AC – 28/03/2025 Item No. – 6.3 (N) (1ab) Sem. III & IV

#### As Per NEP 2020

### Aniversity of Mumbai



#### Syllabus for Minor Vertical 2 (Scheme – II)

Fac	ulty of Science		
Boa	ard of Studies in Mathematics		
Sec	cond Year Programme in Minor (Mathematics)		
Ser	III & IV		
Title	e of Paper	Sem. III	<b>Total Credits</b>
Cho	pose any one of the following:		4
1.	a) Calculus- III		2
	b) PM-3A Calculus III		2
OR			
2.	a) Vector Spaces	III	2
Ī	b) PM-3B Vector Spaces		2
OR			
3.	a) Basic Mathematics in Real Life II	III	2
	b) PM-3C Basic Mathematics in Real Life II	III	2
Title	e of Paper	Sem. IV	Total Credits
Fol	lowing Courses are Compulsory		6
1)	Calculus IV	IV	2
2)	Ordinary Differential Equations	IV	2
3)	PM-4 Calculus IV and Ordinary Differential Equations	IV	2
Fro	m the Academic Year	l	2025-26

## Sem. - III

#### Syllabus B.Sc. (Mathematics) (Sem.- III)

#### Name of the Course: Calculus III (Minor I)

Sr.	Heading	Particulars	
No	Tiedding	i articulars	
1	Description the courses	Calculus finds extensive	
I	Description the course:		
	Including but not limited to:	applications in diverse fields such as	
		Physics, Chemistry, Biotechnology,	
		Engineering, among others. This	
		course aims to instill a deep	
		understanding of Mathematical	
		Analysis as it forms a rigorous	
		foundation for Calculus. Learners	
		will explore properties of Real	
		Numbers, delve into concepts like	
		Series and Riemann integration of	
		functions. To provide practical	
		context, the course incorporates	
		applications of integration, offering	
		students a broader perspective on the	
		diverse uses of acquired knowledge.	
2	Vertical:	Minor	
3	Туре:	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 provides an introduction to advanc	ed concepts in analysis with a strong	
	emphasis on rigor. It aims to prepare students f	for more advanced courses in abstract	
	analysis. The focus of the course is on developing	ng formal proof skills, which not only	
	deepens comprehension of the subject but also extends to broader applications in		

mathematics. **CO1:** Provide a solid understanding of fundamental principles and methods, equipping students with the skills to apply mathematical ideas and tools through modeling, solving, and interpretation.

**CO2**: Illustrate the expansive nature of the subject by fostering the acquisition of essential mathematical tools for continued studies across various scientific fields.

**CO3**: Foster students' comprehensive development by placing emphasis on problemsolving skills, nurturing creative talents, and enhancing communication abilities, all of which are vital for a range of employment opportunities.

**CO4**: Ensure exposure to both global and local issues within the realm of Mathematical Sciences, allowing learners to explore diverse aspects of the discipline.

8	Course Outcomes (OC):			
	After completion of the course, students will be able to			
	OC1 Understand and remember the concepts such as convergence/ divergence of			
	series, Riemann Integration, beta-gamma functions and related results.			
	OC2: Apply the formulae and concepts to solve the examples related to series,			
	Riemann Integral, area between two curves etc.			
	OC3: Analyse the convergence and divergence of series and integrability of given			
	function.			
	OC4: Justify/ check the integrability of function, absolute and conditional			
	convergence of series.			
	<b>OC5:</b> Construct counter examples related to absolutely convergent/ divergent series,			
	non-integrable functions etc.			
9	Modules: -			
	Module 1: Infinite Series (15 Lectures)			
	1. Infinite series in $\mathbb{R}$ . Definition of convergence and divergence. Basic examples			
	including geometric series. Elementary results such as if $\sum_{n=1}^{\infty} a_n$ is convergent then			
	$a_n \rightarrow 0$ but converse is not true. Cauchy Criterion, Algebra of convergent series and			
	related examples.			
	2. Tests for convergence: Comparison Test, Limit Comparison Test (without proof),			
	Ratio Test (without proof), Root Test (without proof), Examples, p- series test.			
	3. Alternating series. Leibnitz's Test. Examples. Absolute convergence, absolute			
	convergence implies convergence but not conversely. Conditional Convergence.			
	Module 2: Riemann Integration and Applications (15 Lectures)			
	1. Idea of approximating the area under a curve by inscribed and circumscribed			
	rectangles. Partitions of an interval. Refinement of a partition. Upper and Le			
	Riemann sums for a bounded real valued function defined on a closed and bound			
	interval in $\mathbb{R}$ . Definition of Riemann integral.			
	2. Criterion for Riemann integrability, Characterization of the Riemann integral as the			
	limit of a sum. (without proof). Examples.			
	3. Algebra of Riemann integrable functions and basic results such as if (i) $f:[a,b] \rightarrow \mathbb{R}$			
	is integrable, then $\int_{a}^{b} f(x)dx = \int_{a}^{c} f(x)dx + \int_{c}^{b} f(x)dx$ (without proof) (ii)  f  is			
	integrable and $\left \int_{a}^{b} f(x)dx\right  \leq \int_{a}^{b}  f (x)dx$ (iii) If $f(x) \geq 0$ for all $x \in [a,b]$ then			
	$\int_{a}^{b} f(x) dx \ge 0$			
	4. Riemann integrability of a continuous function. Integrability of a bounded function			
	whose set of discontinuities has only finitely many points (without proof). Riemann			
	integrability of monotone functions.			
	5. First and Second Fundamental Theorems of Calculus.			
	6. Area between the two curves. Lengths of plane curves. Surface area of surfaces of			
	revolution.			
	7. Gamma and Beta functions and their properties. Relationship between them (without			
	proof).			
10	Recommended Reference Books:			
	1. Sudhir Ghorpade, Balmohan Limaye; A Course in Calculus and Real Analysis			
	(second edition); Springer.			
	2. R.R. Goldberg; Methods of Real Analysis; Oxford and IBH Pub. Co., New Delhi,			
	1970.			
	3. Calculus and Analytic Geometry (Ninth Edition); Thomas and Finney; Addison-			

	Wesley, Reading Mass., 1998.					
	4. T. Apostol; Calculus Vol. 2; John Wiley.					
11	Additional Reference Books					
	-			Real Analysis; CRC Press, 2014		
			udhary; A First	Course in Mathematical Analysis,		
		sa, New Delhi, 1996.				
		Stewart; Calculus, Booke/C				
			d A. Weinstein	; Basic Multivariable Calculus;		
	Sprin	-				
			; Introduction t	o Real Analysis Second Ed.; John		
		y, New Yorm, 1992.				
	6. M.	H. Protter; Basic Elements	of Real Analys	is; Springer-Verlag, New York, 1998.		
		Schen	<u>ne of the Exan</u>	<u>nination</u>		
	The p	performance of the learners s		-		
	•	Internal Continuous Asse				
	•	Semester End Examination				
	•		g is required fo	or internal and semester-end		
		examinations.				
12	Inter	nal Continuous Assessmen	t: 40%	Semester End Examination: 60%		
13	Cont	inuous Evaluation through	• Ouizzes			
15		Tests, presentations, project				
		ve writing, assignments etc.	is, tote play,			
	(at lea					
	Sr.	Particulars	Marks			
	No.		1,1,1,1,1,1,5			
	1	A class test of 10 marks	10			
		is to be conducted during				
		each semester in an				
		Offline mode.				
	2	Project on any one topic	05			
		related to the syllabus or				
		a quiz (offline/online) on				
		one of the modules.				
	3	Seminar/ group	05			
		presentation on any one				
		topic related to the				
		syllabus.				
		er pattern of the Test (Off	line Mode			
		n One hour duration):				
	_	Definitions/Fill in the blank				
		e or False with Justification.	(04			
		ks: 4 x 1).				
	-	Attempt any 2 from 3				
		criptive questions. (06 mark	s: 2			
	× 3)					

14	Format o	f Question P	aper:	
	The semester-end examination will be of 30 marks marks of one hour			
duration covering the entiresyllabus of the semester.				
Note: Attempt any TWO questions out of TH			Е.	
	Q.No.1	Module 1	Attempt any <b>THREE</b> out of <b>FOUR</b> .	15 Marks
		and 2	(Each question of 5 marks)	
			(a) Question based on OC1	
			(b) Question based on OC2	
			(c) Question based on OC3	
			(d) Question based on OC4/OC5	
	Q.No.2	Module 1	Attempt any <b>THREE</b> out of <b>FOUR</b> .	15 Marks
		and 2	(Each question of 5 marks)	
			(a) Question based on OC1	
			(b) Question based on OC2	
			(c) Question based on OC3	
			(d) Question based on OC4/OC5	
	Q.No.3	Module 1	Attempt any <b>THREE</b> out of <b>FOUR</b> .	15 Marks
		and 2	(Each question of 5 marks)	
` <b>1</b>		(a) Question based on OC1		
			(b) Question based on OC2	
			(c) Question based on OC3	
			(d) Question based on OC4/OC5	

#### Name of the Course: PM-3A Calculus III (Minor I)

~		: PNI-SA Calculus III (Milliof I)		
Sr.	Heading	Particulars		
No.				
1	<b>Description the course:</b>	Problem-solving is a fundamental aspect of any		
	Including but not limited	Mathematics course. While advanced courses often		
	to:	emphasize the theoretical nature of the subject, engaging		
		in problem-solving reinforces concepts and enhances		
		learners' ability to analyze existing problems and devise		
		solutions. This activity not only motivates learners but also		
		empowers them to formulate new results, propose		
		conjectures, and develop innovative theories.		
2	Vertical:	Minor		
- 3		Practical		
4	Type: Credits:	2 credits		
4	Creans:			
		(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 emphases on problem solving and motivates to think on the basic concepts of			
		pares students to study further courses.		
	<b>CO1.</b> 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. These are necessary for various kinds of employment.			
		4. To give adequate exposure to global and local concerns that would help learners		
	explore many aspects of Ma			
8	Course Outcomes (OC):			
	After completion of the course	e, students will be able to		
	<b>OC1</b> : Apply the formulae at	nd concepts to solve the examples related to series, Riemann		
	Integral, area between two curves etc.			
	<b>OC2</b> : Analyze the convergence and divergence of series and integrability of given			
	function.			
	<b>OC3</b> : Justify/ check the integrability of function, absolute and conditional			
	convergence of series.			
	<b>OC4:</b> Construct counter examples related to absolutely convergent/ divergent series, non-			
	integrable functions etc.			
9	Modules: -			
-	Practical for Calculus III (30	Hours)		
	1. Convergent and diverg	ent series and algebra of convergent series.		
	2. Comparison and limit of	· · · · ·		
	1			
	3. Ratio test and root test.			
	4. Alternating Series and	p-series test.		

