AC – 28/03/2025 Item No. – 6.3 (N) (1ab) Sem. III & IV As Per NEP 2020

University of Mumbai



Syllabus for Minor Vertical 2 (Scheme – I and III)

Bo	ard of Studies in Mathematics		
Se	cond Year Programme in Minor (Mathematics)		
Se	mester		III & IV
Tit	le of Paper	Total Credits 4	
Ch	oose any one of the following:		
1	a) Calculus- III	III	2
	b) PM-3A Calculus III		2
OF	2		
2	a) Vector Spaces	III	2
	b) PM-3B Vector Spaces		2
OF	R		
3	a) Basic Mathematics in Real Life II	III	2
	b) PM-3C Basic Mathematics in Real Life II		2
Tit	le of Paper	Total Credits 4	
Ch	oose any one of the following:		
1	a) Calculus IV	IV	2
	b) PM-4A Calculus IV	IV	2
OF	R		
2	a) Linear Algebra	IV	2
	b) PM-4B Linear Algebra	IV	2
OF	R I I I I I I I I I I I I I I I I I I I	I	
3	a) Basic Mathematics in Real Life III	IV	2
	b) PM-4C Basic Mathematics in Real Life III	IV	2
	From the Academic Year	I	2025-26

Sem. - III

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

Name of the Course: Calculus III (Minor I)

Sr.	Heading Particulars		
No	Treating		
1	Description the course: Including but not limited to:	Calculus finds extensive 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	Type:	Theory	
4	Credits:	2 credits	
5	Hours Allotted:	(1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)30 Hours	
6	Marks Allotted:	50 Marks	
7	 Course Objectives (CO): This course provides an introduction to advanced concepts in analysis with a stron emphasis on rigor. It aims to prepare students for more advanced courses in abstract analysis. The focus of the course is on developing formal proof skills, which not onl deepens comprehension of the subject but also extends to broader applications i mathematics. CO1: Provide a solid understanding of fundamental principles and methods, equippin 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 problem solving skills, nurturing creative talents, and enhancing communication abilities, all o which are vital for a range of employment opportunities. CO4: Ensure exposure to both global and local issues within the realm of Mathematica 		

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 giver
	function.
	OC4: Justify/ check the integrability of function, absolute and conditional
	convergence of series.
	OC5: 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 R. Definition of convergence and divergence. Basic examples
	including geometric series. Elementary results such as if $\sum_{n=1}^{\infty} a_n$ is convergent the
	$a_n \rightarrow 0$ 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 Lower
	Riemann sums for a bounded real valued function defined on a closed and bounded
	interval in 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 (withou 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
	1. Ajit Kumar, S.Kumaresan; A Basic Course in Real Analysis; CRC Press, 2014

Wile	G. Bartle and D. R. Sher y, New Yorm, 1992.		to Real Analysis Second Ed.; John sis; Springer-Verlag, New York, 199
	Sc	cheme of the Exa	<u>mination</u>
The	performance of the learn	ers shall be evalua	ted in two parts.
	• Internal Continuous A		
•	• Semester End Examin		
		ssing is required f	for internal and semester-end
Into	examinations.	mont. 100/	Semester End Examination: 60%
inter	mai Continuous Assess	ment: 40%	Semester End Examination: 007
Cont	tinuous Evaluation thro	ough: Ouizzes.	
	s Tests, presentations, pr		
	ive writing, assignments		
(at le	ast 3)		
Sr.	Particulars	Marks	
No.			
1	A class test of 10	10	
	marks is to be		
	conducted during		
	each semester in an Offline mode.		
2	Project on any one	05	
2	topic related to the	05	
	syllabus or a quiz		
	(offline/online) on		
	one of the modules.		
3	Seminar/ group	05	
	presentation on any		
	one topic related to		
	the syllabus.]
wit	per pattern of the Test (h One hour duration):		
_	Definitions/Fill in the b e or False with Justificat		
	rks: 4 x 1).		
	Attempt any 2 from 3		
-	criptive questions. (06 r	narks: 2	
× 3) Format of Question Paper:			

	Note: Attempt any TWO questions out of THREE.		
Q.No.1	Module 1	Attempt any THREE out of FOUR .	15
	and 2	(Each question of 5 marks)	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 THREE out of FOUR .	15
	and 2	(Each question of 5 marks)	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 THREE out of FOUR .	15
	and 2	(Each question of 5 marks)	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: PM-3A Calculus III (Minor I)			
Sr.	Heading	Particulars		
No.				
1	Description the course: Including but not limited to:	Problem-solving is a fundamental aspect of any Mathematics course. While advanced courses often 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	Type:	Practical 2 and its		
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 7	Marks Allotted: Course Objectives (CO):	50 Marks		
8	 This course emphases on problem solving and motivates to think on the basic concepts of Algebra and Analysis with rigour and prepares students to study further courses. 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. These are necessary for various kinds of employment. CO4. To give adequate exposure to global and local concerns that would help learners explored many aspects of Mathematical Sciences. 			
o	 Course Outcomes (OC): After completion of the course, students will be able to OC1: Apply the formulae and concepts to solve the examples related to series, Riemann Integral, area between two curves etc. OC2: Analyze the convergence and divergence of series and integrability of given function. OC3: Justify/ check the integrability of function, absolute and conditional convergence of series. OC4: Construct counter examples related to absolutely convergent/ divergent series, non- 			
9				
2	Integrable functions etc. Modules: - Practical for Calculus III (30 Hours) 1. Convergent and divergent series and algebra of convergent series. 2. Comparison and limit comparison test. 3. Ratio test and root test. 4. Alternating Series and p-series test. 5. Absolute and conditional convergence.			

Nome of the Courses DM 3A Coloulus III (Minor I)

		n integral and its				
		ental Theorems		1 1 0		
		9. Area between two curves, lengths of plane curves and surface area of				
		of revolution.				
	10. Beta and	d Gamma functi	ons.			
10		l Reference Boo Ghorpade Balm		; A Course in Calculus and Real Analysi	s (secon	
		; Springer.		, A Course in Calculus and Real Analysi	is (second	
	· · · · · · · · · · · · · · · · · · ·	i e	s of Peal An	alysis; Oxford and IBH Pub. Co., New D	alhi	
	2. K.K. OC 1970.	nuberg, method	S OI Keal Alla	arysis, Oxford and IBH I do. Co., New D	enn,	
		s and Analytic (Geometry (Ni	nth Edition); Thomas and Finney; Addis	on-	
		, Reading Mass.	•	nui Eartion), Thomas and Thiney, Tradis	on	
	•	tol; Calculus Vo		ilev.		
			01. 2, 90111 V			
11	Additional Re		an: A Basic (Course in Real Analysis: CRC Press 201	Δ	
	 Ajit Kumar, S.Kumaresan; A Basic Course in Real Analysis; CRC Press, 2014 D. Somasundaram and B. Choudhary: A First Course in Mathematical Analysis 					
		 D. Somasundaram and B. Choudhary; A First Course in Mathematical Analysis, Narosa, New Delhi, 1996. 				
		 K. Stewart; Calculus, Booke/Cole Publishing Co, 1994. 				
	 K. Stewart, Calculus, Booke/Cole Lubising Co, 1994. J. E. Marsden, A.J. Tromba and A. Weinstein; Basic Multivariable Calculus; Springer. 					
	 F. E. Marsden, A.F. Homba and A. Weinstein, Base Multivariable Calculus, Springer. R.G. Bartle and D. R. Sherbert; Introduction to Real Analysis Second Ed. ; John 					
	Wiley, New Yorm, 1992.					
	 M. H. Protter; Basic Elements of Real Analysis; Springer-Verlag, New York, 1998. 					
	o. III. II. Hotel, Busic Elements of Real Hindrysis, Springer Verlag, Rew Tork, 1990.					
			Scheme of the	he Examination		
12	Internal Conti	nuous Assessm	ent: 40%	Semester End Examination: 60%		
13	Quizzes, Cla	v aluation throu ass Tests, presen lay, creative wri e.	itations,			
	Sr. Particul	ars	Marks			
	No. 1 Objectiv	ve question test	10			
		performance	05			
	3 Viva	Performance	05			
	Paper patter Mode):	n of the Test (O	Offline			
		ny 5 from 8) Mu	ultiple			
	choice questions. (10 marks: 5×2)					

	four MCQ or four MCQ or						
14	Format of Que	estion Pape	er:				
	and 30 marks s	he Semester shall be con-	r III, Practical examinations of thr ducted based on both the modules n paper shall have two questions.				
		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 × 2 = 10 Marks)			
	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.						

Name of the Course: Vector Spaces (Minor II)

Sr. No.	Heading	Particulars		
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	 Course Objectives (CO): 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. 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, remember the concepts and properties vector spaces. OC2: Apply the formulas and the concepts to solve examples 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	Modules: - Module 1: Vector spaces and subspa			
	 (a) Definition of a vector space over <i>R</i>. Examples such as: (i)Euclidean space <i>Rⁿ</i>. (ii) The space of <i>m</i> × <i>n</i> matrices over <i>R</i>. (iii)The space of polynomials with real coefficients. 			

