and Docstrings. Mathematical operators +, - *, **, %. PEMDAS. Arithmetic expressions, Mixed-Mode Arithmetic and type

		Conversion, type(), Input( ), print( ), id(), int( ), str( ), float( ) • Practical based on assigning values to variables, by accepting the values from the user, and then performing basic operations on them. • Practical based on obtaining the values of complicated math expressions.
	3.	Boolean expressions and Conditional Structure (if-then-else-elif) • Practical based on accepting income from the user and finding the income tax to be paid by the user. • Practical based on accepting a number and checking whether the number is positive, zero or negative (Application to Law of Trichotomy). • Practical based on accepting two positive integers and checking whether they are co-prime or not. (Application to coprime numbers).
	4.	Math Directory and the built-in functions and values (like, pi, e etc.) • Practical based on verification of $\|a+b\| \leq \|a\| + \|b\|$ and other properties of absolute value function. (Application to absolute value function). • Practical based on accepting three positive numbers from the user and checking whether a triangle is possible with these three numbers as its sides, and if such a triangle is possible then stating its type (Equilateral, Isosceles, Scalene). • Practical based on accepting sides of a triangle and finding its internal angles and area. • Practical based on accepting three positive numbers from the user and checking whether a triangle is possible with these three numbers as its sides, and if such a triangle is possible then stating its type (Acute-angled, Right-angled, Obtuse-angled).
	5.	Loop Structure with pre-known number of iterations (for loop) • Practical based on accepting a non-negative integer from the user and finding its factorial. • Practical based on accepting a positive integer *n* from the user and writing first *n* terms of Fibonacci Sequence
	6.	• Practical based on getting positive integral roots of Brahmagupta's equation (usually called Pelle's equation) $Nx^2 + 1 = y^2$, within some intervals for *x*, *y* and *n*. • Practical based on accepting an even positive integer (greater than 2) from the user and expressing it as sum of two primes, thereby verifying Goldbach conjecture.
	7.	Loop Structure with pre-unknown number of iterations (while loop)

		• Practical based on accepting a positive real number x from the user and finding smallest positive integer n such that $1+\frac{1}{2}+\cdots+\frac{1}{n}$ exceeds x. (This gives an idea that the sequence $1, 1+\frac{1}{2}, 1+\frac{1}{2}+\frac{1}{3}$, ... could be unbounded and hence divergent)
	8.	• Practical based on finding all the integral roots (lying in some fixed interval, to be decided by the user) of a given polynomial. • Practical based on accepting a positive integer from the user and getting square root of the same to the desired level of accuracy. • Practical based on accepting a positive real number from the user, say epsilon, and getting value of E, which will be within the epsilon distance from the actual value of the Euler's number e. (The actual value of e may be assumed to be the built-in value of e)
10	**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	
11	**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.	
12	**Internal Continuous Assessment: 40%**	**Semester End Examination: 60%**
13	**Continuous Evaluation through:** Quizzes, Class Tests, presentation, project, role play, creative writing, assignment etc. (at least 3)	

Mid semester practical examination of 20 marks will be conducted on **covered syllabus (at least 50% of total syllabus)** of one hour duration as per the following pattern.

Sr. No.	Title	Marks
1.	Quiz comprising of MCQs (Attempt any 5 out of 8) (Online/Offline)	05
2.	Class Test comprising of Problems/ Programs (Attempt any 2 out of 4)	10
3.	Viva	05

14 **Format of Question Paper:**

The performance of the learners shall be evaluated into two parts.

- Internal Continuous Assessment of 20 marks.
- Semester End Examination of 30 marks.
- Separate head of passing is required for internal, and semester end practical examination.

Semester End Practical Examination (30 marks):

Semester end practical examination of 30 marks **on entire syllabus** will be conducted of three hours duration as per the following pattern.

Sr. No.	Title	Marks
1.	Problems/ Programs (Attempt any 5 out of 8)	25 Marks
2.	Journal	05 Marks

The students are required to perform 75% of the Practical for the journal to be duly certified. The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

Name of the Course: Data Analytics I (SEC I)

Sr. No.	Heading	Particulars
1	**Description the course: Including but not limited to:**	The course contains the methods of systematic statistical analysis and interpretation of the data with the help of MS Excel/ R software.
2	**Vertical:**	Skill Enhancement Course
3	**Type:**	Practical
4	**Credits:**	2 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)
5	**Hours Allotted:**	60 Hours
6	**Marks Allotted:**	50 Marks
7	**Course Objectives (CO):** This course gives introduction to basic concepts and various tools related to data analysis. Also this course enables students to represent data using various statistical tools and analyze the data using Excel / R-Programming. Some of the important objectives of this course are CO1: to give deep understanding of fundamental statistical concepts and apply this knowledge to real-world scenarios. CO2: to develop practical skills of analyzing data and graphical representation using softwares, particularly Excel/ R. CO3: to enhance critical thinking skills by analyzing and interpreting statistical findings. CO4: to develop effective communication skills and conveying statistical findings through graphical representations and written analysis. CO5: to learn to apply statistical concepts creatively to solve real-world problems, demonstrating adaptability and innovation in different professional contexts.	
8	**Course Outcomes (OC):** After completion of the course, the learners will be able to OC1: remember and recall key statistical terminologies and concepts. OC2: understand the foundational principles of statistics and data representation. OC3: apply statistical concepts and measures to real-world datasets. OC4: analyze data patterns, relationships and distributions using statistical tools. OC5: evaluate statistical measures for different types of data and scenarios. OC6: develop the ability to create various graphical representations for qualitative and quantitative data.	
9	**Modules: -** **Module 1: Organization and Representation of Data (30 Hours)**	