	5. Absolute and conditional convergence.					
	6. Upper sum and lower sum.					
	7. Riemann integral and its properties.					
	8. Fundamental Theorems of Calculus.					
	9. Area between two curves, lengths of plane curves and surface area of					
	surfaces of revolution.					
	10. Beta and Gamma functions.					
10						
10	Recommended Reference Books:	A Course in Colorday and Deal Anglesia				
		A Course in Calculus and Real Analysis				
	(second edition); Springer.					
	2. R.R. Goldberg; Methods of Real Ana 1970.	lysis; Oxford and IBH Pub. Co., New Delhi,				
		th Edition); Thomas and Finney; Addison-				
	Wesley, Reading Mass., 1998.					
	4. T. Apostol; Calculus Vol. 2; John Wi	lev				
		icy.				
11	Additional Reference Books					
	1. Ajit Kumar, S.Kumaresan; A Basic C	ourse in Real Analysis; CRC Press, 2014				
	2. D. Somasundaram and B. Choudhary	; A First Course in Mathematical Analysis,				
	Narosa, New Delhi, 1996.					
	3. K. Stewart; Calculus, Booke/Cole Pul	blishing Co, 1994.				
		-				
	4. J. E. Marsden, A.J. Tromba and A. Weinstein; Basic Multivariable Calculus; Springer.					
	<ol> <li>Springer.</li> <li>R.G. Bartle and D. R. Sherbert; Introduction to Real Analysis Second Ed. ; John</li> </ol>					
	Wiley, New Yorm, 1992.					
	6. M. H. Protter; Basic Elements of Real Analysis; Springer-Verlag, New York,					
	1998.					
	Scheme of the Examination					
10		Source for Early English of the COD/				
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)					
	(at least 5)					
	Sr. Particulars Marks					
	No.					
	1Objective question test10					
	2 Overall performance 05					
	3 Viva 05					
1						

	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.				
	Format of Q	uestion Pa	per:		
	and 30 marks	the Semes shall be co	: ter III, Practical examinations of the onducted based on both the modul- tion paper shall have two questions	es.	
		Q. No. 1	Five out of Eight multiple choice questions (four from module 1 and four from module 2) (OC1 to OC3)	$Marks (3 \times 5 = 15 Marks)$	
		Q. No.2	Io.2Attempt any Two out of Four (two from module 1 and two from module 2). (OC3 and OC4) $(5 \times 2 = 10)$ Marks)		
	Marks for J	ournals:			
	For both Mo 1. Journal:		Module 2 .5 marks for each module 1 & mod	lule 2)	
	certified. Th	e students amination,	red to perform 75% of the Practica are required to present a duly certification failing which they will not be allo	fied journal for appearing	

#### Name of the Course: Vector Spaces (Minor II)

Sr.	Heading Particulars		
No.	8		
1	Description of the course: Including but not limited to:	This course covers fundamental concepts in linear algebra, concepts in mathematics with applications across various fields including physics, engineering, computer science, and economics. Learners will learn about subspaces, spanning sets, linear independence, and basis vectors, crucial concepts that form the building blocks of vector space theory.	
2	Vertical:	Minor	
3	Туре:	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	<ul> <li>Course Objectives (CO):</li> <li>This course gives an introduction to vector spaces and system of linear equations and its solutions. Also, it deals with the basics of vector spaces, covering different examples and dealing with finite-dimensional vector spaces.</li> <li>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.</li> <li>CO2. To reflect the broad nature of the subject and develop mathematical tools for continuing further study in various fields of sciences.</li> <li>CO3. To enhance students' overall development, problem-solving skills, creative talent, and power of communication are necessary for various kinds of employment.</li> <li>CO4. To give adequate exposure to global and local concerns that would help learners explore many aspects of Mathematical Sciences.</li> </ul>		
8	Course Outcomes (OC): After completion of the course, students will be able to OC1: Understand, remember the concepts and properties vector spaces. OC2: Apply the formulas and the concepts to solve examples on subspaces, sum and intersection of subspaces. OC3: To analyse the properties of vector spaces, row space and column space of a matrix OC4: Justify or check a set to be a vector space. OC5: Construct counterexamples related to vector spaces and subspaces.		
9	OC5: Construct counterexamples related to vector spaces and subspaces.         Modules: -         Module 1: Vector spaces and subspaces (15 Hours)		

<b></b>	(a) Definition of a vector space over <i>R</i> . Examp	las such as:			
		ies such as.			
	(i)Euclidean space $\mathbb{R}^n$ .				
	(ii) The space of $m \times n$ matrices over $R$ .				
	(iii)The space of polynomials with real coef				
	(b) Subspaces: definition, criterion for a nor	empty subset to be a subspace of a			
	vector space. Examples, including:				
	(i) Lines in $R^2$ , Lines and planes in $R^3$ .				
	(ii) The solutions of a homogeneous system	of linear equations.			
	(iii) The spaces of symmetric, skew-symmetric	1			
	and diagonal matrices.				
	(iv) The space of polynomials with real coe	fficients of degree $< n$ .			
	(c) The sum, union and intersection of subspace	•			
	Introduction to quotient space.				
	Module 2: System of linear equations, Linear co	mbination Basis of vector snaces (15			
	Hours)	momation, Dasis of vector spaces (15			
	(a) (i) Introduction to linear systems, Mat				
	homogeneous and non-homogeneous linea	r equations, row echelon form, Gauss			
	Elimination.				
	(ii) Linear combination of vectors.				
	(iii) Linear span of a subset of a vector spac	e.			
	(iv) Linear dependence and independence o	f a set.			
	(b) Basis of a vector space, Dimension of a vector space. The discussion of these				
	concepts is for finitely generated vector spa				
	(c) (i) Row space, column space of a $m \times n$ matrix over $R$ and row rank, column of a matrix.				
	(ii) Equivalence of row rank and column rank, computing the rank of a matrix row reduction.				
10	Text Books				
	1. Kenneth Hoffman and Ray Kunze, Linear Alg	ebra, 2nd edition, Pearson.			
	2. Howard Anton, Chris Rorres, Elementary Line				
	3. Serge Lang, Introduction to Linear Algebra, S				
	4. S Kumaresan, Linear Algebra: A Geometric A				
11	Reference Books	rr			
<b>**</b>	1. Sheldon Axler, Linear Algebra done right, Spr	inger			
	2. Gareth Williams, Linear Algebra with Applica	•			
	<ol> <li>Bareth Williams, Elitear Algebra with Applica</li> <li>David W. Lewis, Matrix theory.</li> </ol>	tions, jones and Dartiett I donshers.			
	Scheme of the Exam	ination			
	The performance of the learners shall be ev	aluated in two parts.			
	<ul> <li>Internal Continuous Assessment of 20 marks.</li> </ul>				
	<ul> <li>Semester examination of 30 marks.</li> </ul>				
	<ul> <li>A separate head of passing is required for in</li> </ul>	nternal and semester-end examinations			
	- A separate near or passing is required for in	normai and semester-end examinations.			
12	Internal Continuous Assessment: 40%	Semester End Examination: 60%			

-	-	rojects, role pla	ay, creative		
		etc. (at least 3)	1		
	Particulars		Marks		
No.					
	A class test of		10		
		during each			
	emester in an				
	•	ny one topic	05		
		syllabus or a			
	of the modules	nline) on one			
		presentation	05		
		pic related to	05		
	he syllabus.	pie ielated to			
Paper	pattern of the	e Test (Offline	Mode with		
One-H	- Iour Duration	n):			
01: De	efinitions/Fill i	in the blanks/ T	True		
-		ation. (04 Mar			
4 x 1).		× ×			
Q2:	Attempt any 2	from 3 descrip	otive		
question	ns. (06 marks: 1	2 × 3)			
	of Question I	-			
		mination will b		s of one-hour	duration,
covering		labus of the ser			
		ote: Attempt a			
Q.No.1		Attempt any			15 Marks
	and 2	(Each questi		· · · · · · · · · · · · · · · · · · ·	
		. , _	tion based o tion based o		
			stion based of		
			stion based of the stion based of the state		
Q.No.2	2 Module 1	Attempt any			15 Marks
×	and 2	(Each questi			15 WHIRS
		· ·	tion based o		
			tion based o		
			tion based o		
			tion based o		
Q.No.3	B Module 1	Attempt any			15 Marks
-	and 2	(Each questi			
	1	· ·			
		(a) Ques	tion based o		
			tion based o		
		(b) Ques		n OC2	