	(b) Subspaces: definition, criterion for a nonempty 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, upper triangular, lower triangular,						
	and diagonal matrices.						
	(iv) The space of polynomials with real coefficients of degree $\leq n$.						
	(c) The sum, union and intersection of subspaces, direct sum of vector spaces. Cosets,						
	Introduction to quotient space. Module 2: System of linear equations, Linear combination, Basis of vector spaces (15						
	Hours)						
	 (a) (i) Introduction to linear systems, Matrix representation of the system of homogeneous and non-homogeneous linear equations, row echelon form, Gauss Elimination. (ii) Linear combination of vectors. 						
	(iii) Linear span of a subset of a vector space	е.					
	(iv) Linear dependence and independence of						
	(b) Basis of a vector space, Dimension of a	-					
	concepts is for finitely generated vector space	•					
	(c) (i) Row space, column space of a $m \times n$ matrix	rank and row rank, column rank					
	of a matrix.						
	(ii) Equivalence of row rank and column ra	ink, computing the rank of a matrix by					
	row reduction.						
10	Text Books						
	1. Kenneth Hoffman and Ray Kunze, Linear Algebra, 2nd edition, Pearson.						
	2. Howard Anton, Chris Rorres, Elementary Linear Algebra, Wiley Student Edition).						
	3. Serge Lang, Introduction to Linear Algebra, Springer.						
11	4. S Kumaresan, Linear Algebra: A Geometric Approach, PHI Learning.						
11	Reference Books						
	1. Sheldon Axler, Linear Algebra done right, Spri	•					
	 Gareth Williams, Linear Algebra with Applicat David W. Lewis, Matrix theory. 	uons, Jones and Bartieu Publishers.					
-	•	·					
	Scheme of the Exami	Scheme of the Examination					
	The performance of the learners shall be evaluated in two parts.						
1	-	-					
	 The performance of the learners shall be eva Internal Continuous Assessment of 20 mark 	-					
	 Internal Continuous Assessment of 20 mark Semester examination of 30 marks. 	28.					
	• Internal Continuous Assessment of 20 mark	28.					
12	 Internal Continuous Assessment of 20 mark Semester examination of 30 marks. A separate head of passing is required for ir 	ternal and semester-end examinations.					
12	 Internal Continuous Assessment of 20 mark Semester examination of 30 marks. 	28.					
	 Internal Continuous Assessment of 20 mark Semester examination of 30 marks. A separate head of passing is required for ir Internal Continuous Assessment: 40%	ternal and semester-end examinations.					
12 13	 Internal Continuous Assessment of 20 mark Semester examination of 30 marks. A separate head of passing is required for ir Internal Continuous Assessment: 40% Continuous Evaluation through: Quizzes, Class 	ternal and semester-end examinations.					
	 Internal Continuous Assessment of 20 mark Semester examination of 30 marks. A separate head of passing is required for ir Internal Continuous Assessment: 40% Continuous Evaluation through: Quizzes, Class Tests, presentations, projects, role play, creative 	ternal and semester-end examinations.					
	 Internal Continuous Assessment of 20 mark Semester examination of 30 marks. A separate head of passing is required for ir Internal Continuous Assessment: 40% Continuous Evaluation through: Quizzes, Class Tests, presentations, projects, role play, creative writing, assignments, etc. (at least 3) 	ternal and semester-end examinations.					
	 Internal Continuous Assessment of 20 mark Semester examination of 30 marks. A separate head of passing is required for ir Internal Continuous Assessment: 40% Continuous Evaluation through: Quizzes, Class Tests, presentations, projects, role play, creative writing, assignments, etc. (at least 3) Sr. Particulars Marks 	ternal and semester-end examinations.					
	 Internal Continuous Assessment of 20 mark Semester examination of 30 marks. A separate head of passing is required for ir Internal Continuous Assessment: 40% Continuous Evaluation through: Quizzes, Class Tests, presentations, projects, role play, creative writing, assignments, etc. (at least 3) Sr. Particulars Marks No. 	ternal and semester-end examinations.					
	 Internal Continuous Assessment of 20 mark Semester examination of 30 marks. A separate head of passing is required for ir Internal Continuous Assessment: 40% Continuous Evaluation through: Quizzes, Class Tests, presentations, projects, role play, creative writing, assignments, etc. (at least 3) Sr. Particulars Marks No. A class test of 10 marks is to 10 	ternal and semester-end examinations.					
	 Internal Continuous Assessment of 20 mark Semester examination of 30 marks. A separate head of passing is required for ir Internal Continuous Assessment: 40% Continuous Evaluation through: Quizzes, Class Tests, presentations, projects, role play, creative writing, assignments, etc. (at least 3) Sr. Particulars Marks No. 	as. Internal and semester-end examinations.					

	1 4 1 4 41	11 1			
	related to the				
	quiz (offline/or of the modules.	,			
	Seminar/group				
-	on any one top	-			
	the syllabus.	sic related to			
	the syndous.				
Paper	v pattern of the	Test (Offline Mode with			
-	Hour Duration				
		n the blanks/ True			
-		ation. (04 Marks:			
4 x 1)		``			
,		from 3 descriptive			
-	ns. (06 marks: 2	-			
Forma	t of Question F	aper:			
The semester-end examination will be of 30 marks of one-hour duration,					
coverin	· · ·	abus of the semester.			
Note: Attempt any TWO questions out of THREE.					
Q.No.		Attempt any THREE out of FOUR .	15 Marks		
	and 2	(Each question of 5 marks)			
		(a) Question based on OC1			
		(b) Question based on OC2			
		(c) Question based on OC3			
O N-	2 Madala 1	(d) Question based on OC4/OC5	15 Marks		
Q.No.	2 Module 1 and 2	Attempt any THREE out of FOUR . (Each question of 5 marks)	15 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 THREE out of FOUR .	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: PM-3B Vector Spaces (Minor II)

a		PMI-3B vector Spaces (Milnor II)		
Sr. No.	Heading	Particulars		
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		
7	its soutions. Also, it deals we examples and dealing with find CO1. To give sufficient know perception of numerous power them by modelling, solving, an CO2. To reflect the broad nate continuing further study in var CO3. To enhance students' o talent, and the power of comployment. CO4. To give adequate exposu explore many aspects of Mathematical continuing further study in the power of the comployment.	ledge of fundamental principles, methods, and a clear s of mathematical ideas and tools and the skills to use ad interpreting. ure of the subject and develop mathematical tools for ious fields of sciences. verall development, problem-solving skills, creative ommunication are necessary for various kinds of re to global and local concerns that would help learners		
8	Course Outcomes (OC): After completion of the course, students will be able to OC1: Apply the formulas and the concepts to solve examples related to vector spaces. 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: -			
	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 space4.Subspaces of Polynomial space5.Subspaces of Matrix space6.Sum of subspaces7.Intersection of subspaces8.Union of subspaces			

	9. 10.	Direct sum of subspaces Cosets, Quotient spaces								
		I A C INFINITY								
	Module 2: System of linear equations, Linear combination, Basis of vector spaces (30 Hours)									
	1. System of linear equations									
	2.	Linear combination of vect	ors							
	3.	Linear span of vectors in ve	ector spaces							
	4.	Linear dependence.								
	5.	Linear independence.								
	6.	Standard Basis of vector sp	baces.							
	7.	Basis of vector spaces								
	8. 9.	Dimension of vector spaces Row rank and column rank								
	<i>9</i> . 10.	Computing rank of matrix								
10		Books	by fow feduce							
11	 Serge Lang, Introduction to Linear Algebra, Springer. S Kumaresan, Linear Algebra: A Geometric Approach, PHI Learning. Reference Books Sheldon Axler, Linear Algebra done right, Springer. Gareth Williams, Linear Algebra with Applications, Jones and Bartlett Publishers. David W. Lewis, Matrix theory. 									
		Scher	ne of the Ex	amination						
2	Inter	nal Continuous Assessme	ent: 40%	Semester End Examination: 60%						
13	Qu projec	inuous Evaluation throug nizzes, Class Tests, present cts, role play, creative writi nments, etc. ast 3)	ations,							
	Sr. No.	Particulars	Marks							
	1	Objective question test	10							
	2	Overall performance	05							
	3	Viva	05							
	Рар	er pattern of the Test (Of	ffline							

paper, f	ting the qu our MCQs	estion on module on module 2		
	f Question of examina	-		
		er III, Practical examinations of		
and 30 ma	arks shall b	e conducted based on both mod	dules.	
Domany	tom The -	notion nonor shall have to	nationa	
Paper pat	tern: The q	uestion paper shall have two q	uestions.	
		Five out of Eight multiple	-	
		choice questions (four from		
	Q. No.	module 1 and four from	n $(3 \times 5 = 15)$	
	1	module 2)	Marks)	
		(OC1 to OC3)		
		Attempt any Two out of		
	Q.	Four (two from module 1	$(5 \times 2 = 10)$	
	No.2	and two from module 2).	Marks)	
		(OC3 and OC4)		
Marks for	Journals:			
For both M	Module 1 a	nd Module 2,		
		(2.5 marks for each module 1	& module 2)	
	-	uired to perform 75% of the pr	5	
		nts are required to present a du	•	
at the pra	actical exar	nination, failing which they wi	II not be allowed to app	pear for

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

		or 111)
Sr. No.	Heading	Particulars
1	Description of the course: Including but not limited to:	To demonstrate the importance of mathematics in real life by considering interdisciplinary applications of basic concepts in real life.
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	crucial role of mathematics in other scie will be able to see mathematics being a CO1: To develop methods for polynon CO2: To identify row echelon form an CO3: To associate mathematical notation management. CO4: To recognize the role of geometr	the basic concepts of mathematics, which highlights the ences. In this course, students from various science streams applied in their area of interest and learn nial interpolation. d row reduced echelon form for matrices. on for solving real-life problems like those related to forest ry (in particular Platonic solids) in science streams.
8	platonic solids and Matrices OC2: Apply the formulas and concepts equations recurrence relations, matrice OC3: Examine and investigate the grow Law using matrices.	blynomials, polynomial graphs, Fibonacci sequence, s to solve problems and examples related to quadratic s and platonic solids wth matrices, echelon form of matrices, and Kirchhoff's matrices and applications of the golden ratio.
9	 Relation between roots and coefficient polynomial of degree three (some spect 4. Fibonacci numbers: motivation and 5. Sunflower and Golden ratio. Polynomial interpolation: Statement degree two. 	ions for repeated roots, discriminant ree two when roots are real. Example: (monic; not monic) ents of a polynomial (degree two), plotting ific examples). recurrence relation. Simple examples of recurrence. of the problem and motivation; calculation in d multiplication formula for two matrices under