	1. Introduction to statistics, concept of descriptive statistics and inferential statistics, difference between population and sample. 2. Qualitative and quantitative variables, types of quantitative variable viz. discrete and continuous, cross section data and time series data. Problems based on • data sets to be taken from web or other sources. • identifying the variable and the nature of the variable (qualitative or quantitative). • identifying the type of quantitative variable, such as discrete or continuous. • identifying the data as cross section or time series. 3. Organization and graphical representation of qualitative data: Bar graphs and pie charts. Problems based on • working with charts of qualitative data using Excel/ R. • understanding the Bar graphs and Pie charts, and interpretation of the data. 4. Organization and graphical representation of quantitative data, histogram, frequency polygon, frequency curve, stem and leaf plot, box and Whisker plot. Problems based on • working with charts of quantitative data using Excel/R. • plotting frequency polygon, curve, stem and leaf plot and box and Whisker plot.
	Module 2: Elementary Statistical Measures (30 Hours)
	1. Concept of Measures of central tendency, the basic measures of central tendency, such as Mean, Median and Mode, for raw data. Problems based on • finding Mean of the raw data. • finding Median of the raw data. • finding Mode of the raw data. 2. Grouped Data and measures of central tendency for grouped data for discrete random variable. Problems based on • finding Mean of the grouped data for a discrete variable. • finding Median of the grouped data for a discrete variable. • finding Mode of the grouped data for a discrete variable. 3. Mean, Median and Mode for Continuous random variable. Problems based on • finding Mean of the grouped data for a continuous variable. • finding Median of the grouped data for a continuous variable. • finding Mode of the grouped data for a continuous variable. 4. Measures of dispersion, such as range, coefficient of range, variance and standard deviation. Problems based on • finding range and coefficient of range of the data. • finding variance and standard deviation of the data.
10	**Text Books**

<table>
<tr><td></td><td colspan="2">1. Fundamentals of Mathematical Statistics,12th Edition, S. C. Gupta and V. K. Kapoor, Sultan Chand & Sons, 2020.
2. Statistics for Business and Economics, 11th Edition, David R. Anderson, Dennis J. Sweeney
and Thomas A. Williams, Cengage Learning, 2011.
3. Introductory Statistics, 8th Edition, Prem S. Mann, John Wiley & Sons Inc., 2013.</td></tr>
<tr><td>11</td><td colspan="2">Reference Books
1. A First Course in Statistics, 12th Edition, James McClave and Terry Sincich, Pearson
Education Limited, 2018.
2. Introductory Statistics, Barbara Illowsky, Susan Dean and Laurel Chiappetta, OpenStax,
2013.
3. Hands-On Programming with R, Garrett Grolemund, O'Reilly.</td></tr>
<tr><td>12</td><td>Internal Continuous Assessment: 40%</td><td>Semester End Examination: 60%</td></tr>
<tr><td>13</td><td colspan="2">Continuous Evaluation through: Quizzes, Class Tests, presentation, project, role play, creative writing, assignment etc.
(at least 3)

Mid semester practical examination of 20 marks will be conducted on covered syllabus (at least 50% of total syllabus) of one hour duration as per the following pattern.
<table>
<tr><th>Sr. No.</th><th>Title</th><th>Marks</th></tr>
<tr><td>1.</td><td>Quiz comprising of MCQs (Attempt any 5 out of 8) (Online/Offline)</td><td>05</td></tr>
<tr><td>2.</td><td>Class Test comprising of Problems/ Programs (Attempt any 2 out of 4)</td><td>10</td></tr>
<tr><td>3.</td><td>Viva</td><td>05</td></tr>
</table></td></tr>
<tr><td>14</td><td colspan="2">Format of Question Paper:
The performance of the learners shall be evaluated into two parts.
• Internal Continuous Assessment of 20 marks.
• Semester End Examination of 30 marks.
• Separate head of passing is required for internal, and semester end practical examination.

Semester End Practical Examination (30 marks):
Semester end practical examination of 30 marks on entire syllabus will be conducted of three hours duration as per the following pattern.
<table>
<tr><th>Sr. No.</th><th>Title</th><th>Marks</th></tr>
</table></td></tr>
</table>

	1.	Problems/ Programs (Attempt any 5 out of 8)	25 Marks
	2.	Journal	05 Marks

The students are required to perform 75% of the Practical for the journal to be duly certified. The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

Sem. – II

Syllabus
B.A./ B.Sc. (Mathematics)
(Sem.- II)
Name of the Course: Real Analysis - II

Sr. No.	Heading	Particulars
1	**Description the course:** **Including but not limited to:**	Calculus has a wide range of applications in Science and Technology, like Physics, Chemistry, Biotechnology, Engineering etc. The Mathematical Analysis provides rigorous foundation to Calculus, and so the course aims to make learners gain the insight of Analysis, by learning various properties of Real Numbers, concepts like Sequences, limits and continuity of functions, and the derivatives. In order that the learner gets a feel of the variety of applications of the knowledge gained, the course also includes the applications of differentiation.
2	**Vertical:**	Major
3	**Type:**	Theory
4	**Credits:**	2 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)
5	**Hours Allotted:**	30 Hours
6	**Marks Allotted:**	50 Marks
7	**Course Objectives (CO):** This course gives introduction to basic concepts of Analysis with rigor and prepares students to study further courses in Analysis. In this course, importance is given to formal proofs which also enhances understanding of the subject of Mathematics as a whole. CO1. 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. CO2. To reflect the broad nature of the subject and develop mathematical tools for continuing further study in various fields of sciences. CO3. To enhance students' overall development, problem solving skills, creative talent and power of communication are necessary for various kinds of employment. CO4. To give adequate exposure to global and local concerns that would help learners explore many aspects of Mathematical Sciences.	
8	**Course Outcomes (OC):** After completion of the course, students will be able to OC1: understand the concepts of limits and continuity of functions. OC2: explain the concept of limit, continuity and differentiability of a function. OC3: apply the derivatives and obtain maxima/minima of functions and other	