#### Name of the Course: PM-3B Vector Spaces (Minor II)

C		PNI-3B vector Spaces (Minor II)		
Sr.	Heading	Particulars		
No.				
1	Description of the course: Including but not limited to:	This course covers fundamental concepts in linear algebra, concepts in mathematics with applications across various fields including physics, engineering, computer science, and economics. Learners will learn about subspaces, spanning sets, linear independence, and basis vectors, crucial concepts that form the building blocks of vector space theory.		
2	Vertical: Minor			
3	Туре:	Practical		
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		
	<ul> <li>This course gives an introduction to vector spaces and system of linear equations and its solutions. Also, it deals with the basics of vector spaces, covering different examples and dealing with finite-dimensional vector spaces.</li> <li>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.</li> <li>CO2. To reflect the broad nature of the subject and develop mathematical tools for continuing further study in various fields of sciences.</li> <li>CO3. To enhance students' overall development, problem-solving skills, creative talent, and the power of communication are necessary for various kinds of employment.</li> <li>CO4. To give adequate exposure to global and local concerns that would help learners explore many aspects of Mathematical Sciences.</li> </ul>			
8	Course Outcomes (OC):After completion of the course, students will be able toOC1: Apply the formulas and the concepts to solve examples related to vectorspaces.OC2: To analyse and test the property of vector subspaces on sets.OC3: To check linear independence, and dependence of vectors.OC4: Construct basis and counter-examples related to vector spaces and subspaces.Modules: -Machel 1: Vector process and probables (20 Herror)			
	Module 1: Vector spaces and subspaces (30 Hours)         1.       Vector spaces-I (Examples)         2.       Vector spaces-II (To check which of the given sets are vector spaces)         3.       Subspaces of Euclidean space         4.       Subspaces of Polynomial space         5.       Subspaces of Matrix space			

	6	Sum of subspaces					
	<u>6.</u> 7.	Sum of subspaces Intersection of subspaces					
	8.     Union of subspaces						
	9.	Direct sum of subspaces					
	10.	Cosets, Quotient spaces					
	10.	cosets, Quotient spaces					
	Mod	ula 2. System of linear equation	ns, Linear combination, Basis of vector				
		es (30 Hours)	is, Emear combination, basis of vector				
	1.	System of linear equations					
	2.	Linear combination of vectors					
	3.	Linear span of vectors in vector s	paces				
	4.	Linear dependence.	1				
	5.	Linear independence.					
	6.	Standard Basis of vector spaces.					
	7.	Basis of vector spaces					
	8.	Dimension of vector spaces.					
	9.	Row rank and column rank of the	e matrix.				
	10.	Computing rank of matrix by rov	reduction.				
10	Text	Books					
	1	. Kenneth Hoffman and Ray K	unze, Linear Algebra, 2nd edition, Pearson.				
	2	. Howard Anton, Chris Rorres,	Elementary Linear Algebra, Wiley Student				
		Edition.					
		. Serge Lang, Introduction to L	• • •				
			: A Geometric Approach, PHI Learning.				
11		rence Books					
		. Sheldon Axler, Linear Algebr					
	2	Publishers.	bra with Applications, Jones and Bartlett				
	2						
	3. David W. Lewis, Matrix theory.						
		Scheme of	the Examination				
12	Inter	nal Continuous Assessment: 4	0%Semester End Examination: 60%				
13	Cont	inuous Evaluation through:					
		uizzes, Class Tests, presentations	S,				
	-	cts, role play, creative writing,					
	assig	nments, etc.					
	(at lea	ast 3)					
	Sr.	Particulars Ma	rks				
	No.						
	11110.						
	1	LUblective question feet 10					
	1	Objective question test10Overall performance05	<u> </u>				
	1 2 3	Objective question test10Overall performance05Viva05					

	Paper pattern o Mode):	f the Test (Offline					
		5 from 8) Multiple- . (10 marks: 5 × 2)					
	Duration: 1Hrs While setting the paper, four MC 1 and four MC both.	Qs on module					
14	Format of Quest Scheme of exam	-					
	At the end of Semester III, Practical examinations of three hours duration and 30 marks shall be conducted based on both modules. Paper pattern: The question paper shall have two questions.						
	Q. N 1	o. Five out of Eight multi choice questions (four f module 1 and four f module 2) (OC1 to OC3)	from Marks				
	Q. No.	Attempt any Two out of Four (two from module 1 and two from module 2). (OC3 and OC4)	$1 \qquad (5 \times 2 = 10)$				
	Marks for Journals:						
	For both Module Journal: 5 ma	1 and Module 2, rks (2.5 marks for each module	e 1 & module 2)				
	certified. The stu	idents are required to present a xamination, failing which they	e practical for the journal to be duly a duly certified journal for appearing y will not be allowed to appear for				

#### Name of the Course: Basic Mathematics in Real Life-II (Minor III)

Uanding						
Heading	Particulars					
Description of the course:	To demonstrate the importance of mathematics in real life					
Including but not limited to:	by considering interdisciplinary applications of basic					
	concepts in real life.					
Vertical:	Minor					
Type: Theory						
• •	2 credits					
cituits.	(1 credit = 15 Hours for Theory or 30 Hours of Practical					
	work in a semester)					
Houng Allottod.	30 Hours					
Hours Allotted:	30 Hours					
Marks Allotted:	50 Marks					
Course Objectives (CO):						
	the basic concepts of mathematics, which highlights the					
crucial role of mathematics in other sci	ences. In this course, students from various science streams					
will be able to see mathematics being	applied in their area of interest and learn					
CO1: To develop methods for polynor	nial interpolation.					
	on for solving real-life problems like those related to forest					
	6 I I I I I I I I I I I I I I I I I I I					
	ry (in particular Platonic solids) in science streams.					
Course Outcomes (OC):						
	ts will be able to					
-	olynomials, polynomial graphs, Fibonacci sequence,					
-						
-	s to solve problems and examples related to quadratic					
1	1					
• •	war maarees, eeneron form of matrices, and Knellioff s					
e	matrices and applications of the golden ratio					
•	11 0					
	ation (15 Hours)					
•						
	ree two when roots are real. Example: (monic; not monic)					
	- · · · · · · · · · · · · · · · · · · ·					
polynomial of degree three (some spec						
	recurrence relation. Simple examples of recurrence.					
	recurrence relation. Simple examples of recurrence.					
5. Sunflower and Golden ratio.						
	af the method and as the start is a set of the start is t					
6. Polynomial interpolation: Statement	t of the problem and motivation; calculation in					
6. Polynomial interpolation: Statement degree two.						
6. Polynomial interpolation: Statement degree two.	t of the problem and motivation; calculation in ad multiplication formula for two matrices under					
	Vertical:         Type:         Credits:         Hours Allotted:         Marks Allotted:         Course Objectives (CO):         This course is a balanced mixture of crucial role of mathematics in other sci will be able to see mathematics being a CO1: To develop methods for polynor CO2: To identify row echelon form an CO3: To associate mathematical notatimanagement.         CO4: To recognize the role of geometr         Course Outcomes (OC):         After completion of the course, studen OC1: Understand and remember the pplatonic solids and Matrices         OC2: Apply the formulas and concept:         equations recurrence relations, matrice         OC3: Examine and investigate the gro         Law using matrices.         OC4: Justify and check the inverse of OC5: Design and construct circuits usite         Modules: -         Module 1: Polynomials and interpol         1. Solving a quadratic equation: condified and provide a construct circuits usite         Modules: -         Module 1: Polynomial graph for deg         3. Relation between roots and coefficied					

	8. Forest management—I: introduction to growth matrix.
	9. Forest management II: Statements and notations for optimal sustainable yield.
	10. Forest management III : Computation of solution
	11. Row echelon and Row reduced echelon form: Definition and computation in 2 by
	2 matrices.
	12. Row echelon and row reduced echelon form: computation in 3 by 3 matrices.
	13. Definition of the inverse of a matrix, Elementary matrices and calculation of inverse
	in particular examples (size 2,3)
	14. Polynomial interpolation in degree three: simple examples.
	15. Vander monde matrix and computation of its determinant (by stating properties of
	determinant).
	Module 2: Applications of linear systems and introduction to platonic solids (15 Hours)
	1. Kirchoff's laws recall and setting up notation.
	2. Kirchoff's laws and determination of current in a circuit (setting up a linear system of
	equations).
	3. Kirchoff's laws and explicit examples.
	4. Cofactor, Adjoint of a Matrix: Definitions.
	5. Computation of cofactor and adjoint of two by two matrices.
	6. Computation of cofactor and adjoint of three by three matrices.
	7. Formula stating the relation between a matrix, adjoint, and inverse.
	8. Computation of adjoint and inverse for higher-size matrices.
	9. Relation between invertibility and uniqueness of solution to a linear system of equations
	(only statement) and examples.
	10. Counting edges, faces, and vertices in planar and non-coplanar figures. Statement of
	Euler's formula.
	11. Platonic solids: introducing five platonic solids with names, verifying Euler's formula.
	12. Proof of the existence of only five platonic solids.
	13. Duals of platonic solids, the existence of molecules in the shape of platonic solids, and
	the impossibility of certain crystal shapes.
	14. George Mendel and his experiment and introduction to
	The hardy-Weinberg principle in population genetics
	15. Punnett square and associated binomial expansions.
10	Text Books:
	1. Hermann Weyl, Symmetry, Princeton University Press, 1952.
	2. Elementary Linear Algebra Application Version, H. Anton, C. Rorres, Wiley, Tenth
	Edition.
11	Reference Books:
	1. Contemporary Abstract Algebra, J. A. Gallian, Narosa publishing house.
	2. Tipler, Paul (2004). Physics for Scientists and Engineers: Electricity, Magnetism, Light,
	and Elementary Modern Physics (5th ed.). W. H. Freeman.
	and Elementary Wodern Physics (5th ed.). W. H. Preeman.
	Scheme of the Examination
	The performance of the learners shall be evaluated in two parts.
	<ul> <li>Internal Continuous Assessment of 20 marks.</li> </ul>
	• Semester-end examination of 30 marks.
	• A separate head of passing is required for internal and semester-end examinations.