	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).
	 Kirchoff's laws and explicit examples. 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.
	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.
	 Semester-end examination of 50 marks. A separate head of passing is required for internal and semester-end examinations.
	• A separate nead of passing is required for internal and semester-end examinations.
12	Internal Continuous Assessment: 40% Semester End Examination: 60%

105			on through: Q ojects, role pla								
		ssignments, e		ay, cleativ	e						
	least 3	-	ite.								
Sr		, rticulars		Marks							
No											
1	be	conducted	0 marks is to during each Offline mode.	10							
2	Pro rel qu	oject on an ated to the iz (offline/or	y one topic syllabus or a nline) on one	05							
3	Se on	0 1	presentation bic related to	05							
Q1: 07 (0	ne Ho Defini False 4 Mar	ur Duration	the blanks/ Tru ation.	ıe	ith						
qu	rmat o	s. (06 marks: f Question P	2 × 3)								
qu	rmat o	is. (06 marks: f Question P he semester-e	2 × 3)	on will be			of one I	hour d	uration	,	
qu	rmat o	s. (06 marks: f Question P he semester-e covering th	2×3) Paper: and examination	on will be us of the s	semes	ster.				,	
For	rmat o	s. (06 marks: f Question P he semester-e covering th	2 × 3) Paper: end examination e entire syllab ote: Attempt any (Each questing) (a) Questing) (b) Questing) (c) Questin	on will be us of the s my TWO THREE on of 5 m tion based tion based	eemess quess out o arks) l on (l on (l on (ster. stions of of FOUE DC1 DC2 DC3	<u>ut of T</u> R.			,	
qu For Q.	rmat o Tl .No.1	s. (06 marks: f Question P he semester-e covering th No Module 1 and 2	2 × 3) Paper: end examination te entire syllab ote: Attempt any (Each questing (a) Questing (b) Questing (c) Questing	on will be us of the s my TWO THREE on of 5 m tion based tion based tion based	eemessemess out o arks) d on (d on (d on (d on (ster. stions of of FOUE DC1 DC2 DC3 DC4/OC	ut of T R.		Е <u>.</u> 15 Ма	rks	
qu For Q.	rmat o Tl	s. (06 marks: f Question P he semester-e covering th No Module 1	2 × 3) Paper: end examination e entire syllab ote: Attempt any (Each questing (a) Questing (b) Questing (c) Questing	on will be us of the s my TWO THREE on of 5 m tion based tion based tion based THREE on of 5 m tion based	emes out o arks) l on (l on (l on (l on (out o arks) l on (ster. stions of of FOUF DC1 DC2 DC3 DC4/OC of FOUF DC1	ut of T R.		Ε.	rks	
qu For Q.	rmat o Tl .No.1	s. (06 marks: f Question P he semester-e covering th <u>No</u> Module 1 and 2 Module 1	2 × 3) Paper: end examination e entire syllab ote: Attempt any (Each questing (a) Questing (b) Questing (c) Questing	on will be us of the s my TWO THREE on of 5 m tion based tion based tion based tion based tion based tion based tion based tion based tion based	emes ques out o arks) l on (l on (l on (out o arks) l on (l on (l on (ster. stions of of FOUE DC1 DC2 DC3 DC4/OC of FOUE DC1 DC2 DC2 DC3	ut of T R. 25 R.		Е <u>.</u> 15 Ма	rks	
qu For Q. Q. Q.	rmat o Tl .No.1	s. (06 marks: f Question P he semester-e covering th <u>No</u> Module 1 and 2 Module 1	2 × 3) Paper: end examination e entire syllab ote: Attempt any (Each questi (a) Ques (b) Ques (c) Ques (d) Ques (d) Ques (b) Ques (c) Ques (c) Ques (c) Ques (c) Ques (c) Ques (d) Ques (c)	on will be us of the s my TWO THREE on of 5 m tion based tion based tion based tion based tion based tion based tion based tion based tion based	emess quess out o arks) l on (l on (l on (d on (d on (l on (d on ()))))))))))))))))))))))))))))))))))	ster. stions of of FOUE DC1 DC2 DC3 DC4/OC of FOUE DC1 DC2 DC3 DC2 DC3 DC4/OC of FOUE	ut of T R. 25 R.		Е <u>.</u> 15 Ма	rks	

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

		(Minor III)
Sr. No.	Heading	Particulars
1	Description of the course: Including but not limited to:	To demonstrate the importance of mathematics in real life by considering interdisciplinary 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 7	Marks Allotted: Course Objectives (CO):	50 Marks
	This course is a balanced m highlights the crucial role of from various science streams area of interest and learn CO1: To develop methods fo CO2: To identify row echelon CO3: To associate mathema related to forest management	n form and row reduced echelon form for matrices. tical notation for solving real-life problems like those
8	and examples related to polyn relations. OC2: analyse the solutions of OC3: Check the relation betw the Hardy-Weinberg principle	concepts to solve interpolation problems, problems, nomials up to degree three, equations of recurrence the system of linear equations and graphs yeen non-planar graphs and Euler's formula and verify
9	Modules: -	lynomials and Interpolation (30 Hours)
	1.Computing roots for q2.Plotting polynomials q3.Setting up Recurrence4.Polynomial Interpolat	of degree at most three. Relations.
	 Multiplication of math Computation of Row- Computation of Row- matrices. 	*
	 Multiplication of math Computation of Row- Computation of Row- matrices. 	ices of arbitrary sizes. Echelon Form in 2 by 2 and 3 by 3 matrices. Reduced-Echelon Form in 2 by 2 and 3 by 3 f 2 by 2 matrices and 3 by 3 matrices.

		lle 2: Practicals for Appli onic solids (30 Hours)	cations of li	near systems and introduction to
		Γ		
	1.	Kirchhoff's Law in Comp	-	
	2.	Computing cofactors of 2	-	
	3.	Computing adjoint and in		
	4.	Computing the adjoint an		
	5.			ns of equations using matrices.
	6.	Examples in n by n matrie	ces to Systen	n of Linear Equations.
	7.	Euler's Formula via Exam	nples.	
	8.	Planar Figures and Graph	s, Definition	and Examples.
	9.	Non-Planar Figures and F	Relation to E	uler's Formula.
	10.	Problems based on the Ha		
10	Text	Books:	5	
	1.	Artin, Algebra, Pearson,	Second Editi	on.
		-		on Version, H. Anton, C. Rorres,
	2.	• •	na Applicatio	on version, II. Anton, C. Rones,
		Wiley, Tenth Edition.		
11	Refer	ence Books:		
	1.	Contemporary Abstract A	Algebra, J. A.	. Gallian, Narosa publishing house.
	2.	Tipler, Paul (2004). Phys	ics for Scien	tists and Engineers: Electricity,
		Magnetism, Light, and E	lementary M	odern Physics (5th ed.). W. H.
		Freeman.		
		Precinan.		
		Schen	ne of the Exa	mination
12	Inter	nal Continuous Assessme	nt: 40%	Semester End Examination: 60%
13	Conti	nuous Evaluation throug	h:	
		izzes, Class Tests, presenta		
	-	cts, role play, creative writi		
		iments, etc.	U,	
	(at lea			
	(
	Sr.	Particulars	Marks	
	No.	i urtioururb	ivital R5	
	1	Objective question test	10	
	2	* *	05	
		Overall performance		
	3	Viva	05	
	Pap	er pattern of the Test (Of	fline	
	Mod	-		
		ttempt any 5 from 8) Multi	nle	
			-	
	cnoi	ce questions. (10 marks: 5	× 2)	
	Dura	ation: 1Hrs		
	**71 *1	a gatting the quastion		
	Whi	e setting the question		
		er, four MCQs on module	•	

	both.		
4	Format of Question Scheme of examina	-	
		nester III, Practical examinations e conducted based on both the mo	
	Paper pattern: The qu	lestion paper shall have two quest	ions.
	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 Journals	-	
		(2.5 marks for each module 1 & r	nodule 2)
	certified. The stude	nired to perform 75% of the practing nts are required to present a duly of nination, failing which they will r	certified journal for appea

Sem. – IV

Name of the Course: Calculus IV (Minor I)

C		Derticulars
Sr.	Heading	Particulars
No. 1	Description the course: Including but not limited to:	Calculus finds extensive applications in diverse fields 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. To 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.
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	variables and the principles of differ calculus. CO1 : To develop the understanding proficiency in working with real-value CO2 : To demonstrate competence in of limits and continuity to scalar fields CO3 : To define and compute partial ar and \mathbb{R}^3 , and understand the Mean Valu CO4 : To explore the basic properties o of partial derivatives, and differentiabi CO5 : To utilize concept of differ understanding of tangent planes and m CO6 : To understand higher-order partific Partial Derivatives Theorem, Taylor's T	analyzing neighbourhoods in \mathbb{R}^n and applying concepts and directional derivatives of scalar fields, focusing on \mathbb{R}^2 be Theorem for scalar fields. If differentiability, such as continuity at a point, existence lity when partial derivatives exist and are continuous. erentiation for practical applications, including the
8	product, limit, continuity, derivative OC2 : apply first and second derivati	ne concepts such as Euclidean spaces, norm, inner