	various applications. OC4: verify existence of limit, continuity and differentiability of a function. OC5: find the limits and derivatives. OC6: construct counter examples related to continuous and discontinuous functions etc.
9	**Modules: -** **Module 1: Limit, Continuity and Differentiability (15 Hours)**
	(1) $\varepsilon - \delta$ definition of Limit of a function, uniqueness of limit if it exists, left-hand-limit, right-hand limit, algebra of limits, sandwich theorem, non-existence of limits, $\lim_{x\to\infty} f(x)$, $\lim_{x\to-\infty} f(x)$, $\lim_{x\to a} f(x) = \pm\infty$. (2) Continuous functions: Continuity of a real valued function at a point and on a set using $\varepsilon - \delta$ definition, examples, Continuity of a real valued function at end points of domain using $\varepsilon - \delta$ definition, f is continuous at a if and only if $\lim_{x\to a} f(x)$ exists and equals to $f(a)$, Sequential continuity, Algebra of continuous functions, discontinuous functions, examples of removable and essential discontinuity. (3) Intermediate Value theorem and its applications, Bolzano-Weierstrass theorem (statement only): A continuous function on a closed and bounded interval is bounded and attains its bounds. (4) Differentiation of real valued function of one variable: Definition of differentiability of a function at a point of an open interval, examples of differentiable and non-differentiable functions, differentiable functions are continuous but not conversely, algebra of differentiable functions.
	Module 2: Applications of Derivatives (15 Hours)
	(1) Chain rule, Higher order derivatives, Leibniz rule, Derivative of inverse functions, Implicit differentiation (only examples). (2) Rolle's Theorem, Lagrange's and Cauchy's Mean Value Theorems, applications and examples, Monotone increasing and decreasing functions, examples. (3) L-Hospital's rule (without proof), examples of indeterminate forms, Taylor's theorem with Lagrange's form of remainder with proof, Taylor polynomial and applications. (4) Definition of critical point, local maximum/minimum, necessary condition, stationary points, second derivative test, examples, concave/convex functions, point of inflection, tracing of curves (in Cartesian system).
10	**Text Books** (1) R. R. Goldberg, Methods of Real Analysis, Oxford and IBH, 1964. (2) K. G. Binmore, Mathematical Analysis, Cambridge University Press, 1982. (3) R. G. Bartle-D. R. Sherbert, Introduction to Real Analysis, John Wiley & Sons, 1994.

<table>
<tr><td></td><td colspan="2">(4) Sudhir Ghorpade and Balmohan Limaye, A course in Calculus and Real Analysis,Springer International Ltd, 2000.</td></tr>
<tr><td>11</td><td colspan="2">Reference Books

1.T. M. Apostol, Calculus Volume I, Wiley & Sons (Asia) Pte, Ltd.
2. Richard Courant-Fritz John, A Introduction to Calculus and Analysis, Volume I,Springer.

3. Ajit Kumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, 2014.
4. James Stewart, Calculus, Third Edition, Brooks/ cole Publishing Company, 1994.</td></tr>
<tr><td></td><td colspan="2"><u>Scheme of the Examination</u></td></tr>
<tr><td></td><td colspan="2">The performance of the learners shall be evaluated in two parts.
• Internal Continuous Assessment of 20 marks.
• Semester End Examination of 30 marks.
• A separate head of passing is required for internal and semester-end examinations.</td></tr>
<tr><td>12</td><td>Internal Continuous Assessment: 40%</td><td>Semester End Examination: 60%</td></tr>
<tr><td>13</td><td>Continuous Evaluation through:
Quizzes, Class Tests, presentation, project, role play, creative writing, assignment etc. (at least 3)

<table>
<tr><td>Sr. No.</td><td>Particulars</td><td>Marks</td></tr>
<tr><td>1</td><td>A class test of 10 marks to be conducted during each semester in an Offline mode.</td><td>10</td></tr>
<tr><td>2</td><td>Project on any one topic related to the syllabus or a quiz (offline/online) on one of the modules.</td><td>05</td></tr>
<tr><td>3</td><td>Seminar/ group presentation on any one topic related to the syllabus.</td><td>05</td></tr>
</table>

Paper pattern of the Test (Offline Mode with One hour duration):
Q1: Definitions/Fill in the blanks/ True or False with Justification (04 Marks: 4 x 1).
Q2: Attempt any 2 from 3 descriptive questions. (06 marks: 2 × 3)</td><td></td></tr>
</table>

14 **Format of Question Paper:**

Semester End Examination will be of 30 marks of one hour duration covering entire syllabus of the semester.