2	Internal Continuous Assessment: 40%		Semester	End Exa	aminatio	on: 60%			
3	Conti	inuo	us Evaluatio	on through: Q	uizzes, Class				
				ojects, role pla	-				
	writin	ig, as	signments, e	etc.	-				
	(at lea								
	Sr.	Par	rticulars		Marks				
	No.								
	1	Ac	class test of 1	0 marks is to	10				
		be	conducted	during each					
		sen	nester in an O	Offline mode.					
	2			y one topic	05				
				syllabus or a					
		-		nline) on one					
			the modules.		0.5				
	3		0 1	presentation	05				
			• •	pic related to					
		tne	syllabus.						
	Pan	or na	attern of the	Test (Offline	Mode with				
	-	-	ur Duration						
			,	)• the blanks/ Tru	10				
	-				le				
	I Or H		with Institios	ation					
			with Justifica	ation.					
	(04]	Mark	ks: 4 x 1).		,				
	(04 ) Q2: A	Mark ttem	ks: 4 x 1). pt any 2 fron	n 3 descriptive	2				
1	(04 ) Q2: A ques	Mark ttem stions	ks: 4 x 1). pt any 2 fron s. (06 marks:	n 3 descriptive $2 \times 3$ )					
ŀ	(04 ) Q2: A ques	Mark ttem stions at of	cs: 4 x 1). pt any 2 fron s. (06 marks: f <b>Question P</b>	n 3 descriptive $2 \times 3$ )		0 marks of o	ne hour o	luration,	
ŀ	(04 ) Q2: A ques	Mark ttem stions at of	ks: 4 x 1). pt any 2 fron s. (06 marks: <b>f Question P</b> ne semester-e	a 3 descriptive $2 \times 3$	on will be of 3		ne hour o	luration,	
ŀ	(04 ) Q2: A ques	Mark ttem stions at of	ks: 4 x 1). pt any 2 fron s. (06 marks: <b>f Question P</b> ne semester-e covering th	n 3 descriptive 2 × 3) <b>Paper:</b> end examination	on will be of 3 ous of the sem	ester.		,	
1	(04 ) Q2: A ques	Mark ttem stions at of Th	ks: 4 x 1). pt any 2 from s. (06 marks: f Question P ne semester-e covering th No Module 1	a 3 descriptive $2 \times 3$ ) <b>aper:</b> and examination e entire syllabilities <b>te: Attempt any</b> Attempt any	on will be of 3 ous of the sem <b>my TWO qu</b> <b>THREE</b> out	ester. estions out o of FOUR.		,	ks
ł	(04) Q2: A ques <b>Form</b>	Mark ttem stions at of Th	ks: 4 x 1). pt any 2 from s. (06 marks: f Question P ne semester-e covering th No	n 3 descriptive 2 × 3) Paper: end examination e entire syllab ote: Attempt any (Each questi	on will be of 3 bus of the sem <b>my TWO qu</b> <b>THREE</b> out on of 5 marks	ester. estions out of of FOUR.		<b>E.</b>	ks
4	(04) Q2: A ques <b>Form</b>	Mark ttem stions at of Th	ks: 4 x 1). pt any 2 from s. (06 marks: f Question P ne semester-e covering th No Module 1	n 3 descriptive 2 × 3) Paper: end examination e entire syllab te: Attempt any (Each questing) (a) Questing)	on will be of 3 ous of the sem <b>my TWO qu</b> <b>THREE</b> out on of 5 marks stion based on	ester. estions out of of FOUR. s) OC1		<b>E.</b>	ks
1	(04) Q2: A ques <b>Form</b>	Mark ttem stions at of Th	ks: 4 x 1). pt any 2 from s. (06 marks: f Question P ne semester-e covering th No Module 1	n 3 descriptive 2 × 3) Paper: end examination e entire syllab te: Attempt any (Each questi (a) Ques (b) Ques	on will be of 3 ous of the sem ony TWO qu THREE out on of 5 marks stion based on stion based on	ester. estions out o of FOUR. 3) OC1 OC2		<b>E.</b>	ks
1	(04) Q2: A ques <b>Form</b>	Mark ttem stions at of Th	ks: 4 x 1). pt any 2 from s. (06 marks: f Question P ne semester-e covering th No Module 1	n 3 descriptive 2 × 3) Paper: end examination e entire syllab te: Attempt any (Each questing (a) Questing (b) Questing (c) Questing	on will be of 3 bus of the sem <b>my TWO qu</b> <b>THREE</b> out on of 5 marks stion based on stion based on stion based on	ester. estions out of of FOUR. s) OC1 OC2 OC3		<b>E.</b>	ks
4	(04) Q2: A ques Form	Mark ttem stions at of Th	ks: 4 x 1). pt any 2 from s. (06 marks: f Question P the semester-e covering th No Module 1 and 2	n 3 descriptive 2 × 3) <b>'aper:</b> end examination e entire syllab <b>te: Attempt any</b> (Each questing (a) Questing (b) Questing (c) Questing (d) Questing (d) Questing (c) Questi	on will be of 3 ous of the sem <b>my TWO qu</b> <b>THREE</b> out on of 5 marks stion based on stion based on stion based on	ester. estions out of of FOUR. ) OC1 OC2 OC3 OC4/OC5		E. 15 Mar	
4	(04) Q2: A ques <b>Form</b>	Mark ttem stions at of Th	ks: 4 x 1). pt any 2 from s. (06 marks: f Question P the semester-e covering th No Module 1 and 2 Module 1	n 3 descriptive 2 × 3) Paper: end examination e entire syllab te: Attempt any (Each questi (a) Quess (b) Quess (c) Quess (d) Quess Attempt any	on will be of 3 ous of the sem <b>iny TWO qu</b> <b>THREE</b> out on of 5 marks stion based on stion based on stion based on stion based on stion based on	ester. estions out of of FOUR. of OC1 OC2 OC3 OC4/OC5 of FOUR.		<b>E.</b>	
4	(04) Q2: A ques Form	Mark ttem stions at of Th	ks: 4 x 1). pt any 2 from s. (06 marks: f Question P the semester-e covering th No Module 1 and 2	n 3 descriptive 2 × 3) Paper: end examination e entire syllab te: Attempt any (Each questing) (b) Quessing) (c) Quessi	on will be of 3 ous of the sem on <b>THREE</b> out on of 5 marks stion based on stion based on stion based on stion based on stion based on of <b>THREE</b> out on of 5 marks	ester. estions out of of FOUR. () OC1 OC2 OC3 OC4/OC5 of FOUR. ()		E. 15 Mar	
4	(04) Q2: A ques Form	Mark ttem stions at of Th	ks: 4 x 1). pt any 2 from s. (06 marks: f Question P the semester-e covering th No Module 1 and 2 Module 1	n 3 descriptive 2 × 3) <b>aper:</b> end examination e entire syllab <b>te: Attempt any</b> (Each questinner (Each questinner) (b) Quess (c) Quess (d) Quess (c) Quess (d) Quess (c) Quess	on will be of 3 ous of the sem <b>my TWO qu</b> <b>THREE</b> out on of 5 marks stion based on stion based on stion based on <b>THREE</b> out on of 5 marks stion based on	ester. estions out o of FOUR. ) OC1 OC2 OC3 OC4/OC5 of FOUR. ) OC1		E. 15 Mar	
4	(04) Q2: A ques Form	Mark ttem stions at of Th	ks: 4 x 1). pt any 2 from s. (06 marks: f Question P the semester-e covering th No Module 1 and 2 Module 1	n 3 descriptive 2 × 3) Paper: end examination e entire syllab te: Attempt any (Each questinner (a) Questinner (b) Questinner (c) Questi	on will be of 3 ous of the sem <b>my TWO qu</b> <b>THREE</b> out on of 5 marks stion based on stion based on stion based on <b>THREE</b> out on of 5 marks stion based on stion based on stion based on stion based on the stion based on	ester. estions out of of FOUR. ) OC1 OC2 OC3 OC4/OC5 of FOUR. ) OC1 OC1 OC2 OC2 OC3 OC4/OC5		E. 15 Mar	
4	(04) Q2: A ques Form	Mark ttem stions at of Th	ks: 4 x 1). pt any 2 from s. (06 marks: f Question P the semester-e covering th No Module 1 and 2 Module 1	n 3 descriptive 2 × 3) Paper: end examination e entire syllab te: Attempt any (Each questing) (b) Quessing) (c) Quessi	on will be of 3 ous of the sem on y TWO qu THREE out on of 5 marks stion based on stion based on stion based on to based on to of 5 marks stion based on stion based on stion based on stion based on stion based on stion based on stion based on	ester. estions out of of FOUR. () OC1 OC2 OC3 OC4/OC5 of FOUR. () OC1 OC2 OC3 OC1 OC2 OC3		E. 15 Mar	
4	(04) Q2: A ques Form	Mark ttem stions at of Th o.1	ks: 4 x 1). pt any 2 from s. (06 marks: f Question P he semester-e covering th No Module 1 and 2 Module 1 and 2	n 3 descriptive 2 × 3) Paper: end examination e entire syllab te: Attempt any (Each questinner (Each questinner) (b) Quess (c) Quess (c) Quess (d) Quess (b) Quess (c) Quess (	on will be of 3 ous of the sem <b>my TWO qu</b> <b>THREE</b> out on of 5 marks stion based on stion based on stion based on <b>THREE</b> out on of 5 marks stion based on stion based on stion based on stion based on stion based on stion based on stion based on	ester. estions out o of FOUR. ) OC1 OC2 OC3 OC4/OC5 of FOUR. ) OC1 OC2 OC3 OC1 OC2 OC3 OC4/OC5 )		E. 15 Mar	ks
4	(04) Q2: A ques Form	Mark ttem stions at of Th o.1	cs: 4 x 1). pt any 2 from s. (06 marks: f Question P the semester-end covering the No Module 1 and 2 Module 1 and 2	n 3 descriptive 2 × 3) 2 aper: end examination e entire syllab te: Attempt any (Each questinner (a) Questinner (b) Questinner (b) Questinner (c) Questinner (c) Questinner (a) Questinner (c) Qu	on will be of 3 ous of the sem <b>iny TWO qu</b> <b>THREE</b> out on of 5 marks stion based on stion based on stion based on <b>THREE</b> out on of 5 marks stion based on stion based on	ester. estions out of of FOUR. ) OC1 OC2 OC3 OC4/OC5 of FOUR. ) OC1 OC2 OC3 OC2 OC3 OC4/OC5 of FOUR.		E. 15 Mar	ks
4	(04) Q2: A ques Form	Mark ttem stions at of Th o.1	ks: 4 x 1). pt any 2 from s. (06 marks: f Question P he semester-e covering th No Module 1 and 2 Module 1 and 2	n 3 descriptive 2 × 3) Paper: end examination e entire syllab te: Attempt any (Each questinner (Each questinner) (C) Questinner) (C) Questinner) (Each questinner) (Each questinner) (Each questinner) (C) Questinner)	on will be of 3 ous of the sem <b>my TWO qu</b> <b>THREE</b> out on of 5 marks stion based on stion based on stion based on the third based on the third based on stion based on	ester. estions out of of FOUR. () OC1 OC2 OC3 OC4/OC5 of FOUR. () OC1 OC2 OC3 OC1 OC2 OC3 OC4/OC5 of FOUR. () OC3 OC4/OC5 () OC3 OC4/OC5 () OC3 OC4/OC5 () () () () () () () () () ()		E. 15 Mar	ks
4	(04) Q2: A ques Form	Mark ttem stions at of Th o.1	cs: 4 x 1). pt any 2 from s. (06 marks: f Question P the semester-end covering the No Module 1 and 2 Module 1 and 2	n 3 descriptive 2 × 3) Paper: end examination e entire syllab te: Attempt any (Each questinner (Each questinner) (b) Quess (c) Quess (	on will be of 3 ous of the sem <b>my TWO qu</b> <b>THREE</b> out on of 5 marks stion based on stion based on stion based on <b>THREE</b> out on of 5 marks stion based on stion based on	ester. estions out of of FOUR. () OC1 OC2 OC3 OC4/OC5 of FOUR. () OC1 OC2 OC3 OC4/OC5 of FOUR. () OC4/OC5 of FOUR. () OC3 OC4/OC5 () OC1 OC2 OC3 OC4/OC5 () OC1 () () () () () () () () () ()		E. 15 Mar	ks
4	(04) Q2: A ques Form	Mark ttem stions at of Th o.1	cs: 4 x 1). pt any 2 from s. (06 marks: f Question P the semester-end covering the No Module 1 and 2 Module 1 and 2	n 3 descriptive 2 × 3) 2 aper: end examination e entire syllab te: Attempt any (Each questinner (a) Questinner (b) Questinner (b) Questinner (c) Questinner (c) Questinner (a) Questinner (c) Questinner (b) Questinner (c) Questinner (c) Questinner (c)	on will be of 3 ous of the sem <b>my TWO qu</b> <b>THREE</b> out on of 5 marks stion based on stion based on stion based on the third based on the third based on stion based on	ester. estions out of of FOUR. (0) (		E. 15 Mar	ks