9	derivative and continuity, partial derivatives and total derivative etc. Iodules: -
9	Iodules: - Iodule 1: Functions of Several Variables (15 Lectures)
	1 Review of vectors in \mathbb{R}^n [with emphasis on \mathbb{R}^2 and \mathbb{R}^3] and basic notions such addition and scalar multiplication, inner product, length (norm) and distance betwee two points.
	2 Real-valued functions of several variables (Scalar fields). Graph of a function. Le sets (level curves, level surfaces, etc). Examples. Vector valued functions of sev variables (Vector fields). Component functions. Examples.
	3 Sequence in \mathbb{R}^n [with emphsis on \mathbb{R}^2 and \mathbb{R}^3] and their limits. Neighbourhoods in Limits and continuity of scalar fields. Sequential characterizations (without pro Composition of continuous functions. Algebra of limits and continuity (Results v proofs). Iterated and simultaneous limits of scalar fields. Limits and continuity of ve fields. Algebra of limits and continuity of vector fields. (without proofs).
	4 Partial derivatives, directional derivatives and gradient of scalar fields (with emph on \mathbb{R}^2 and \mathbb{R}^3). Existence of directional derivative implies continuity. Mean Va Theorem for scalar fields.
	5 Differentiability of scalar fields (in terms of linear transformation). Concept of t derivative and its uniqueness, basic results such as (i) continuity at a point differentiability, (ii)existence of partial derivatives at a point of differentiability and differentiability when the partial derivatives exist and are continuous.
	Iodule 2: Applications of Differentiability (15 Lectures)
	1 Relation between total derivative and gradient of a function. Chain rule (without pro Geometric properties of gradient. Tangent planes.
	2 Euler's Theorem, Higher order partial derivatives. Mixed Partial Derivatives Theo (n=2).
	3 Taylor's Theorem for twice continuously differentiable functions (without proof).
	4 The maximum and minimum rate of change of scalar fields. Notions of local maxi local minima and saddle points. First Derivative Test. Examples. Hessian matrix. Sec Derivative Test for functions of two variables (statement only). Examples. Method Lagrange Multipliers.
10	ecommended Reference Books:
	T. Apostol; Calculus, Vol. 2 (Second Edition); John Wiley.
	Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariable Calculus and Analysis Second Edition); Springer.
	Walter Rudin; Principles of Mathematical Analysis; McGraw-Hill, Inc.
	J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus; Springer.
	D. Somasundaram and B. Choudhary; A First Course in Mathematical Analysis, Narosa ew Delhi, 1996.
	K. Stewart; Calculus; Booke/Cole Publishing Co, 1994.
11	dditional Reference Books
	Calculus and Analytic Geometry, G.B. Thomas and R. L. Finney, (Ninth Edition); Addis

	Wesley, 1998.								
	2. Howard Anton; Calculus- A new	Horizon, (Six	th Edition); John Wi	ley and Sons I	nc, 1999.				
	3. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Calculus; University Press of Florida, 2012.								
	4. S C Malik and Savita Arora; Math	nematical An	alysis; New Age Inte	rnational Publ	ishers.				
	Sche	me of the Ex	amination						
	The performance of the learn	ners shall be	evaluated in two part	S.					
	Internal Continuous Assessr	nent of 20 ma	-						
	Semester End ExaminationA separate head of passing i		internal and semeste	er-end examina	tions.				
12	Internal Continuous Assessment:	40%	Semester End E	xamination: (60%				
13	Continuous Evaluation through: (- ,	5						
	Tests, presentations, projects, role province of writing, assignments etc.	lay, creative							
	(at least 3)	Maulto							
	Sr. Particulars No.	Marks							
	1 A class test of 10 marks is to								
	be conducted during each semester in an Offline mode.								
	2 Project on any one topic								
	related to the syllabus or a								
	quiz (offline/online) on one of the modules.								
	3 Seminar/ group presentation								
	on any one topic related to the syllabus.								
	the synabus.								
	Paper pattern of the Test (Offlin	e Mode with							
	One hour duration): Q1: Definitions/Fill in the blanks/ T	rue							
	or False with Justification.								
	(04 Marks: 4 x 1). Q2: Attempt any 2 from 3 descriptiv	ve.							
	questions. (06 marks: 2×3)	<u> </u>							
14	Format of Question Paper: The semester-end examinati	on will be of	20 marks of one hou	r duration agus	wing the				
	entire syllabus of the semester		SO marks of one nou		ang me				
			estions out of THRI	EE.					
	Q.No.1 Module Attempt any T	HREE out o	f FOUR.	15 Marks					
	1 and 2 (Each question	n of 5 marks)							
		on based on (on based on (
		on based on (
	(d) Questi	on based on (DC4/OC5						

Q.No.2	Module	Attempt any THREE out of FOUR .	15 Marks
	1 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	Attempt any THREE out of FOUR .	15 Marks
	1 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: PM-4A Calculus IV (Minor I)

Inclustor2Vert3Type4Cred5Hour6Mari7Cour6Mari7Cour6Mari7Cour6Mari7Cour6Mari7Cour6Mari6Mari7Cour6Mari7Cour6Mari7Cour6Mari7Cour6Mari7Cour6Mari7Cour6Mari7Cour6After00Our01Our02Our03Our04Our05Our05Our06Our <th>Heading</th> <th>Particulars</th>	Heading	Particulars			
1Desc Inclu to:2Inclu to:2Vert3Type4Cred5Hour6Mari7Cour6Mari7Cour6Mari7Cour6Mari7Cour6Mari7Cour6Mari7Cour6Mari7Cour6Mari7Cour6Mari7Cour6Mari7Cour6Mari7Cour6Mari7Cour6Mari7Cour6After00Our01Our9Mod9Mod	Heading	Falticulais			
3Type4Cred5Hour6Mari7Cour7Cour6Mari7Cour7Cour0CO0CO1CO0CO1CO <trr>1CO1CO<trr></trr></trr>	Description the course: Including but not limited	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.			
4Cred5Hour6Mari7Cour7Cour7Cour00Cour00Cour8Cour00Cour01Cour02Cour03Cour04Cour05Cour06Cour07Cour08Cour09Mod00Cour00Cour01Cour02Cour03Cour04Cour05Cour06Cour07Cour08Cour09Cour00Cour00Cour01Cour02Cour03Cour04Cour05Cour06Cour07Cour08Cour09Cour	Vertical:	Minor			
5Hour6Mari7Cour7Cour7Cour00CO01CO02CO03CO04CO05CO100CO101CO102CO103CO104CO104CO105CO105CO106CO107CO108Cour109Mod100Prace	Гуре:	Practical			
6Mar7Com7Com1equCOperuseCOconConconCon </th <th>Credits:</th> <th>2 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)</th>	Credits:	2 credits (1 credit = 15 Hours for Theory or 30 Hours of Practical work in a semester)			
7Coun Thi equ CO per use CO con CO con CO tal em CO tal em CO tal em CO tal em CO tal em CO tal em CO tal em CO tal em CO tal em CO tal em 	Hours Allotted:	30 Hours			
ThiequCOperUseCOconCOtalemCOlea8ComAfterOOOOderOOOOdi9ModPrace	Marks Allotted:	50 Marks			
After OC OC der OC OC di 9 Mod Prac	 This course introduces basic concepts of Calculus, Linear Algebra and different equation with rigour and prepares students to study further courses. CO1. To give sufficient knowledge of fundamental principles, methods, and a cle perception of numerous powers of mathematical ideas and tools and the skills use them by modelling, solving and interpreting. CO2. To reflect the broad nature of the subject and develop mathematical tools to continuing further study in various fields of sciences. CO3. To enhance students' overall development, problem solving skills, creati talent, and power of communication, which are necessary for various kinds employment. CO4. To give adequate exposure to global and local concerns that would he learners explore many aspects of Mathematical Sciences. 				
	 Course Outcomes (OC): After completion of the course, students will be able OC1: apply first and second derivative tests to find extreme values of scalar fields OC2: verify the relationship between Differentiability and Continuity, directional derivative and continuity etc. OC3: check differentiability and continuity of scalar and vector fields. OC4: create counter examples related to continuity and differentiability, directional derivative and continuity, partial derivatives and total derivative etc. Modules: - Practical for Calculus IV (30 Hours) 				
2. 3. 4.	iterated limits. 2. Directional derivatives, partial derivatives and mean value theorem of scalar fields. 3. Differentiability of scalar field and Total derivative.				