Note: Attempt any TWO questions out of THREE.			
Q.No.1	Module 1 and 2	Attempt any **THREE** out of **FOUR**. (Each question of 5 marks) (a) Question based on OC1/OC2 (b) Question based on OC3 (c) Question based on OC4 (d) Question based on OC5/OC6	15 Marks
Q.No.2	Module 1 and 2	Attempt any **THREE** out of **FOUR**. (Each question of 5 marks) (a) Question based on OC1/OC2 (b) Question based on OC3 (c) Question based on OC4 (d) Question based on OC5/OC6	15 Marks
Q.No.3	Module 1 and 2	Attempt any **THREE** out of **FOUR**. (Each question of 5 marks) (a) Question based on OC1/OC2 (b) Question based on OC3 (c) Question based on OC4 (d) Question based on OC5/OC6	15 Marks

Name of the Course: Discrete Mathematics

Sr. No.	Heading	Particulars
1	**Description of the course: Including but not limited to:**	Discrete mathematics is very much a "real world' mathematics. Discrete Mathematics has a wide range of applications in Science and Technology, like Engineering, computer sciences etc. Problem-solving techniques are necessary for writing complicated software and play a significant role in data analytics.
2	**Vertical:**	Major
3	**Type:**	Theory
4	**Credits:**	2 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)
5	**Hours Allotted:**	30 Hours
6	**Marks Allotted:**	50 Marks
7	**Course Objectives (CO):** This course introduces basic concepts of Discrete Mathematics with rigour and prepares students to study further courses in linear and abstract algebra. Formal proofs are emphasized which also enhance understanding of the subject of Mathematics as a whole. CO1. 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. CO2. To reflect the broad nature of the subject and develop mathematical tools for continuing further study in various fields of sciences. CO3. To enhance students' overall development, problem-solving skills, creative talent, and power of communication are necessary for various kinds of employment. CO4. To give adequate exposure to global and local concerns that would help learners explore many aspects of Mathematical Sciences.	
8	**Course Outcomes (OC):** After completion of the course, students will be able to OC1: understand various counting techniques which are used to handle problems on finite sets and apply them in day-to-day life. OC2: learn addition and multiplication principles, two-way counting and inclusion and exclusion principles. OC3: apply mathematical logic to solve problems. OC4: formulate polynomials with desired roots. OC5: evaluate the number of partitions using Sterling numbers. OC6: design problems based on the pigeonhole principle.	
9	**Modules: -**	

	Module 1: Preliminary Counting (15 Hours)
	(1) Countable and uncountable sets examples such as $\mathbb{N}, \mathbb{Z}, \mathbb{N} \times \mathbb{N}, \mathbb{Q}, (0,1), \mathbb{R}$. (2) Addition and multiplication principle, counting sets of pairs, two ways counting. (3) Stirling numbers of the second kind. Simple recursion formulae satisfied by $S(n,k)$ for $= 1,2,\cdots,n-1,n$. (4) Pigeonhole principle simple and strong form and examples, its applications to geometry. (5) Recurrence Relations, the definition of homogeneous, non-homogeneous, linear, non-linear recurrence relation, solving homogeneous as well as non-homogeneous recurrence relations by using iterative methods, solving a homogeneous recurrence relation of second degree using algebraic method proving the necessary result.
	Module 2: Advanced Counting (15 Hours)
	(1) Permutation and combination of sets and multi-sets, circular permutations, emphasis on solving problems. (2) Binomial and Multinomial Theorem, Pascal identity, examples of standard identities such as the following with emphasis on combinatorial proofs. ➢ $\sum_{k=0}^{r} \binom{m}{k}\binom{n}{r-k} = \binom{m+n}{r}$ ➢ $\sum_{i=0}^{k} \binom{k}{i}^2 = \binom{2k}{k}$ ➢ $\sum_{i=r}^{n} \binom{i}{r} = \binom{n+1}{r+1}$ ➢ $\sum_{i=0}^{n} \binom{n}{i} = 2^n$ (3) Non-negative integer solutions of the equation $x_1 + x_2 + \cdots + x_k = n$. (4) Principle of inclusion and exclusion, its applications, derangements, explicit formula for d_n, deriving the formula for Euler's function $\phi(n)$.
10	**Text Books** 1. Norman Biggs, Discrete Mathematics, Oxford University Press. 2. Richard Brualdi, Introductory Combinatorics, John Wiley and Sons.

11 **Reference Books**

1. V. Krishnamurthy, Combinatorics-Theory and Applications, Affiliated East West Press.
2. Discrete Mathematics and its Applications, Tata McGraw Hills.
3. Schaum's outline series, Discrete Mathematics,
4. Allen Tucker, Applied Combinatorics, John Wiley and Sons.
5. Sharad Sane, Combinatorial Techniques, Springer.

Scheme of the Examination

The performance of the learners shall be evaluated in two parts.

- Internal Continuous Assessment of 20 marks.
- Semester End Examination of 30 marks.
- A separate head of passing is required for internal and semester-end examinations.

12 **Internal Continuous Assessment: 40%** | **Semester End Examination: 60%**

13 **Continuous Evaluation through:**

Quizzes, Class Tests, presentations, projects, role play, creative writing, assignments etc.
(at least 3)

Sr. No.	Particulars	Marks
1	A class test of 10 marks is to be conducted during each semester in an Offline mode.	10
2	Project on any one topic related to the syllabus or a quiz (offline/online) on one of the modules.	05
3	Seminar/ group presentation on any one topic related to the syllabus.	05

Paper pattern of the Test (Offline Mode with One hour duration):

Q1: Definitions/Fill in the blanks/ True or False with Justification. (04 Marks: 4 x 1).

Q2: Attempt any 2 from 3 descriptive questions. (06 marks: 2×3)

14 **Format of Question Paper:**

The semester-end examination will be of 30 marks of one hour duration covering the entire syllabus of the semester.