#### Name of the Course: PM-3C Basic Mathematics in Real Life-II (Minor III)

<u> </u>		Ninor III)
Sr.	Heading	Particulars
No.		
1	<b>Description of the course:</b>	To demonstrate the importance of mathematics in
	Including but not limited	real life by considering interdisciplinary
•	to:	applications of basic concepts in real life.
2	Vertical:	Minor
3	Туре:	Practical
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	<b>Course Objectives (CO):</b>	
	•	sture of the basic concepts of mathematics, which
		athematics in other sciences. In this course, students
	0 0	vill be able to see mathematics being applied in their
	area of interest and learn	6 I I
	CO1: To develop methods for p	polynomial interpolation.
		form and row reduced echelon form for matrices.
	-	al notation for solving real-life problems like those
	related to forest management.	6 I I I I I I I I I I I I I I I I I I I
	e	f geometry (in particular Platonic solids) in science
	streams.	8, ( F
8	<b>Course Outcomes (OC):</b>	
_	After completion of the course,	students will be able to
	-	oncepts to solve interpolation problems, problems,
		mials up to degree three, equations of recurrence
	relations.	
	OC2: analyse the solutions of the	he system of linear equations and graphs
	•	en non-planar graphs and Euler's formula and verify
	the Hardy-Weinberg principle.	
		relations and design circuits based on Kirchhoff's
	Law	6
9	Modules: -	
-		nomials and Interpolation (30 Hours)
	1. Computing roots for qua	adratic equations
	2. Plotting polynomials of	1
	01.	6
	3. Setting up Recurrence R	
	4. Polynomial Interpolation	*
	<b>5 M</b> <sub>22</sub> <b>1</b> 4 <sup>1</sup> 2 <sup>2</sup> 2 <sup>4</sup>	an of oulsituany airea
	5. Multiplication of matric	
	6. Computation of Row-Ed	chelon Form in 2 by 2 and 3 by 3 matrices.
	<ol> <li>Computation of Row-Ed</li> <li>Computation of Row-Ref</li> </ol>	
	<ol> <li>Computation of Row-Ec</li> <li>Computation of Row-Rematrices.</li> </ol>	chelon Form in 2 by 2 and 3 by 3 matrices.

	9.	Polynomial Interpolation						
	10.	Vandermonde Determina	int and Invert	bility.				
	Module 2: Practicals for Applications of linear systems and introduction to Platoonic solids (30 Hours)							
	1. Kirchhoff's Law in Computing Current in given examples.							
	2.	Computing cofactors of 2						
	3.	Computing adjoint and in						
	4.	Computing the adjoint an		•				
	5.	-		is of equations using matrices.				
	6. 7.	Examples in n by n matri		of Linear Equations.				
	7.	Euler's Formula via Exan Planar Figures and Graph		and Examples				
	<u>o.</u> 9.	Non-Planar Figures and H		*				
	10.	Problems based on the Ha						
10		Books:	ardy wenneed	g principie.				
		Artin, Algebra, Pearson,	Second Edition	on				
		•						
	۷.	• •	na Applicatio	on Version, H. Anton, C. Rorres,				
		Wiley, Tenth Edition.						
11	Refe	rence Books:						
			Algebra, J. A.	Gallian, Narosa publishing house.				
		<ol> <li>Contemporary Abstract Algebra, J. A. Gaman, Narosa publishing house.</li> <li>Tipler, Paul (2004). Physics for Scientists and Engineers: Electricity,</li> </ol>						
	_	-		odern Physics (5th ed.). W. H.				
		Freeman.	iementary wi					
		i ioomun.						
		<u>Schen</u>	ne of the Exa	mination				
2	Inter	nal Continuous Assessme	nt: 40%	Semester End Examination: 60%				
3	Cont	inuous Evaluation throug	h:					
-		uizzes, Class Tests, present						
	-	cts, role play, creative writi						
		nments, etc.						
	(at lea	(at least 3)						
	Sr.	Particulars	Marks					
	No.	i articuluit	TATALICO					
	1	Objective question test	10					
	2	Overall performance	05					
	3	Viva	05					
			~~					
	Pan	er pattern of the Test (Of	fline					
	-	er pattern of the Test (Of de):	fline					
	Mo	-						

Duration: 1Hrs While setting the o paper, four MCQ 1 and four MCQs both.	s on module			
Format of Question Scheme of examin	-			
and 30 marks shall b	mester III, Practical examinations be conducted based on both the m uestion paper shall have two que	odules.		
Q. No. 1	Five out of Eight multiple- choice questions (four from module 1 and four from module 2) (OC1 to OC3)	Marks $(3 \times 5 = 15$ Marks)		
Q. No.2	Attempt any Two out of Four (two from module 1 and two from module 2). (OC3 and OC4)	$(5 \times 2 = 10)$ Marks)		
Marks for Journal	s:			
For both Module 1 and Module 2, Journal: 5 marks (2.5 marks for each module 1 & module 2)				
certified. The stude	uired to perform 75% of the pracents are required to present a duly mination, failing which they will	certified journal for appeari		

# Sem. - IV

#### Syllabus B.Sc. (Mathematics) (Sem.- IV) Name of the Course: Calculus IV

#### Heading **Particulars** Sr. No. 1 **Description the course:** Calculus finds extensive applications in diverse fields **Including but not limited to:** such as Physics, Chemistry, Biotechnology, Engineering, and more. This course seeks to provide learners with a comprehensive understanding of Multivariable Calculus, building upon a rigorous foundation laid by Mathematical Analysis. Through the exploration of various properties of derivatives of scalar fields and vector fields. Students will gain valuable insights into the analytical aspects of Multivariable Calculus. То enhance practical understanding, the course incorporates real-world applications of differentiation in multiple dimensions, allowing learners to grasp the diverse uses of the acquired knowledge. Minor 2 Vertical: 3 Theory Type: 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 aims to equip students with a comprehensive understanding of functions of several variables and the principles of differentiation for scalar and vector fields in multivariable calculus.

**CO1**: To develop the understanding of vectors in  $\mathbb{R}^n$  focusing on  $\mathbb{R}^2$  and  $\mathbb{R}^3$  and acquire proficiency in working with real-valued functions of several variables.

**CO2**: To demonstrate competence in analyzing neighbourhoods in  $\mathbb{R}^n$  and applying concepts of limits and continuity to scalar fields.

**CO3**: To define and compute partial and directional derivatives of scalar fields, focusing on  $\mathbb{R}^2$  and  $\mathbb{R}^3$ , and understand the Mean Value Theorem for scalar fields.