5. Chain rule, higher order partial derivatives and mixed partial d scalar fields. 6. Maximum and minimum rate of change of scalar fields. Findir Hessian/Jacobian matrix. 7. Taylor's Theorem. 8. Finding maxima, minima and saddle points. Second derivative extrema of functions of two variables and method of Lagrange 9. Wronskian and linear independence of solutions. 10. Higher order homogeneous linear differential equations with c coefficients. 10 Text Books 1. Apostol; Calculus, Vol. 2 (Second Edition); John Wiley. 2. Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariabl Analysis (Second Edition); Springer. 3. Walter Rudin; Principles of Mathematical Analysis; McGraw- 4. J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivar Springer. 5. D. Somasundaram and B.Choudhary; A First Course in Analysis, Narosa New Delhi, 1996. 6. K. Stewart; Calculus; Booke/Cole Publishing Co, 1994. 11 Reference Books 1. Calculus and Analytic Geometry, G.B. Thomas and R. L. Finr Edition); Addison-Wesley, 1998. 2. Howard Anton; Calculus- A new Horizon, (Sixth Edition); Jol Sons Inc, 1999. 3. S L Gupta and Nisha Rani; Principles of Real Analysis;	g test for multipliers. onstant e Calculus and Hill, Inc. able Calculus;
 Maximum and minimum rate of change of scalar fields. Findir Hessian/Jacobian matrix. Taylor's Theorem. Finding maxima, minima and saddle points. Second derivative extrema of functions of two variables and method of Lagrange Wronskian and linear independence of solutions. Higher order homogeneous linear differential equations with c coefficients. Higher order homogeneous linear differential equations with c coefficients. Apostol; Calculus, Vol. 2 (Second Edition); John Wiley. Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariabl Analysis (Second Edition); Springer. Walter Rudin; Principles of Mathematical Analysis; McGraw- J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivar Springer. D. Somasundaram and B.Choudhary; A First Course in Analysis, Narosa New Delhi, 1996. K. Stewart; Calculus; Booke/Cole Publishing Co, 1994. Reference Books Calculus and Analytic Geometry, G.B. Thomas and R. L. Finr Edition); Addison-Wesley, 1998. Howard Anton; Calculus- A new Horizon, (Sixth Edition); Jol Sons Inc, 1999. S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers. 	test for multipliers. onstant e Calculus and Hill, Inc. able Calculus;
Hessian/Jacobian matrix. 7. Taylor's Theorem. 8. Finding maxima, minima and saddle points. Second derivative extrema of functions of two variables and method of Lagrange 9. Wronskian and linear independence of solutions. 10. Higher order homogeneous linear differential equations with c coefficients. 10 Text Books 1. Apostol; Calculus, Vol. 2 (Second Edition); John Wiley. 2. Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariabl Analysis (Second Edition); Springer. 3. Walter Rudin; Principles of Mathematical Analysis; McGraw- 4. J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivar Springer. 5. D. Somasundaram and B.Choudhary; A First Course in Analysis, Narosa New Delhi, 1996. 6. K. Stewart; Calculus; Booke/Cole Publishing Co, 1994. 11 Reference Books 1. Calculus and Analytic Geometry, G.B. Thomas and R. L. Finr Edition); Addison-Wesley, 1998. 2. Howard Anton; Calculus- A new Horizon, (Sixth Edition); Jol Sons Inc, 1999. 3. S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. 4. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. 5. S C Malik and Savita Arora; Mathematical Analysis; New	test for multipliers. onstant e Calculus and Hill, Inc. able Calculus;
 8. Finding maxima, minima and saddle points. Second derivative extrema of functions of two variables and method of Lagrange 9. Wronskian and linear independence of solutions. 10. Higher order homogeneous linear differential equations with c coefficients. 10 Text Books Apostol; Calculus, Vol. 2 (Second Edition); John Wiley. Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariabl Analysis (Second Edition); Springer. Walter Rudin; Principles of Mathematical Analysis; McGraw- J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivar Springer. D. Somasundaram and B.Choudhary; A First Course in Analysis, Narosa New Delhi, 1996. K. Stewart; Calculus; Booke/Cole Publishing Co, 1994. 11 Reference Books Calculus and Analytic Geometry, G.B. Thomas and R. L. Finr Edition); Addison-Wesley, 1998. Howard Anton; Calculus- A new Horizon, (Sixth Edition); Jol Sons Inc, 1999. S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers. 	multipliers. onstant e Calculus and Hill, Inc. able Calculus;
 extrema of functions of two variables and method of Lagrange 9. Wronskian and linear independence of solutions. 10. Higher order homogeneous linear differential equations with c coefficients. 10 Text Books Apostol; Calculus, Vol. 2 (Second Edition); John Wiley. Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariabl Analysis (Second Edition); Springer. Walter Rudin; Principles of Mathematical Analysis; McGraw-4. J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivari Springer. D. Somasundaram and B.Choudhary; A First Course in Analysis, Narosa New Delhi, 1996. K. Stewart; Calculus; Booke/Cole Publishing Co, 1994. 11 Reference Books Calculus and Analytic Geometry, G.B. Thomas and R. L. Finr Edition); Addison-Wesley, 1998. Howard Anton; Calculus- A new Horizon, (Sixth Edition); Jol Sons Inc, 1999. S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers. 	multipliers. onstant e Calculus and Hill, Inc. able Calculus;
9. Wronskian and linear independence of solutions. 10. Higher order homogeneous linear differential equations with c coefficients. 10 Text Books 1. Apostol; Calculus, Vol. 2 (Second Edition); John Wiley. 2. Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariabl Analysis (Second Edition); Springer. 3. Walter Rudin; Principles of Mathematical Analysis; McGraw-4. 4. J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivari Springer. 5. D. Somasundaram and B.Choudhary; A First Course in Analysis, Narosa New Delhi, 1996. 6. K. Stewart; Calculus; Booke/Cole Publishing Co, 1994. 11 Reference Books 1. Calculus and Analytic Geometry, G.B. Thomas and R. L. Finr Edition); Addison-Wesley, 1998. 2. Howard Anton; Calculus- A new Horizon, (Sixth Edition); Jol Sons Inc, 1999. 3. S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. 4. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. 5. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers.	onstant e Calculus and Hill, Inc. able Calculus;
 Higher order homogeneous linear differential equations with c coefficients. Text Books Apostol; Calculus, Vol. 2 (Second Edition); John Wiley. Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariabl Analysis (Second Edition); Springer. Walter Rudin; Principles of Mathematical Analysis; McGraw- J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivar Springer. D. Somasundaram and B.Choudhary; A First Course in Analysis, Narosa New Delhi, 1996. K. Stewart; Calculus; Booke/Cole Publishing Co, 1994. Reference Books Calculus and Analytic Geometry, G.B. Thomas and R. L. Finr Edition); Addison-Wesley, 1998. Howard Anton; Calculus- A new Horizon, (Sixth Edition); Jol Sons Inc, 1999. S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers. 	e Calculus and Hill, Inc. able Calculus;
 coefficients. 10 Text Books Apostol; Calculus, Vol. 2 (Second Edition); John Wiley. Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariabl Analysis (Second Edition); Springer. Walter Rudin; Principles of Mathematical Analysis; McGraw- J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivar Springer. D. Somasundaram and B.Choudhary; A First Course in Analysis, Narosa New Delhi, 1996. K. Stewart; Calculus; Booke/Cole Publishing Co, 1994. 11 Reference Books Calculus and Analytic Geometry, G.B. Thomas and R. L. Finr Edition); Addison-Wesley, 1998. Howard Anton; Calculus- A new Horizon, (Sixth Edition); Jol Sons Inc, 1999. S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers. 	e Calculus and Hill, Inc. able Calculus;
 10 Text Books Apostol; Calculus, Vol. 2 (Second Edition); John Wiley. Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariabl Analysis (Second Edition); Springer. Walter Rudin; Principles of Mathematical Analysis; McGraw- J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivar Springer. D. Somasundaram and B.Choudhary; A First Course in Analysis, Narosa New Delhi, 1996. K. Stewart; Calculus; Booke/Cole Publishing Co, 1994. 11 Reference Books Calculus and Analytic Geometry, G.B. Thomas and R. L. Finr Edition); Addison-Wesley, 1998. Howard Anton; Calculus- A new Horizon, (Sixth Edition); Jol Sons Inc, 1999. S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers. 	Hill, Inc. able Calculus;
 Apostol; Calculus, Vol. 2 (Second Edition); John Wiley. Sudhir Ghorpade, Balmohan Limaye; A Course in Multivariabl Analysis (Second Edition); Springer. Walter Rudin; Principles of Mathematical Analysis; McGraw- J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivar Springer. D. Somasundaram and B.Choudhary; A First Course in Analysis, Narosa New Delhi, 1996. K. Stewart; Calculus; Booke/Cole Publishing Co, 1994. Reference Books Calculus and Analytic Geometry, G.B. Thomas and R. L. Finr Edition); Addison-Wesley, 1998. Howard Anton; Calculus- A new Horizon, (Sixth Edition); Jol Sons Inc, 1999. S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers. 	Hill, Inc. able Calculus;
 Analysis (Second Edition); Springer. Walter Rudin; Principles of Mathematical Analysis; McGraw- J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivari Springer. D. Somasundaram and B.Choudhary; A First Course in Analysis, Narosa New Delhi, 1996. K. Stewart; Calculus; Booke/Cole Publishing Co, 1994. 11 Reference Books Calculus and Analytic Geometry, G.B. Thomas and R. L. Finr Edition); Addison-Wesley, 1998. Howard Anton; Calculus- A new Horizon, (Sixth Edition); Jol Sons Inc, 1999. S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers. 	Hill, Inc. able Calculus;
 Analysis (Second Edition); Springer. Walter Rudin; Principles of Mathematical Analysis; McGraw- J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivari Springer. D. Somasundaram and B.Choudhary; A First Course in Analysis, Narosa New Delhi, 1996. K. Stewart; Calculus; Booke/Cole Publishing Co, 1994. 11 Reference Books Calculus and Analytic Geometry, G.B. Thomas and R. L. Finr Edition); Addison-Wesley, 1998. Howard Anton; Calculus- A new Horizon, (Sixth Edition); Jol Sons Inc, 1999. S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers. 	Hill, Inc. able Calculus;
 Walter Rudin; Principles of Mathematical Analysis; McGraw- J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivari Springer. D. Somasundaram and B.Choudhary; A First Course in Analysis, Narosa New Delhi, 1996. K. Stewart; Calculus; Booke/Cole Publishing Co, 1994. Reference Books Calculus and Analytic Geometry, G.B. Thomas and R. L. Finr Edition); Addison-Wesley, 1998. Howard Anton; Calculus- A new Horizon, (Sixth Edition); Jol Sons Inc, 1999. S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers. 	able Calculus;
 J. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivari Springer. D. Somasundaram and B.Choudhary; A First Course in Analysis, Narosa New Delhi, 1996. K. Stewart; Calculus; Booke/Cole Publishing Co, 1994. Reference Books Calculus and Analytic Geometry, G.B. Thomas and R. L. Finr Edition); Addison-Wesley, 1998. Howard Anton; Calculus- A new Horizon, (Sixth Edition); Jol Sons Inc, 1999. S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers. 	able Calculus;
 Springer. 5. D. Somasundaram and B.Choudhary; A First Course in Analysis, Narosa New Delhi, 1996. 6. K. Stewart; Calculus; Booke/Cole Publishing Co, 1994. 11 Reference Books Calculus and Analytic Geometry, G.B. Thomas and R. L. Finr Edition); Addison-Wesley, 1998. Howard Anton; Calculus- A new Horizon, (Sixth Edition); Jol Sons Inc, 1999. S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers. 	
 D. Somasundaram and B.Choudhary; A First Course in Analysis, Narosa New Delhi, 1996. K. Stewart; Calculus; Booke/Cole Publishing Co, 1994. Reference Books Calculus and Analytic Geometry, G.B. Thomas and R. L. Finr Edition); Addison-Wesley, 1998. Howard Anton; Calculus- A new Horizon, (Sixth Edition); Joh Sons Inc, 1999. S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers. 	Mathematical
 Analysis, Narosa New Delhi, 1996. 6. K. Stewart; Calculus; Booke/Cole Publishing Co, 1994. 11 Reference Books Calculus and Analytic Geometry, G.B. Thomas and R. L. Finr Edition); Addison-Wesley, 1998. Howard Anton; Calculus- A new Horizon, (Sixth Edition); Joh Sons Inc, 1999. S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers. 	
 K. Stewart; Calculus; Booke/Cole Publishing Co, 1994. Reference Books Calculus and Analytic Geometry, G.B. Thomas and R. L. Finr Edition); Addison-Wesley, 1998. Howard Anton; Calculus- A new Horizon, (Sixth Edition); Joh Sons Inc, 1999. S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers. 	
 Reference Books Calculus and Analytic Geometry, G.B. Thomas and R. L. Finr Edition); Addison-Wesley, 1998. Howard Anton; Calculus- A new Horizon, (Sixth Edition); Jol Sons Inc, 1999. S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers. 	
 Calculus and Analytic Geometry, G.B. Thomas and R. L. Finr Edition); Addison-Wesley, 1998. Howard Anton; Calculus- A new Horizon, (Sixth Edition); Joh Sons Inc, 1999. S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers. 	
 Edition); Addison-Wesley, 1998. 2. Howard Anton; Calculus- A new Horizon, (Sixth Edition); Joh Sons Inc, 1999. 3. S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. 4. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. 5. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers. 	
 Howard Anton; Calculus- A new Horizon, (Sixth Edition); Joh Sons Inc, 1999. S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers. 	ey, (Ninth
 Sons Inc, 1999. 3. S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. 4. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. 5. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers. 	n Wiley and
 S L Gupta and Nisha Rani; Principles of Real Analysis; Vikas house PVT LTD. Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers. 	in whey and
 Shabanov, Sergei; Concepts in Calculus, III: Multivariable Ca University Press of Florida, 2012. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers. 	Publishing
University Press of Florida, 2012. 5. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers.	
5. S C Malik and Savita Arora; Mathematical Analysis; New Ag Publishers.	culus;
Publishers.	International
	mernational
Scheme of the Examination	
12 Internal Continuous Assessment: 40% Semester End Exami	nation: 60%
Semester End Examination: 60%	
13 Continuous Evaluation through:	
Quizzes, Class Tests, presentations,	
projects, role play, creative writing,	
assignments etc.	
(at least 3)	
Sr. Particulars Marks	
No.	
1 Objective question test 10	
2 Overall performance 05	
3 Viva 05	
<u>1</u>	