Note: Attempt any TWO questions out of THREE.			
Q.No.1	Module 1 and 2	Attempt any **THREE** out of **FOUR**. (Each question of 5 marks) (a) Question based on OC1/OC2 (b) Question based on OC3 (c) Question based on OC4 (d) Question based on OC5/OC6	15 Marks
Q.No.2	Module 1 and 2	Attempt any **THREE** out of **FOUR**. (Each question of 5 marks) (a) Question based on OC1/OC2 (b) Question based on OC3 (c) Question based on OC4 (d) Question based on OC5/OC6	15 Marks
Q.No.3	Module 1 and 2	Attempt any **THREE** out of **FOUR**. (Each question of 5 marks) (a) Question based on OC1/OC2 (b) Question based on OC3 (c) Question based on OC4 (d) Question based on OC5/OC6	15 Marks

Name of the Course: Practical - II

Sr. No.	Heading	Particulars
1	**Description the course: Including but not limited to:**	Problem solving forms one of the basic aspects of any course in Mathematics. Higher courses in Mathematics focus mainly on the theoretical nature of the subject, nevertheless, the problem- solving activity strengthens the concepts and helps the learners develop their ability to think over the existing problems in the subject, and also to create and crack new problems! This way a learner is not just motivated, but elevated too, to formulate new results, suggest new postulates (known as conjectures), and design new theories.
2	**Vertical:**	Major
3	**Type:**	Practical
4	**Credits:**	2 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)
5	**Hours Allotted:**	60 Hours
6	**Marks Allotted:**	50 Marks
7	**Course Objectives (CO):** This course introduces basic concepts of Algebra and Analysis with rigour and prepares students to study further courses. Formal proofs are emphasized which also enhance understanding of the subject of Mathematics as a whole. CO1. 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. CO2. To reflect the broad nature of the subject and develop mathematical tools for continuing further study in various fields of sciences. CO3. To enhance students' overall development, problem solving skills, creative talent and power of communication are necessary for various kinds of employment. CO4. To give adequate exposure to global and local concerns that would help learners explore many aspects of Mathematical Sciences.	
8	**Course Outcomes (OC):** After completion of the course, students will be able to OC1: understand the concepts of limits and continuity of functions also counting techniques which are used to handle problems on finite sets and apply in day-to-day life. OC2: explain the concept of limit, continuity and differentiability of a function & learn addition and multiplication principles and two ways counting.	

OC3: apply the derivatives and obtain maxima/minima of functions and other various applications, also mathematical logic to solve problems.
OC4: verify existence of limit, continuity, and differentiability of a function.
OC5: find the limits and derivatives, evaluate number of partitions using Sterling numbers.
OC6: construct counter examples related to continuous and discontinuous functions etc and to design problems based on the pigeonhole principle.

9 **Modules: -**

Module 1: Practical for Real Analysis II (30 Hours)

1.	Limit of function and Sandwich theorem.
2.	Continuous and discontinuous functions.
3.	Algebra of limits and continuous functions.
4.	Intermediate value theorem, Bolzano-Weierstrass theorem.
5.	Properties of differentiable functions.
6.	Derivatives of inverse functions and implicit functions.
7.	Higher order derivatives and Leibnitz rule.
8.	Mean value theorems.
9.	Indeterminate forms.
10.	Applications of derivatives.

Module 2: Practical for Discrete Mathematics (30 Hours)

1.	Countable and Uncountable Sets.
2.	Counting Principles, Two Way Counting.
3.	Stirling numbers of the second kind.
4.	Pigeon hole principle.
5.	Recurrence relation.
6.	Permutations and Combinations of sets and multi-set and circular permutations.
7.	Multinomial theorem and Identities.
8.	Permutation and combination of multi-set.
9.	Principle of inclusion and exclusion.
10.	Derangements and Euler's function $\phi(n)$.

10 **Text Books**

(1) R. R. Goldberg, Methods of Real Analysis, Oxford and IBH, 1964.

(2) K. G. Binmore, Mathematical Analysis, Cambridge University Press, 1982.

(3) R. G. Bartle-D. R. Sherbert, Introduction to Real Analysis, John Wiley & Sons, 1994.

(4) Sudhir Ghorpade and Balmohan Limaye, A course in Calculus and

<table>
<tr><td></td><td colspan="2">Real Analysis, Springer International Ltd, 2000.
(5) Norman Biggs, Discrete Mathematics, Oxford University Press.
(6) Richard Brualdi, Introductory Combinatorics, John Wiley and Sons.</td></tr>
<tr><td>11</td><td colspan="2">Reference Books

(1) T. M. Apostol, Calculus Volume I, Wiley & Sons (Asia) Pte, Ltd.
(2) Richard Courant-Fritz John, A Introduction to Calculus and Analysis, Volume I,Springer.
(3) Ajit kumar and S. Kumaresan, A Basic Course in Real Analysis, CRC Press, 2014.
(4) James Stewart, Calculus, Third Edition, Brooks/ cole Publishing Company, 1994.
(5) Discrete Mathematics and its Applications, Tata McGraw Hills Schaum's outline series, Discrete Mathematics
(6) Allen Tucker, Applied Combinatorics, John Wiley and Sons
(7) Sharad Sane, Combinatorial Techniques, Springer</td></tr>
<tr><td></td><td colspan="2"><u>Scheme of the Examination</u></td></tr>
<tr><td>12</td><td>Internal Continuous Assessment: 40%</td><td>Semester End Examination: 60%</td></tr>
<tr><td>13</td><td>Continuous Evaluation through:
Quizzes, Class Tests, presentations, projects, role play, creative writing, assignments etc.
(at least 3)

<table>
<tr><td>Sr. No.</td><td>Particulars</td><td>Marks</td></tr>
<tr><td>1</td><td>Objective question test</td><td>10</td></tr>
<tr><td>2</td><td>Overall performance</td><td>05</td></tr>
<tr><td>3</td><td>Viva</td><td>05</td></tr>
</table>

Paper pattern of the Test (Offline Mode):
Q1: (Attempt any 5 from 8) Multiple choice questions. (10 marks: 5 × 2)

Duration: 1Hrs
While setting question paper four MCQ on module 1 and four MCQ on module 2 both.</td><td></td></tr>
</table>