**CO4**: To explore the basic properties of differentiability, such as continuity at a point, existence of partial derivatives, and differentiability when partial derivatives exist and are continuous.

**CO5**: To utilize concept of differentiation for practical applications, including the understanding of tangent planes and maxima-minima.

**CO6**: To understand higher-order partial derivatives and their applications, including the Mixed Partial Derivatives Theorem, Taylor's Theorem for twice continuously differentiable functions, the Method of Lagrange Multipliers and the Second Derivative Test for functions of two variables.

### 8 Course Outcomes (OC): After completion of the course, students will be able OC1: understand and remember the concepts such as Euclidean spaces, norm, inner product, limit, continuity, derivatives of scalar fields etc.

	OC3: and co	apply first and second derivative tests to find extreme values of scalar fields. verify the relationship between Differentiability and Continuity, directional derivative ontinuity etc.
	OC5:	check differentiability and continuity of scalar and vector fields. create counter examples related to continuity and differentiability, directional ative and continuity, partial derivatives and total derivative etc.
9	Module Module	es: - e 1: Functions of Several Variables (15 Lectures)
	8	Review of vectors in $\mathbb{R}^n$ [with emphasis on $\mathbb{R}^2$ and $\mathbb{R}^3$ ] and basic notions such as addition and scalar multiplication, inner product, length (norm) and distance between two points.
	S	Real-valued functions of several variables (Scalar fields). Graph of a function. Level sets (level curves, level surfaces, etc). Examples. Vector valued functions of several variables (Vector fields). Component functions. Examples.
		Sequence in $\mathbb{R}^n$ [with emphsis on $\mathbb{R}^2$ and $\mathbb{R}^3$ ] and their limits. Neighbourhoods in $\mathbb{R}^n$ . Limits and continuity of scalar fields. Sequential characterizations (without proof), Composition of continuous functions. Algebra of limits and continuity (Results with proofs). Iterated and simultaneous limits of scalar fields. Limits and continuity of vector fields. Algebra of limits and continuity of vector fields. (without proofs).
	(	Partial derivatives, directional derivatives and gradient of scalar fields (with emphasis on $\mathbb{R}^2$ and $\mathbb{R}^3$ ). Existence of directional derivative implies continuity. Mean Value Theorem for scalar fields.
		Differentiability of scalar fields (in terms of linear transformation). Concept of total derivative and its uniqueness, basic results such as (i) continuity at a point of differentiability, (ii) existence of partial derivatives at a point of differentiability and (iii) differentiability when the partial derivatives exist and are continuous.
	Module	2: Applications of Differentiability (15 Lectures)
	1 I	Relation between total derivative and gradient of a function. Chain rule (without proof). Geometric properties of gradient. Tangent planes.
		Euler's Theorem, Higher order partial derivatives. Mixed Partial Derivatives Theorem (n=2).
	3 7	Taylor's Theorem for twice continuously differentiable functions (without proof).
	1   1	The maximum and minimum rate of change of scalar fields. Notions of local maxima, local minima and saddle points. First Derivative Test. Examples. Hessian matrix. Second Derivative Test for functions of two variables (statement only). Examples. Method of Lagrange Multipliers.
10	Recom	nended Reference Books:
	1. T. Ap	oostol; Calculus, Vol. 2 (Second Edition); John Wiley.
		ir Ghorpade, Balmohan Limaye; A Course in Multivariable Calculus and Analysis Edition); Springer.
	3. Walte	er Rudin; Principles of Mathematical Analysis; McGraw-Hill, Inc.
	4. J. E. I	Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus; Springer.
	5. D. So	masundaram and B. Choudhary; A First Course in Mathematical Analysis, Narosa

	New Delhi, 1996.							
	6. K. Stewart; Calculus; Booke/Cole Publishing Co, 1994.							
11	Additional Reference Books							
	1. Calculus and Analytic Geometry, G.B. Thomas and R. L. Finney, (Ninth Edition); Addiso Wesley, 1998.							
	2. Howard Anton; Ca	alculus- A new H	łorizon, (Si	xth	Edition); John Wiley and Sons Inc, 1999.			
	3. Shabanov, Sergei; Florida, 2012.	Concepts in Cal	culus, III: N	/Iul	tivariable Calculus; University Press of			
	4. S C Malik and Sav	vita Arora; Mathe	ematical Ar	naly	sis; New Age International Publishers.			
		Scher	ne of the E	xar	nination			
	<ul><li>Internal Cont</li><li>Semester End</li></ul>	tinuous Assessm d Examination of	ent of 20 m f 30 marks.	ark	aluated in two parts. s. aternal and semester-end examinations.			
12	Internal Continuou	s Assessment: 4	0%		Semester End Examination: 60%			
	Quizzes, Class Tests, play, creative writing (at least 3)			e				
	be conducted semester in an 2 Project on a	f 10 marks is to d during each o Offline mode. any one topic	10					
	quiz (offline/ of the module							
	U U	up presentation opic related to	05					
	Paper pattern of th One hour duration Q1: Definitions/Fill i or False with Justifi (04 Marks: 4 x 1). Q2: Attempt any 2 fr questions. (06 mark	n): in the blanks/ Transform form 3 descriptive	ue	1				

The semester-end examination will be of 30 marks of one hour duration covering							
		bus of the semester.					
		ote: Attempt any TWO questions out of TI					
Q.No.1	Module 1	Attempt any <b>THREE</b> out of <b>FOUR</b> .	15 Marks				
	and 2	(Each question of 5 marks)					
		(a) Question based on OC1					
		(b) Question based on OC2					
		(c) Question based on OC3					
		(d) Question based on OC4/OC5					
Q.No.2	Module 1	Attempt any <b>THREE</b> out of <b>FOUR</b> .	15 Marks				
	and 2	(Each question of 5 marks)					
		(a) Question based on OC1					
		(b) Question based on OC2					
		(c) Question based on OC3					
		(d) Question based on OC4/OC5					
Q.No.3	Module 1	Attempt any <b>THREE</b> out of <b>FOUR</b> .	15 Marks				
-	and 2	(Each question of 5 marks)					
		(a) Question based on OC1					
		(b) Question based on OC2					
		(c) Question based on OC3					
		(d) Question based on OC4/OC5					

~	Name of the Course: Ordi	
Sr.	Heading	Particulars
No.		
1	Description the course: Including but not limited to:	This course covers fundamental concepts differential equations. It includes a review of differential equations and its solution, understanding homogeneous and non- homogeneous higher order linear differential equations. Additionally, the course delves into concepts like differential operators, method of variation of parameters and method of undetermined coefficients of solving higher order linear differential equations with constant coefficients.
2	Vertical:	Minor
3	Туре:	Theory
4	Credits:	2 credits
		(1  credit = 15  Hours for Theory or 30 Hours of)
5	Hours Allotted:	Practical work in a semester) 30 Hours
5	Hours Anotteu:	50 Hours
6	Marks Allotted:	50 Marks
7	Course Objectives (CO):	
9	equations and prepares students to st course, importance is given to basic equations which also enhances under <b>CO1.</b> To give sufficient knowled differential equations and a clear per and tools and the skills to use them b <b>CO2.</b> To reflect the broad nature of continuing further study in various f <b>CO3.</b> To enhance students' overall d and power of communication are new <b>CO4.</b> To give adequate exposure to	evelopment, problem solving skills, creative talent cessary for various kinds of employment. global and local concerns that would help learners
8	explore many aspects of Mathematic	cal Sciences.
	Course Outcomes (OC):	
	<b>Course Outcomes (OC):</b> After completion of the course, studen	ts will be able to
	Course Outcomes (OC): After completion of the course, studen OC1: Understand and remember bas	ts will be able to sic concept of differential equations and various
	Course Outcomes (OC): After completion of the course, studen OC1: Understand and remember bas methods of solving higher order line	ts will be able to sic concept of differential equations and various
	Course Outcomes (OC): After completion of the course, studen OC1: Understand and remember bas methods of solving higher order line OC2: apply the methods of solving b coefficients.	ts will be able to sic concept of differential equations and various ar ordinary differential equations. linear differential equations with constant
	Course Outcomes (OC): After completion of the course, studen OC1: Understand and remember bas methods of solving higher order line OC2: apply the methods of solving b coefficients. OC3: verify the given solutions of d	ts will be able to sic concept of differential equations and various ar ordinary differential equations. inear differential equations with constant ifferential equations are linearly dependent or
	Course Outcomes (OC): After completion of the course, studen OC1: Understand and remember bas methods of solving higher order line OC2: apply the methods of solving b coefficients. OC3: verify the given solutions of d independent and also to verify auxili	ts will be able to sic concept of differential equations and various ar ordinary differential equations. linear differential equations with constant ifferential equations are linearly dependent or ary equations have real or complex roots.
	Course Outcomes (OC): After completion of the course, studen OC1: Understand and remember bas methods of solving higher order line OC2: apply the methods of solving b coefficients. OC3: verify the given solutions of d independent and also to verify auxili	ts will be able to sic concept of differential equations and various ar ordinary differential equations. inear differential equations with constant ifferential equations are linearly dependent or