	Paper pattern of tMode):Q1: (Attempt any 5choice questions. (from 8) Multiple	
	Duration: 1Hrs While setting que four MCQ on mo four MCQ on mo	dule 1 and	
4	Format of Question	n Paper:	
		tion: mester IV, Practical examinations be conducted based on both the mo	
	Paper pattern: The c	uestion paper shall have two ques	tions.
	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 Journa	ls:	
	For both Module 1 1. Journal: 5 mark	and Module 2 s (2.5 marks for each module 1 &	module 2)
	duly certified. The	quired to perform 75% of the Prac students are required to present a actical examination, failing which nination.	duly certified journal for

Name of the Course: Linear Algebra (Minor II)

Sr. No. 1 2	Heading Description of the course: Including but not limited to:	Particulars The system of linear equations arises naturally in other science courses. This course provides a sound knowledge of Matrix theory, starting with the basic requirement of its study in the form of solving a system of equations. Also, it		
	-	in other science courses. This course provides a sound knowledge of Matrix theory, starting with the basic requirement of its study in the		
2		advances the discussion of vector space dealing with linear transformations, developing its connection with matrix theory.		
4	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	 7 Course Objectives (CO): This course gives an introduction to linear transformations with an understanding its geometry. Also, it covers a brief amount of matrix theory. CO1. To give sufficient knowledge of fundamental principles and methods, as wel a clear perception of numerous powers of mathematical ideas and tools and the sk to use them by modelling, solving, and interpreting. CO2. To reflect the broad nature of the subject and develop mathematical tools continuing further study in various fields of sciences. CO3. To enhance students' overall development, problem-solving skills, creative tal and power of communication are necessary for various kinds of employment. CO4. To give adequate exposure to global and local concerns that would help learn 			
8	 After completion of the course, students will be able to OC1: Remember and understand the concept of a system of linear equations, matrices and linear transformations OC2: Calculate and find the solutions to a system of equations using various methods, finding the inverse of matrices OC3: Analyse the linear transformation and its various aspects OC4: Verify the Rank Nullity theorem OC5: Construct counterexamples related to linear transformations 			
9	 Modules: - Module 1: Matrices (15 Hours) (a) Systems of homogeneous and non-homogeneous linear equations, Simple examples of finding solutions of such systems. Geometric and algebraic understanding of the solutions. Algebra of solutions of systems of homogeneous linear equations. A system of homogeneous linear equations with a number of unknowns greater than the number of equations has infinitely many solutions. (b) Equivalence of statements (in which A denotes an n × n matrix) such 			

	as the following.(without proof)
	(i) The system $Ax = b$ of non-homogeneous linear equations has a unique solution.
	(ii) The system $Ax = 0$ of homogeneous linear equations has no nontrivial solution.
	(iii) A is invertible.
	(iv) det $A \neq 0$.
	(v) $\operatorname{rank}(A) = n$. Examples.
	 (c) Elementary matrices. Relation of elementary row operations with elementary matrices. Invertibility of elementary matrices. Consequences such as (i) a square matrix is invertible if and only if its row echelon form is invertible. (ii) Invertible matrices are products of elementary matrices. Examples of the computation of the inverse of a matrix using the Gauss elimination method.
	Module 2: Linear Transformation (15 Hours)
	 (a) Definition of a linear transformation of vector spaces; elementary properties. Examples. Sums and scalar multiples of linear transformations. Composites of linear transformations. A Linear transformation of V → W; where V, W are vector spaces over R and V is a finite-dimensional vector space is completely determined by its action on an ordered basis of V.
	(b) Null space (kernel) and the image (range) of a linear transformation. Nullity and rank of a linear transformation. Rank-Nullity Theorem (without proof).
	 (c) Matrix associated with linear transformation of V → W where V and W are finite dimensional vector spaces over R. Matrix of the composite of two linear transformations. Invertible linear transformations (isomorphisms), Linear operator, Effect of change of bases on matrices of linear operator. (d) Equivalence of the rank of a matrix and the rank of the associated linear
	(d) Equivalence of the rank of a matrix and the rank of the associated linear transformation. Similar matrices.
10	Text Books:
	1. Kenneth Hoffman and Ray Kunze, Linear Algebra, 2nd edition, Pearson.
	2. Howard Anton, Chris Rorres, Elementary Linear Algebra, Wiley Student
	Edition). 3. Serge Lang, Introduction to Linear Algebra, Springer.
	4. S Kumaresan, Linear Algebra: A Geometric Approach, PHI Learning.
	5. Sheldon Axler, Linear Algebra done right, Springer.
	6. Gareth Williams, Linear Algebra with Applications, Jones and Bartlett Publishers.
	 David W. Lewis, Matrix theory.
11	Reference Books
	 Matrix Analysis and its Applications, Carl D. Mayor, SIAM publications. Linear Algebra, Kenneth Hoffman & Ray Kunze, Prentice-Hall Inc.
	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.