14	**Format of Question Paper:** **Scheme of examination:** At the end of the Semesters I, Practical examinations of three hours duration and 30 marks shall be conducted based on both the modules. Paper pattern: The question paper shall have two questions. **Marks for Journals:** For both Module 1 and Module 2 5. Journal: 5 marks (2.5 marks for each module 1 & module 2) The students are required to perform 75% of the Practical for the journal to be duly certified. The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

Q. No. 1	Five out of Eight multiple choice questions (four on module 1 and four on module 2) (OC1 to OC4)	($3 \times 5 = 15$ Marks)
Q. No.2	Attempt any Two out of Four (two on module 1 and two on module 2). (OC4 and OC5)	($5 \times 2 = 10$ Marks)

Name of the Course: Computing with Python (VSC II)

Sr. No.	Heading	Particulars
1	**Description the course: Including but Not limited to:**	Computing with Python and Doing Mathematics with Python represent two distinct yet interconnected aspects of leveraging Python in the fields of computer science and mathematics. Python is a highly relevant language in both computing and mathematics due to its simplicity, versatility, and extensive libraries. Its readability makes it an excellent choice for expressing computational and mathematical concepts. In computing, Python serves as a powerful language for software development and data manipulation. In mathematics, Python facilitates numerical computing, symbolic mathematics, and visualization, making it a valuable tool for solving complex mathematical problems. Doing Mathematics with Python includes applications in numerical analysis, statistical modelling, symbolic computation, and scientific computing. Proficiency in Computing with Python is highly sought after in the tech industry, where Python is widely used for application development, scripting, and automation. In mathematics, Python's role in scientific computing and data analysis has increased demand for individuals with computational mathematics skills. Individuals skilled in Computing with Python can pursue roles as software developers, data analysts, system administrators, and more. Those proficient in Doing Mathematics with Python may find opportunities in fields like data science, quantitative analysis, research, and academia. The combination of Computing with Python and Doing

		Mathematics with Python provides a comprehensive skill set that aligns well with the demands of both the technology and mathematical sectors. The intersection of computing and mathematics with Python offers a pathway to diverse and rewarding career opportunities
2	**Vertical:**	Vocational Skill Course.
3	**Type:**	Practical
4	**Credits:**	2 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)
5	**Hours Allotted:**	60 Hours
6	**Marks Allotted:**	50 Marks

7 Course Objectives (CO):

CO 1: To understand why Python is a useful scripting language for developers.
CO 2: To learn how to use lists, tuples, and dictionaries in Python programs.
CO 3: To learn how to use indexing and slicing to access data in Python programs.
CO 4: To develop the skill of designing Mathematical user Interfaces with SymPy package in Python
CO 5: To develop SymPy code for different areas of mathematical concepts including calculus, plotting graphs, derivatives and solving simultaneous equations.

8 Course Outcomes (OC):

After completion of the course, students will be able to
OC1. learn operations on strings, list, dictionaries and SymPy package.
OC2. understand how to use functions with arguments in Python.
OC3. apply basic programming techniques for solving problems in mathematics using SymPy Python.
OC4. verify implementation of basic mathematical results of calculus and algebra by using SymPy package.
OC5. evaluate the solutions of complex mathematical problems using Python.
OC6. create programs that plot graphs of trigonometric functions, linear, multiple and pretty printing with SymPy package in python.

9 Modules: -

Module 1: Strings, Lists, Dictionaries (30 Hours)

1.	Concept/Definition of String, Assigning value from user, Operators like +, == and *, Subscript operator and its various functions, len function, The immutability of string. • Practical based on defining new string and defining a variable and assigning it some string value taken from the user. • Practical based on joining two or more strings by using concatenation operator (+), and obtaining multiple copies of a string by using *

	operator, using == operator • Practical based on Subscript Operator, such as accessing elements at a particular index, slicing a substring.
2.	• Practical based on testing of substring (made up of single letter or multiple letters) • Practical based on string methods, such as center, count, endswith, startswith, find, isalpha, isdigit, join, lower, upper, replace, split, strip.
3.	Concept/Definition of List, Assigning value from user, Operators like +, == and *, Subscript operator and its various functions, len function, The mutability of list. • Practical based on defining new list and defining a variable and assigning it some list taken from the user. • Practical based on joining two or more lists by using concatenation operator (+), and obtaining multiple copies of a string by using * operator, using == operator • Practical based Subscript Operator, such as accessing elements at a particular index, slicing a sub-list. • Practical based on replacing element/s from a list.
4.	• Practical based on list methods, such as append, extend, insert and pop (with and without index) • Practical based on sorting a list in ascending/descending order. • Practical based on aliasing a list. • Practical based on tuples.
5.	Concept/Definition of Dictionary, Assigning key-value from user. • Practical based on defining new dictionary, assigning, or adding key-values to an empty dictionary. • Practical based on adding keys and replacing values. • Practical based on accessing values and removing keys. • Practical based on dictionary operations using keywords like len, get, pop, list, clear etc.

Module 2: Doing Math with Python (30 Hours)

1.	Basic operations on numbers (integers and fractions), Getting complex numbers, Doing basic operations on complex numbers. Defining new functions • Practical based on doing simple calculations of numbers, including fractions and complex numbers.