#### Name of the Course: Ordinary Differential Equations

9	Modules: - Module 1: Homogoneous Higher Order Lincor D	formatical Equations (15 Lastures)
	Module 1: Homogeneous Higher Order Linear D(a) The general n-th order linear differential	
	solutions of LDE, existence and uniqueness t	
	classification of D.E.: homogeneous and no	on-homogeneous, general solution of
	homogeneous and non-homogeneous LDF properties.	E, the differential operator and its
	(b) Higher order homogeneous linear differentia	l equations with constant coefficients,
	the auxiliary equations, roots of the auxiliary	1
	repeated, complex and complex repeated.	
	Module 2: Non-Homogeneous Higher Order 1 Lectures)	Linear Differential Equations (15
	(a) Non-homogeneous equations: The inverse	differential operator and particular
	integral, evaluation of $\frac{1}{f(D)}$ for the fund	
	$x^m \sin ax$ (without proof), $x^m \cos ax$ (without proof)	
	and $xV$ (without proof) where V is any funct	ion of <i>x</i> .
	(b) The method of undetermined coefficients. T	-
10	(c) Construction of ordinary differential equation <b>Recommended Reference Books:</b>	n for the given solution.
10	1. George F. Simmons, Differential Equations	with Applications and Historical
	Notes, Taylor's and Francis, Third Edition, 2	2017.
	2. E.D. Rainville and P.E. Bedient; Elementary	Differential Equations; Macmillan.
11	Additional Reference Books:	
	1. E.A. Coddington and R. Carlson: Linear Ord	-
	2. M.D. Raisinghania; Ordinary and Partial Dif	ferential Equations; S. Chand.
	Scheme of the Examin	ation
	The performance of the learners shall be eva	luated in two parts.
	• Internal Continuous Assessment of 20 mark	s.
	• Semester End Examination of 30 marks.	4
	• A separate head of passing is required for in examinations.	ternal and semester-end
12	Internal Continuous Assessment: 40%	Semester End Examination: 60%
10		
13	Continuous Evaluation through:	
	Quizzes, Class Tests, presentations, projects, role	
	play, creative writing, assignments etc.	
	(at least 3)	

Sr. Pa No.	articulars	Marks		
1 A be	class test of 10 marks is e conducted during eac emester in an Offline mod	ch		
2 Pr re qu	roject on any one top lated to the syllabus or iiz (offline/online) on or the modules.	ic 05 a		
3 Se or th	eminar/ group presentation any one topic related e syllabus.	to		
	pattern of the Test (Offli	ine Mode wit	h	
	<b>ur duration):</b> hitions/Fill in the blanks/ '	True		
-	with Justification.			
(04 Mai	·ks: 4 x 1).			
	npt any 2 from 3 descript	ive		
question	ns. (06 marks: $2 \times 3$ )			
Format	of Question Paner			
	of Question Paper:	ntion will be c	of 30 marks of one	e hour duration co
Т	The semester-end examination		of 30 marks of one	e hour duration co
Т	he semester-end examinate entiresyllabus of the se	mester.		
Т	The semester-end examinate the entiresyllabus of the se Note: Attemp	emester. ot any TWO	of 30 marks of one questions out of out of <b>FOUR</b> .	
T tl	The semester-end examination is entiresyllabus of the set of the s	emester. ot any TWO ony THREE of estion of 5 ma	<b>questions out of</b> out of <b>FOUR</b> . rks)	THREE.
T tl	The semester-end examinate the entiresyllabus of the second secon	emester. ot any TWO my THREE of estion of 5 ma uestion based	<b>questions out of</b> out of <b>FOUR</b> . rks) on OC1	THREE.
T tl	The semester-end examination is the semester-end examination is the semester of the semester o	emester. <b>any TWO</b> any <b>THREE</b> of estion of 5 man uestion based uestion based	<b>questions out of</b> out of <b>FOUR</b> . rks) on OC1 on OC2	THREE.
T tl	The semester-end examinate entiresyllabus of the semester-end examinate entiresyllabus of the second	emester. ot any TWO my THREE of estion of 5 ma uestion based uestion based uestion based	questions out of out of FOUR. rks) on OC1 on OC2 on OC3	THREE.
T tt Q.No.1	The semester-end examinate entiresyllabus of the semester-end examinate entiresyllabus of the second	emester. ot any TWO my THREE of estion of 5 ma uestion based uestion based uestion based uestion based	questions out of out of FOUR. rks) on OC1 on OC2 on OC3 on OC4/OC5	THREE. 15 Marks
T tl	The semester-end examinate entiresyllabus of the second examinate Note: Attempt Module 1 Attempt at and 2 (Each que (a) Que (b) Que (c) Que (d) Que Module 1 Attempt at	emester. ot any TWO iny THREE of estion of 5 ma uestion based uestion based uestion based uestion based uestion based	questions out of out of FOUR. rks) on OC1 on OC2 on OC3 on OC4/OC5 out of FOUR.	THREE.
T tt Q.No.1	The semester-end examination is entiresyllabus of the set is entiresyllabus of the set is <b>Note: Attempt</b> Module 1       Attempt attem	emester. ot any TWO a my THREE of estion of 5 ma uestion based uestion based uestion based uestion based uestion based uestion based uestion based uestion based uestion based	questions out of out of FOUR. rks) on OC1 on OC2 on OC3 on OC4/OC5 out of FOUR. rks)	THREE. 15 Marks
T tt Q.No.1	The semester-end examination is entiresyllabus of the set is entiresyllabus of the set is in the set	emester. ot any TWO my THREE of estion of 5 ma uestion based uestion based uestion based uestion based my THREE of estion of 5 ma uestion based	questions out of out of FOUR. rks) on OC1 on OC2 on OC3 on OC4/OC5 out of FOUR. rks) on OC1	THREE. 15 Marks
T tt Q.No.1	The semester-end examinative entiresyllabus of the set	emester. ot any TWO iny THREE of estion of 5 marguestion based uestion based uestion based iny THREE of estion of 5 marguestion based uestion based uestion based uestion based	questions out of out of FOUR. rks) on OC1 on OC2 on OC3 on OC4/OC5 out of FOUR. rks) on OC1 on OC2	THREE. 15 Marks
T tt Q.No.1	The semester-end examinative entiresyllabus of the set Note: Attempt Module 1 Attempt at and 2 (Each que (a) Que (b) Que (c) Que (d) Que and 2 (Each que (d) Que (a) Que (c) Que (d) Que (a) Que (c) Que	emester. ot any TWO my THREE of estion of 5 ma uestion based uestion based uestion based iny THREE of estion of 5 ma uestion based uestion based uestion based uestion based uestion based	questions out of out of FOUR. rks) on OC1 on OC2 on OC3 on OC4/OC5 out of FOUR. rks) on OC1 on OC2	THREE. 15 Marks
T tt Q.No.1	The semester-end examination is entiresyllabus of the semistication is entiresyllabus of the semisticat	emester. ot any TWO my THREE of estion of 5 ma uestion based uestion based uestion based my THREE of estion of 5 ma uestion based uestion based uestion based uestion based uestion based uestion based	questions out of out of FOUR. rks) on OC1 on OC2 on OC3 on OC4/OC5 out of FOUR. rks) on OC1 on OC2 on OC2 on OC2 on OC3	THREE. 15 Marks
T tt Q.No.1	The semester-end examinatethe entiresyllabus of the semester-end examinateNote: AttemptModule 1Attempt aand 2(Each que)(a) Que(b) Que(b) Que(c) Que(d) Que(d) QueModule 1Attempt aand 2(Each que)(a) Que(c) Que(b) Que(c) Que(c) Que(c) Que(d) Que(c) Que(d) Que(c) Que(d) Que(c) Que(d) Que(c) QueModule 1Attempt aand 2(Each que)(Each que)(Each que)	emester. ot any TWO my THREE of estion of 5 made uestion based uestion based uestion based uestion based uestion of 5 made uestion based uestion b	questions out of out of FOUR. rks) on OC1 on OC2 on OC3 on OC4/OC5 out of FOUR. rks) on OC1 on OC2 on OC2 on OC3 on OC4/OC5 out of FOUR. rks)	THREE. 15 Marks 15 Marks
T tt Q.No.1	The semester-end examinatethe entiresyllabus of the semester-end examinateNote: AttemptModule 1Attempt aand 2(Each que)(a) Que(b) Que(b) Que(c) Que(c) Que(d) QueModule 1Attempt aand 2(Each que)(a) Que(b) Que(b) Que(c) Que(c) Que(c) Que(d) Que(c) Que(c) Que(c) Que(c) Que(c) Que(d) Que(c) Que(a) Que(a) Que(a) Que(a) Que(a) Que(a) Que	emester. ot any TWO my THREE of estion of 5 ma uestion based uestion based uestion based uestion based my THREE of estion based uestion based	questions out of out of FOUR. rks) on OC1 on OC2 on OC3 on OC4/OC5 out of FOUR. rks) on OC1 on OC2 on OC3 on OC4/OC5 out of FOUR. rks) on OC4/OC5 out of FOUR. rks) on OC1	THREE. 15 Marks 15 Marks
T tt Q.No.1	he semester-end examinate entiresyllabus of the secNote: AttemptModule 1Attempt a (Each que (a) Que (b) Que (c) Que (d) QueModule 1Attempt a (Each que (d) Que (d) QueModule 1Attempt a (c) Que (d) Que (c) Que (d) Que (c) Que (d) Que (c) Que (d) Que (c)	emester. ot any TWO my THREE of estion of 5 ma uestion based uestion based uestion based uestion based uestion based uestion based uestion based uestion based uestion based uestion of 5 ma uestion of 5 ma uestion of 5 ma uestion based uestion based	questions out of           out of FOUR.           rks)           on OC1           on OC2           on OC3           on OC4/OC5           out of FOUR.           rks)           on OC1           on OC4/OC5           out of FOUR.           rks)           on OC2           on OC3           on OC4/OC5           out of FOUR.           rks)           on OC4/OC5           out of FOUR.           rks)           on OC1           on OC1           on OC1           on OC1	THREE. 15 Marks 15 Marks
T tt Q.No.1	The semester-end examinatethe entiresyllabus of the semester-end examinateNote: AttemptModule 1Attempt atand 2(Each que)(a) Que(b) Que(b) Que(c) Que(d) Que(d) QueModule 1Attempt atand 2(Each que)(a) Que(c) Que(b) Que(c) Que(c) Que(c) Que(d) Que(c) Que<	emester. ot any TWO my THREE of estion of 5 ma uestion based uestion based uestion based uestion based uestion based uestion based uestion based uestion based uestion based uestion of 5 ma uestion based uestion based	questions out of           out of FOUR.           rks)           on OC1           on OC2           on OC3           on OC4/OC5           out of FOUR.           rks)           on OC1           on OC4/OC5           out of FOUR.           rks)           on OC2           on OC3           on OC4/OC5           out of FOUR.           rks)           on OC4/OC5           out of FOUR.           rks)           on OC1           on OC1           on OC1           on OC1	THREE. 15 Marks 15 Marks