Internal Continuous Assessment: 40%					Semes 60%	ter En	d Exa	mina	tion	
Co	ntinuo	ous Evalua	tion through:							
Ou	izzes	Class Tests	, presentations, p	projects, re	ole					
-			g, assignments, e		510					
(at	least 3	3)								
Sr	: Pa	articulars		Marks	7					
N	о.									
1	A	class test of	f 10 marks is to	10						
			d during each							
			n Offline mode.	0.7	_					
2		•	any one topic	05						
			e syllabus or a fonline) on one							
	-	the module	<i>'</i>							
3			p presentation	05						
		-	opic related to							
	th	e syllabus.								
			he test (offline 1		-					
		ir duration finitions/Fil	·	True						
Q	1: Def		in the blanks/ T	True						
Q or (0	1: Def r False)4 Mar	finitions/Fil with Justif ks: 4 x 1).	l in the blanks/ T ication.	True						
Q or (0 Q	1: Def r False 04 Mar 2: Atte	finitions/Fil with Justif ks: 4 x 1). empt any tw	in the blanks/ T ication. yo of the three							
Q or (0 Q de	1: Def r False 04 Mar 2: Atte escript	finitions/Fil with Justif ks: 4 x 1). empt any tw	l in the blanks/ T ication.							
Q or (0 Q de 3)	1: Def r False 04 Mar 2: Atto escript	finitions/Fil with Justif ks: 4 x 1). empt any tw ive question	in the blanks/ T ication. yo of the three ns. (06 marks: 2							
Q or (0 Q de 3) For	1: Def r False 04 Mar 2: Atto escript) rmat (Finitions/Fill with Justif ks: 4 x 1). empt any tw ive question	in the blanks/ T ication. yo of the three ns. (06 marks: 2	×	arks o	f one-h	our du	ration,	,	
Q or (0 Q de 3) For The	1: Def r False 04 Mar 2: Atto escript) rmat of e seme	Finitions/Fil with Justif ks: 4 x 1). empt any tw ive question of Question ester-end ex	in the blanks/ T ication. to of the three ns. (06 marks: 2 Paper:	× e of 30 m	arks o	f one-h	our du	ration,	,	
Q or (0 Q de 3) For The	1: Def r False 04 Mar 2: Atto escript) rmat of e seme	Finitions/Fill with Justif ks: 4 x 1). empt any tw ive question of Question ester-end ex the entire sy	l in the blanks/ T ication. vo of the three ns. (06 marks: 2 Paper: amination will b	× e of 30 m mester.				,		
Q or (0 Q de 3) Foi The cov	1: Def r False 04 Mar (2: Atto escript) rmat o vering	initions/Fil with Justif ks: 4 x 1). empt any tw ive question of Question ester-end ex the entire sy N	in the blanks/ T ication. o of the three ns. (06 marks: 2 Paper: amination will b yllabus of the se ote: Attempt an	× e of 30 m mester. ny TWO (questi	ons ou		IREE	•	nrks
Q or (0 Q de 3) Foi The cov	1: Def r False 04 Mar 2: Atto escript) rmat of e seme	Finitions/Fill with Justif ks: 4 x 1). empt any tw ive question of Question ester-end ex the entire sy	i in the blanks/ T ication. vo of the three ns. (06 marks: 2 Paper: amination will b yllabus of the se	× e of 30 m mester. ny TWO o HREE ou	questi it of F	ons ou		IREE		urks
Q or (0 Q de 3) Foi The cov	1: Def r False 04 Mar (2: Atto escript) rmat o vering	Finitions/Fill with Justificks: 4 x 1). empt any twive question of Question ester-end ex the entire sy N Module	I in the blanks/ T ication. vo of the three ns. (06 marks: 2 Paper: amination will b yllabus of the sec ote: Attempt any T	× be of 30 m mester. hy TWO o HREE ou of 5 mark	questi it of F (s)	ons ou OUR.		IREE	•	urks
Q or (0 Q de 3) Foi The cov	1: Def r False 04 Mar (2: Atto escript) rmat o vering	Finitions/Fill with Justificks: 4 x 1). empt any twive question of Question ester-end ex the entire sy N Module	l in the blanks/ T ication. vo of the three ns. (06 marks: 2 Paper: amination will b yllabus of the sec ote: Attempt any T (Each question (a) Question (b) Question	× ee of 30 m mester. by TWO o HREE ou of 5 mark on based o on based o	questi It of F (s) n OC n OC	ons ou OUR. 1 2		IREE	•	urks
Q or (0 Q de 3) Foi The cov	1: Def r False 04 Mar (2: Atto escript) rmat of vering	Finitions/Fill with Justificks: 4 x 1). empt any twive question of Question ester-end ex the entire sy N Module	l in the blanks/ T ication. vo of the three ns. (06 marks: 2 Paper: amination will b yllabus of the se ote: Attempt any T (Each question (a) Question (b) Question (c) Question	× me of 30 m mester. Ty TWO of HREE out of 5 mark on based of on based of on based of	questi it of F (s) n OC n OC n OC	ons ou OUR . 1 2 3		IREE	•	urks
Q or (0 Q de 3) Foi The cov	1: Def r False)4 Mar (2: Atte escript) rmat of e seme /ering	Finitions/Fill with Justificks: 4 x 1). empt any twive question of Question ester-end ex the entire sy N Module 1 and 2	l in the blanks/ T ication. vo of the three ns. (06 marks: 2 Paper: amination will b yllabus of the se ote: Attempt any T (Each question (a) Question (b) Question (c) Question (d) Question	× me of 30 m mester. Ty TWO of HREE out of 5 mark on based of on based of on based of on based of	questi It of F (s) n OC n OC n OC	ons ou OUR . 1 2 3 4/OC5		IREE	• 15 Ma	
Q or (0 Q de 3) Foi The cov	1: Def r False 04 Mar (2: Atto escript) rmat of vering	Finitions/Fill with Justificks: 4 x 1). empt any twive question of Question ester-end ex the entire sy N Module 1 and 2	l in the blanks/ T ication. vo of the three ns. (06 marks: 2 Paper: amination will b yllabus of the sec ote: Attempt any T (Each question (a) Question (b) Question (c) Question (d) Question Attempt any T	× be of 30 m mester. by TWO o HREE out on based o on based o on based o on based o HREE out	tt of F (s) n OC n OC n OC n OC tt of F	ons ou OUR . 1 2 3 4/OC5		IREE	•	
Q or (0 Q de 3) Foi The cov	1: Def r False)4 Mar (2: Atte escript) rmat of e seme /ering	Finitions/Fill with Justificks: 4 x 1). empt any twive question of Question ester-end ex the entire sy N Module 1 and 2	l in the blanks/ T ication. vo of the three ns. (06 marks: 2 Paper: amination will b yllabus of the se ote: Attempt any T (Each question (a) Question (b) Question (c) Question (d) Question Attempt any T (Each question	× be of 30 m mester. Ty TWO of HREE out on based of on based of on based of on based of HREE out on based of HREE out HREE out	questi tt of F (s) n OC n OC n OC n OC tt of F (s)	ons ou OUR. 1 2 3 4/OC5 OUR.		IREE	• 15 Ma	
Q or (0 Q de 3) Foi The cov	1: Def r False)4 Mar (2: Atte escript) rmat of e seme /ering	Finitions/Fill with Justificks: 4 x 1). empt any twive question of Question ester-end ex the entire sy N Module 1 and 2	l in the blanks/ T ication. vo of the three ns. (06 marks: 2 Paper: amination will b yllabus of the sec ote: Attempt any T (Each question (a) Question (b) Question (c) Question (d) Question Attempt any T	× e of 30 m mester. by TWO o HREE ou of 5 mark on based o on based o on based o HREE ou of 5 mark on based o	questi It of F (s) n OC n OC n OC n OC tt of F (s) n OC	ons ou OUR. 1 2 3 4/OC5 OUR. 1		IREE	• 15 Ma	
Q or (0 Q de 3) Foi The cov	1: Def r False)4 Mar (2: Atte escript) rmat of e seme /ering	Finitions/Fill with Justificks: 4 x 1). empt any twive question of Question ester-end ex the entire sy N Module 1 and 2	l in the blanks/ T ication. vo of the three ns. (06 marks: 2 Paper: amination will b yllabus of the se ote: Attempt any T (Each question (a) Question (b) Question (c) Question (d) Question (a) Question (c) Question (a) Question (c) Question	× be of 30 m mester. by TWO of HREE out on based of on based of on based of HREE out on based of HREE out on based of HREE out on based of DREE out DREE out DR	questi It of F (s) n OC n OC n OC tt of F (s) n OC n OC n OC n OC	ons ou OUR. 1 2 3 4/OC5 OUR. 1 2 3		IREE	• 15 Ma	
Q or (0 Q de 3) For The cov	1: Def r False)4 Mar (2: Atte escript) rmat of e seme /ering	Finitions/Fill with Justificks: 4 x 1). empt any twive question of Question ester-end ex the entire sy N Module 1 and 2	l in the blanks/ T ication. vo of the three ns. (06 marks: 2 Paper: amination will b yllabus of the sec ote: Attempt any T (Each question (a) Question (b) Question (c) Question (d) Question (a) Question (a) Question (b) Question (c) Ques	× e of 30 m mester. by TWO of HREE out on based of on based of on based of hREE out on based of hREE out on based of on based of on based of on based of on babased of on babased of on based of on b	questi It of F (s) n OC n OC n OC t of F (s) n OC n OC n OC n OC n OC	ons ou OUR. 1 2 3 4/OC5 OUR. 1 2 3 4/OC5			• 15 Ma	urks

(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-4B Linear Algebra (Minor II)

		M-4B Linear Algebra (Minor II)				
Sr.	Heading	Particulars				
No. 1	Description of the course: Including but not limited to:	The system of linear equations arises naturally in other science courses. This course provides a sound knowledge of Matrix theory, starting with the basic				
		requirement of its study in the form of solving a				
		system of equations. Also, it advances the				
		discussion of vector space dealing with linear				
		transformations, developing its connection with				
2	Vertical:	matrix theory. 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	Course Objectives (CO):					
		erstanding of system of linear equations with an				
		of its solutions. Also, it covers a brief amount of matrix				
	theory and the theory of linear tr					
		lge of fundamental principles and methods, as well as a owers of mathematical ideas and tools and the skills to				
	use them by modelling, solving,					
		are 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 tale					
	and the power of communication are necessary for various kinds of employment.					
	CO4. To give adequate exposure to global and local concerns that would help learne					
	explore many aspects of Mathem	natical Sciences.				
8	Course Outcomes (OC):					
0	After completion of the course,	students will be able to				
	1	ystem of equations using various methods, and the				
	inverse of matrices					
	OC2: Analyse the null space and rank space related to the linear transformation.					
	OC3: Verify the Rank Nullity theorem					
<u> </u>	OC4: Construct and design counterexamples related to linear transformations					
9	Modules: -					
	Module 1: Practical for Matr	ices (30 Hours)				
	1. System of linear equation					
		ns of a system of linear equations.				
		f a system of linear equations.				
		a system of homogenous linear equations.				
	5. Elementary row operation					
	6. Determinants and rank of					
		ear equations using determinants.				
	-	d their relations with elementary operations on				
1	matrices.					