		• Getting factors of an integer by defining new functions • Checking whether the entered number is even or odd by defining new functions.
	2.	Defining symbols and symbolic operations using sympy • Practical based on defining single symbol and multiple symbols using sympy, and doing simple symbolic calculations (such as $x + x = 2x$, $x \times x = x^2$ etc.
	3.	Working with expressions such as factorizing and expanding, substituting in values, pprint (pretty printing) function. • Practical based on factorizing and expanding expressions. • Practical based on substituting values in expressions and obtaining their value, usage of pprint function.
	4.	Solving equations of first degree and higher degree, solving simultaneous equations • Practical based on solving equations of first degree and higher degree. • Practical based on solving simultaneous equations of first degree in two/three variables, Solving for one variable in terms of the other.
	5.	Plotting graphs in Python using sympy, Basic commands in plotting a graph, range of x • Practical based on plotting linear functions. • Practical based on plotting quadratic and cubic functions
	6.	• Plotting graphs of other functions, such as sin, cos, exp, log. • Practical based on plotting multiple functions.
	7.	Doing Calculus with Python using sympy, use of sympy instead of importing math directory, assumptions with sympy, limit of a function • Practical based on getting values of sin, cos, tan etc. at various points using sympy • Practical based on getting limit of various functions using sympy • Practical based on checking the continuity of a function at a point.
	8.	Instantaneous rate of change and derivative using sympy • Practical based on obtaining derivative of various functions. • Practical based on obtaining the value of the derivative of a function at a point.
	9.	Review of applications of derivatives such as maxima/minima, increasing/decreasing functions • Practical based on obtaining local/global maxima/minima of a function. • Practical based on finding the increasing/decreasing nature of a

	function at a given point.	
10	**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	
11	**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.	
12	**Internal Continuous Assessment: 40%**	**Semester End Examination: 60%**
13	**Continuous Evaluation through:** Quizzes, Class Tests, presentation, project, role play, creative writing, assignment etc. (at least 3) Mid semester practical examination of 20 marks will be conducted on **covered syllabus (at least 50% of total syllabus)** of one duration as per the following pattern.	

Sr. No.	Title	Marks
1.	Quiz comprising of MCQs (Attempt any 5 out of 8) (Online/Offline)	05
2.	Class Test comprising of Problems/ Programs (Attempt any 2 out of 4)	10
3.	Viva	05

14 Format of Question Paper:

The performance of the learners shall be evaluated into two parts.

- Internal Continuous Assessment of 20 marks.
- Semester End Examination of 30 marks.
- Separate head of passing is required for internal, and semester end practical examination.

Semester End Practical Examination (30 marks):

Semester end practical examination of 30 marks **on entire syllabus** will be conducted of three hours duration as per the following pattern.

Sr. No.	Title	Marks
1.	Problems/ Programs (Attempt any 5 out of 8)	25 Marks
2.	Journal	05 Marks

The students are required to perform 75% of the Practical for the journal to be duly certified. The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

Name of the Course: Data Analytics II (SEC II)

Sr. No.	Heading	Particulars
1	**Description the course: Including but Not limited to:**	The course contains the methods of systematic statistical analysis and interpretation of the data with the help of MS Excel/ R software.
2	**Vertical:**	Skill Enhancement Course
3	**Type:**	Practical
4	**Credits:**	2 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)
5	**Hours Allotted:**	60 Hours
6	**Marks Allotted:**	50 Marks
7	**Course Objectives (CO):** This course will enable students to learn various statistical tools for handling bivariate data and they will understand the concepts of Expectation and Variance for probability distributions. Students can analyze and represent the data using Excel / R-Programming. Some of the important objectives of this course are CO1: to define and explain fundamental statistical concepts, including scatter diagrams, correlation, regression and probability. CO2: to apply the Method of Least Squares for curve fitting and regression analysis to analyze real-world datasets. CO3: to interpret the results of correlation coefficients and regression analysis by considering their implications for decision-making. CO4: to analyze the patterns in scattered data and recognize the need for different curve	

	fitting techniques. CO5: to evaluate the strengths and limitations of statistical techniques such as correlation, regression and probability and use statistical analysis to make informed decisions and recommendations in various professional settings.
8	**Course Outcomes (OC):** After completion of the course, the learners will be able to OC1: recall fundamental concepts related to data analysis, including scatter diagrams, correlation and regression and memorize key principles and methods involved in curve fitting and probability theory. OC2: comprehend the relationship between scattered data and the need for curve fitting and understand the different types of correlation coefficients and their interpretations. OC3: apply the method of Least Squares to fit curves and regression lines to the given datasets and use regression techniques to obtain meaningful results from real-world data. Also implement probability concepts to analyze and solve practical problems. OC4: analyze and evaluate the impact of outliers on correlation coefficients and regression lines and also analyze algebraic operations of events and their implications in probability. OC5: synthesize information to choose appropriate regression models based on data characteristics and evaluate the strengths and limitations of correlation and regression techniques in various scenarios. OC6: formulate strategies for finding expectation and variance of a given random variable and also create real-world scenarios that demonstrate the relationship between statistical concepts and practical decision-making.
9	**Modules: -** **Module 1: Curve Fitting and Bivariate Distribution (30 Hours)**
	1. Understanding the scattered nature of the data, concept of fitting a straight line or a curve (of higher degree) to the data, method of least squares (only the idea is to be imparted, the proof etc is not expected), fitting a straight line using the method of least squares Problems based on • plotting scatter diagram of the data. • fitting a straight line to the data. • fitting a curve to the data. 2. Bivariate distribution, the concept of correlation, Karl Pearson's coefficient of correlation, correlation does not imply causation, qualitative data and Spearman's Rank correlation coefficient. Problems based on • identifying Univariate and Bivariate data. • finding Karl Pearson's coefficient of correlation. • correlation versus causation. • obtaining Spearman's Rank correlation coefficient. 3. Concept of regression, obtaining regression lines of both types (y on x and x on y), obtaining means and correlation coefficient from regression lines.