#### Name of the Course: PM-4 Calculus IV and Ordinary Differential Equations

C.	Herline	Equations
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:	Minor
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:	30 Hours
6	Marks Allotted:	50 Marks
7	rigour and prepares students <b>CO1</b> . To give sufficient know perception of numerous pow use them by modelling, solve <b>CO2</b> . To reflect the broad na continuing further study in v <b>CO3</b> . To enhance students' of talent, and power of comm employment.	vledge of fundamental principles, methods, and a clear vers of mathematical ideas and tools and the skills to ing and interpreting. ture of the subject and develop mathematical tools for arious fields of sciences. overall development, problem solving skills, creative unication, which are necessary for various kinds of posure to global and local concerns that would help
8	<ul> <li>and also apply the various m</li> <li>OC2: verify the relationship</li> <li>derivative and continuity etc</li> <li>OC3: check differentiability</li> <li>the complementary functio</li> <li>differential equations.</li> <li>OC4: create counter example</li> </ul>	derivative tests to find extreme values of scalar fields ethods to solve ordinary linear differential equations. between Differentiability and Continuity, directional

1.	Limits and continuity of scalar fields, using "definition and otherwise", iterated limits.
2.	Directional derivatives, partial derivatives and mean value theorem of scalar fields.
3.	Differentiability of scalar field and Total derivative.
4.	Gradient, level sets and tangent planes.
5.	Chain rule, higher order partial derivatives and mixed partial derivatives of scalar fields.
6.	Maximum and minimum rate of change of scalar fields. Finding Hessian/Jacobian matrix.
7.	Taylor's Theorem.
8.	Finding maxima, minima and saddle points. Second derivative test for extrema of functions of two variables and method of Lagrange multipliers.
Mod	ule 2: Ordinary Differential Equation (30 Hours)
1.	Wronskian and linear independence of solutions.
2.	Higher order homogeneous linear differential equations with constan
2	coefficients.
3.	Evaluation of particular integral for $X = e^{ax}$ .
4.	Evaluation of particular integral for $X = sinax, cosax$ .
5.	Evaluation of particular integral for $X = x^m$ , $x^m \sin ax$ , $x^m \cos ax$ .
6.	Evaluation of particular integral for $X = e^{ax}V$ and $X = xV$ where V is any function of x.
7.	Method of undetermined coefficients.
8.	Method of variation of parameters.
<b>T</b> (	
	Books
1	Apostol; Calculus, Vol. 2 (Second Edition); John Wiley.
1 2	Apostol; Calculus, Vol. 2 (Second Edition); John Wiley. Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariable Calculus a Analysis (Second Edition); Springer.
1 2	Apostol; Calculus, Vol. 2 (Second Edition); John Wiley. Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariable Calculus a
1 2 3	<ul> <li>Apostol; Calculus, Vol. 2 (Second Edition); John Wiley.</li> <li>Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariable Calculus a Analysis (Second Edition); Springer.</li> <li>Walter Rudin; Principles of Mathematical Analysis; McGraw-Hill, Inc.</li> </ul>
1 2 3	<ul> <li>Apostol; Calculus, Vol. 2 (Second Edition); John Wiley.</li> <li>Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariable Calculus a Analysis (Second Edition); Springer.</li> <li>Walter Rudin; Principles of Mathematical Analysis; McGraw-Hill, Inc.</li> <li>J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus</li> </ul>
1 2 3 4	<ul> <li>Apostol; Calculus, Vol. 2 (Second Edition); John Wiley.</li> <li>Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariable Calculus a Analysis (Second Edition); Springer.</li> <li>Walter Rudin; Principles of Mathematical Analysis; McGraw-Hill, Inc.</li> <li>J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculu Springer.</li> <li>D. Somasundaram and B.Choudhary; A First Course in Mathematical</li> </ul>
1 2 3 4 5	<ul> <li>Apostol; Calculus, Vol. 2 (Second Edition); John Wiley.</li> <li>Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariable Calculus a Analysis (Second Edition); Springer.</li> <li>Walter Rudin; Principles of Mathematical Analysis; McGraw-Hill, Inc.</li> <li>J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus Springer.</li> <li>D. Somasundaram and B.Choudhary; A First Course in Mathematical Analysis, Narosa New Delhi, 1996.</li> </ul>
1 2 3 4 5 6	<ul> <li>Apostol; Calculus, Vol. 2 (Second Edition); John Wiley.</li> <li>Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariable Calculus a Analysis (Second Edition); Springer.</li> <li>Walter Rudin; Principles of Mathematical Analysis; McGraw-Hill, Inc.</li> <li>J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus Springer.</li> <li>D. Somasundaram and B.Choudhary; A First Course in Mathematic Analysis, Narosa New Delhi, 1996.</li> <li>K. Stewart; Calculus; Booke/Cole Publishing Co, 1994.</li> </ul>
1 2 3 4 5 6	<ul> <li>Apostol; Calculus, Vol. 2 (Second Edition); John Wiley.</li> <li>Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariable Calculus a Analysis (Second Edition); Springer.</li> <li>Walter Rudin; Principles of Mathematical Analysis; McGraw-Hill, Inc.</li> <li>J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus Springer.</li> <li>D. Somasundaram and B.Choudhary; A First Course in Mathematical Analysis, Narosa New Delhi, 1996.</li> <li>K. Stewart; Calculus; Booke/Cole Publishing Co, 1994.</li> <li>George F. Simmons, Differential Equations with Applications and Historica</li> </ul>
1 2 3 4 5 6	<ul> <li>Apostol; Calculus, Vol. 2 (Second Edition); John Wiley.</li> <li>Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariable Calculus a Analysis (Second Edition); Springer.</li> <li>Walter Rudin; Principles of Mathematical Analysis; McGraw-Hill, Inc.</li> <li>J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus Springer.</li> <li>D. Somasundaram and B.Choudhary; A First Course in Mathematical Analysis, Narosa New Delhi, 1996.</li> </ul>
1 2 3 4 5 6 7	<ul> <li>Apostol; Calculus, Vol. 2 (Second Edition); John Wiley.</li> <li>Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariable Calculus a Analysis (Second Edition); Springer.</li> <li>Walter Rudin; Principles of Mathematical Analysis; McGraw-Hill, Inc.</li> <li>J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus Springer.</li> <li>D. Somasundaram and B.Choudhary; A First Course in Mathematical Analysis, Narosa New Delhi, 1996.</li> <li>K. Stewart; Calculus; Booke/Cole Publishing Co, 1994.</li> <li>George F. Simmons, Differential Equations with Applications and Historica</li> </ul>

11	Refer	ence Books			
		1. Calculus and Analytic Geometry, G.B. Thomas and R. L. Finney, (Ninth			
		Edition); Addison-Wesle	•	• * *	
<ol> <li>Howard Anton; Calculus- A new Horizon, (Sixth Edition); John Wile Sons Inc, 1999.</li> </ol>			rizon, (Sixth Edition); John Wiley and		
	3.	-	ni; Principle	s of Real Analysis; Vikas Publishing	
		house PVT LTD.			
	4.	-	-	llus, III: Multivariable Calculus;	
		University Press of Flori			
	5.	S C Malik and Savita Ar Publishers.	ora; Mathen	natical Analysis; New Age International	
	6		ferential Fa	uations with Applications and Historical	
	0.	•	-		
	_	Notes, Taylor's and Fran	-	-	
	7.	E.D. Rainville and P.E. I Macmillan.	Bedient; Ele	mentary Differential Equations;	
		Scher	ne of the Ex	<u>amination</u>	
12	Inter	nal Continuous Assessme	ent: 40%	Semester End Examination: 60%	
12	Intern			Schester Line Lauminuton, 0070	
13	Qu projec	<b>inuous Evaluation throug</b> nizzes, Class Tests, present cts, role play, creative writh ments etc. ast 3)	ations,		
	(ut lot				
	Sr. No.	Particulars	Marks		
	1	Objective question test	10		
	2	Overall performance	05		
	3	Viva	05		
	Pap	er pattern of the Test (Of	ffline		
	Mod	·			
	- `	Attempt any 5 from 8) Mu ce questions. (10 marks: 5	1		
	Whi four	tion: 1Hrs ile setting question paper MCQ on module 1 and MCQ on module 2 both			
14	Form	at of Question Paper:			
	At the	ne of examination: e end of the Semester IV, H 0 marks shall be conducted		minations of three hours duration oth the modules.	

Q. No.	Five out of Eight multiple choice questions (four from module 1 and four from module 2) (OC1 to OC3)	Marks $(3 \times 5 = 15)$ Marks)
Q. No.2	Attempt any Two out of Four (two from module 1 and two from module 2). (OC3 and OC4)	$(5 \times 2 = 10)$ Marks)
Iarks for Journa or both Module 1 . Journal: 5 marl		nodule 2)

Sd/-Sign of the BOS Chairman Prof. B.S. Desale BOS in Mathematics

appear for the examination.

Sd/-Sign of the Offg. Associate Dean Dr. Madhav R. Rajwade Faculty of Science & Technology Sd/-Sign of the Offg. Dean Prof. Shivram S. Garje Faculty of Science & Technology