	Problems based on • finding regression line from the data. • finding the point of intersection of the regression lines and verifying that it gives means of x and y. • identifying the type (x on y or y on x) regression lines and estimating the values of y for different values of x, estimating values of x for different values of y. **(Note: It is expected to perform practicals with the help of Excel or R software.)**
	Module 2: Elementary Probability (30 Hours)
	1. Concept of random experiment, sample point and sample space, discrete Sample space, definition of event, algebra of events, operations of events, mutually exclusive events, exhaustive and complementary events. Problems based on • random experiment and identifying its outcomes, sample points and sample space. • finding union and intersection of events. • identifying mutually exclusive, exhaustive and complementary events. 2. The three definitions along with their explanation of probability viz. Classical/Mathematical, Empirical, Axiomatic. Addition theorem on Probability. Problems based on • probability of events. • addition theorem of probability. 3. Multiplication principle in probability, conditional probability, independent events, Bayes' theorem (without proof). Problems based on • multiplication law of probability. • conditional probabilities and identifying the events as independent or not. • Bayes' theorem. 4. Random experiment and Probability Distribution of a random variable, expectation and variance of a random variable. Problems based on • obtaining probability distribution of a random variable. • finding expectation and variance of a random variable. • verifying expectation as mean.
10	**Text Books** 1. Fundamentals of Mathematical Statistics,12th Edition, S. C. Gupta and V. K. Kapoor, Sultan Chand & Sons, 2020. 2. Statistics for Business and Economics, 11th Edition, David R. Anderson, Dennis J. Sweeney and Thomas A. Williams, Cengage Learning, 2011. 3. Introductory Statistics, 8th Edition, Prem S. Mann, John Wiley & Sons Inc., 2013.
11	**Reference Books** 1. A First Course in Statistics, 12th Edition, James McClave and Terry Sincich, Pearson Education Limited, 2018. 2. Introductory Statistics, Barbara Illowsky, Susan Dean and Laurel Chiappetta, OpenStax, 2013. 3. Hands-On Programming with R, Garrett Grolemund, O'Reilly.

<table>
<tr><td>12</td><td>Internal Continuous Assessment: 40%</td><td>Semester End Examination: 60%</td></tr>
<tr><td>13</td><td colspan="2">Continuous Evaluation through:
Quizzes, Class Tests, presentation, project, role play, creative writing, assignment etc.
(at least 3)

Mid semester practical examination of 20 marks will be conducted on covered syllabus (at least 50% of total syllabus) of one duration as per the following pattern.

<table>
<tr><th>Sr. No.</th><th>Title</th><th>Marks</th></tr>
<tr><td>1.</td><td>Quiz comprising of MCQs (Attempt any 5 out of 8) (Online/Offline)</td><td>05</td></tr>
<tr><td>2.</td><td>Class Test comprising of Problems/ Programs (Attempt any 2 out of 4)</td><td>10</td></tr>
<tr><td>3.</td><td>Viva</td><td>05</td></tr>
</table>
</td></tr>
<tr><td>14</td><td colspan="2">Format of Question Paper:

The performance of the learners shall be evaluated into two parts.
• Internal Continuous Assessment of 20 marks.
• Semester End Examination of 30 marks.
• Separate head of passing is required for internal, and semester end practical examination.

Semester End Practical Examination (30 marks):
Semester end practical examination of 30 marks on entire syllabus will be conducted of three hours duration as per the following pattern.

<table>
<tr><th>Sr. No.</th><th>Title</th><th>Marks</th></tr>
<tr><td>1.</td><td>Problems/ Programs (Attempt any 5 out of 8)</td><td>25 Marks</td></tr>
<tr><td>2.</td><td>Journal</td><td>05 Marks</td></tr>
</table>

The students are required to perform 75% of the Practical for the journal to be duly certified. The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.</td></tr>
</table>

Letter Grades and Grade Points:

Semester GPA/ Programme CGPA Semester/ Programme	% of Marks	Alpha-Sign/ Letter Grade Result	Grading Point
9.00 – 10.00	90.0 – 100	O (Outstanding)	10
8.00 - < 9.00	80.0 - < 90.0	A+ (Excellent)	9
7.00 - < 8.00	70.0 - < 80.0	A (Very Good)	8
6.00 - < 7.00	60.0 - < 70.0	B+ (Good)	7
5.50 - < 6.00	55.0 - < 60.0	B (Above Average)	6
5.00 - < 5.50	50.0 - < 55.0	C (Average)	5
4.00 - < 5.00	40.0 - < 50.0	P (Pass)	4
Below 4.00	Below 40.0	F (Fail)	0
Ab (Absent)	-	Ab (Absent)	0

Note: This syllabus is applicable to IDOL students as well, with effect from 2025-26.

Appendix B

Justification for B.A./ B.Sc. (Mathematics)

1.	Necessity for starting the course:	It was old course and now it is revised in accordance with NEP 2020.
2.	Whether the UGC has recommended the course:	Yes. It is a UGC recommended course.
3.	Whether all the courses have commenced from the academic year 2024-25	Yes.
4.	The courses started by the University are self-financed, whether adequate numbers of eligible permanent faculties are available?	It may or may not be. At least 50% of sanctioned post must filled.
5.	To give details regarding the duration of the Course and is it possible to compress the course?	It is four-year course and not possible to compress.
6.	The intake capacity of each course and no. of admissions given in the current academic year:	Varying with individual intake capacity of colleges.
7.	Opportunities of Employability / Employment available after undertaking these courses:	Industrial sector, banking and finance sector, research and teaching and having scope to go for higher education.

Sign of the BOS Chairman
Dr. Bhausaheb S Desale
The Chairman, Board of Studies in Mathematics

Sign of the Offg. Associate Dean
Dr. Madhav R. Rajwade
Faculty of Science & Technology

Sign of the Offg. Dean
Prof. Shivram S. Garje
Faculty of Science & Technology