	9.]	Invertibility of elementary	y matrices.			
	10. 0	Computing the inverse of	a matrix by	the Gauss elimination method.		
-	Module	e 2: Practical for Linear	Transform	ation (30 Hours)		
	1. I	Linear transformations an	d their eleme	entary properties.		
	-	Composite of linear transf				
	3. Determining linear transformation by knowing its action on basis vectors.					
		Null space and image space				
		Rank and nullity of a linea Theorem.	ar transforma	ation with verification of rank-nullity		
	6. (Computing matrix associa	ated with a li	near transformation.		
	7. 1	Matrix associated with a c	composite of	two linear transformations.		
		Effect on change of basis	on linear tra	nsformation.		
		Similar matrices.				
0	10. 1 Text Bo	*	matrix with t	he associated linear transformation.		
	4. 5 5. 6 6. 0 7. 1 Referen 1. Matu	Sheldon Axler, Linear Al Gareth Williams, Linear A Publishers. David W. Lewis, Matrix to nce Books rix Analysis and its Appli	ebra - A Geo gebra done r Algebra with theory. cations, Carl	ometric Approach, PHI Learning.		
		Schem	e of the Exa	mination		
2	Interna	l Continuous Assessmer	nt: 40%	Semester End Examination: 60%		
3	Quiz projects	uous Evaluation throug zzes, Class Tests, presenta s, role play, creative writin nents etc. 3)	ations,			
	No. 1 0 2 0	Particulars Objective question test Overall performance Viva	Marks 10 05 05			
	Mode	pattern of the Test (Off): Attempt any 5 from 8) Mu				

While s paper, f	-	uestion on module on module 2.	
Format of	of Question	Paper:	
Scheme	e of examina	ation:	
and 30 i	marks shall	ster IV, Practical examinations of be conducted based on both modu question paper shall have two ques	les.
	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)
		s:	

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

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

	`			
Sr. No.	Heading	Particulars		
1	Description of the course: Including but not limited to:	To underline the importance of concepts in mathematics that have physical interpretation, especially in other sciences like physics and chemistry.		
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	and chemistry. In this course, st introduced to fundamental concepts CO1: To identify eigenvalues and e CO2: To develop insight into the cr	ross-product of vectors. real-life puzzles and games to make it easy to		
8	 Course Outcomes (OC): OC1: Remember and understand the concept of inner product spaces OC2: Calculate and find the inner products, moments, Eigenvalues Eigenvector and orthogonal vectors OC3: Analyse the Cauchy-Schwarz inequality and the symmetries of triangles OC4: Verify the Cauchy-Schwarz inequality. 			
9	OC5: Construct counterexamples related to inner product spaces			

	11. Cauchy-Schwarz inequality (real numbers) stat	-			
	12. Problems based on Cauchy-Schwarz inequa	ality, like finding the maximum			
	possible value of a dot product.13. Inner product spaces with complex coefficient	e			
	14. Proof of Cauchy-Schwarz inequality for comp				
	15. Hermitian and unitary matrices and their exam				
	Module 2: Eigenvalues and eigenvector orthone	-			
	(15 Hours)	j			
	1. Definition of eigenvector and eigenvalue.				
	2. Examples of eigenvector and eigenvalue in 2 by	2 matrices.			
	3. Examples of eigenvectors and eigenvalues in 3	by three matrices.			
	4. Gram-Schmidt orthogonalization process: form				
	5. Gram-Schmidt orthogonalization process with e	examples.			
	6. Playing cards and counting permutations (order	•			
	7. Further problems on cards.				
	8. Set game: introduction, counting: Calculation o	f total number of cards			
	calculation of the number of sets, calculation of ca				
		itus with certain properties.			
	9. Permutations of an equilateral triangle.10. Writing composition tables for symmetries (group) of equilateral triangles.				
	11. Permutation on four symbols.				
	12. Rule for composition of above permutations.				
	13. Symmetries of the square.				
	14. Writing a composition table for symmetries of	a square.			
	15. Introduction to quaternions and their composit	ion table.			
10	Text Books:				
	1. Halliday and Resnick's Principles of Physi				
	2. Hoffman and Kunze, Linear Algebra, Seco	ond Edition, Pearson.			
11	Reference Books:				
	1. Shaeffer, R.E. <i>Elementary Structures for A</i>				
	2. Elementary Linear Algebra Application Vo	ersion, H. Anton, C. Rorres,			
	Wiley & Sons.				
	Scheme of the Examin	ation			
	The performance of the learners shall be evaluated	l in two parts.			
	Internal Continuous Assessment of 20 ma	rks.			
	• Semester-end examination of 30 marks.				
	• A separate head of passing is required for	internal and semester-end			
10	examinations.				
12	Internal Continuous Assessment: 40%	Semester End Examination:			
		60%			

	g, assignments	projects, role pla , etc.	•		
(at lea					
Sr. No.	Particulars		Marks		
1	A class test o	f 10 marks is to	10		
		d during each n Offline mode.			
2	related to the	any one topic e syllabus or a fonline) on one es.	05		
3	Seminar/ gro	up presentation opic related to	05		
-	-	he test (offline r	node with		
	hour duration				
-		l in the blanks/			
	or False with	Justification.			
	Marks: 4 x 1).				
	Attempt two of	-			
-	tions. (06 mark				
	at of Question		6.00	1 (1	
		amination will b			r,
duratio		e entire syllabus			
	N	ote: Attempt an	iy TWO qi	lestions out of	THREE.
Q.No	o.1 Module	Attempt any T	HREE out	of FOUR	15 Mark
Q.110	1 and 2	(Each question			
	1 and 2	(a) Question		·	
		(b) Questio			
		(c) Questio			
		(d) Questio			
Q.No	0.2 Module	Attempt any T			15 Mark
	1 and 2	(Each question			
		(a) Questio			
		(b) Questio	on based on	OC2	
		(c) Questio	on based on	OC3	
		(d) Questio	on based on	OC4/OC5	
Q.No	o.3 Module	Attempt any T	HREE out	of FOUR .	15 Mark
	1 and 2	(Each question		· · · · · · · · · · · · · · · · · · ·	
		(a) Questio			
		(b) Questio			
	1	(a) Quastia	on based on	OC3	
		(d) Questio			

Name of the Course: PM-4C Basic Mathematics in Real Life-III (Minor IV)

~		(Minor IV)
Sr.	Heading	Particulars
No.		
1	Description of the course:	To underline the importance of concepts in
	Including but not limited	mathematics that have physical interpretation,
	to:	especially in other sciences like physics and
2	Vertical:	chemistry. Minor
3	Type:	Practical
4	Credits:	2 credits
		(1 credit = 15 Hours for Theory or 30 Hours of
5	Hours Allotted:	Practical work in a semester) 30 Hours
<u> </u>	Marks Allotted:	50 Marks
7	Course Objectives (CO):	JU WIAIKS
/	•	oncepts of mathematics applicable, especially in physics
		rse, students from various science streams will be
		ncepts from mathematics relevant to daily life and learn
	CO1: To identify eigenvalue	
	• •	the cross-product of vectors.
		with real-life puzzles and games to make it easy to
	understand.	
	CO4: recognizes symmetries	in existing objects.
8	Course Outcomes (OC):	
	After completion of the cour	
		cross product, inner product, Norm, moments of force,
	Eigenvalues Eigenvectors an	
		aces, Cauchy-Schwarz inequality and the symmetries
	of triangles	
		warz inequality and permutations as a function.
0		ples related to inner product spaces.
9	Modules: - Module 1: Practical for line spaces (30 Hours)	ear dependence, independence and inner product
	1. Checking Linear depe	ndence and independence.
		pan of Vectors and Examples of Finding the Span.
	3. Calculations based or	
		moment about a point.
		based on cross-product.
	6. Verification of inner	product via examples for real vector spaces.
		ct spaces, examples and properties.
	8. Definition of vector s	pace over real and complex numbers, Examples.
	9. Inner product spaces	over complex numbers, Definition and Examples.
	· · · · ·	nvectors with basic calculations.
	Module 2: Practical for eig symmetry (30 Hours)	envalues and eigenvector orthonormalisation and

	1.	Eigenvectors and Linear	<u> </u>	
	2.	Orthogonalization Formu		
	3.	Gram-Schmidt process w	with examples	only of the rom real plane.
	4.	Gram-Schmidt process w	*	
	5.	Problems based on perm	utations and t	heir composition, Examples.
	6.	Problems based on the fo	ormula for per	mutations with possible constraints.
	7.	Problems based on the se		
	8.	Composition of two perm	nutations and	further properties.
	9.	Symmetries of rectangles	s and pentago	ns and other figures.
	10.	Symmetries of letters of	the alphabet of	f Indian languages and English.
10	Text	Books:		
	1.	Halliday and Resnick's F	Principles of P	hysics, Wiley, Eleventh Edition.
	2.	Hoffman and Kunze, Lir	near Algebra,	Second Edition, Pearson.
11	Refer	ence Books:		
	1.	Shaeffer, R.E. Elementar	ry Structures j	for Architects and Builders.
	2.	Elementary Linear Algel	bra Applicatio	on Version, H. Anton, C. Rorres,
		Wiley & Sons.		
		Scher	ne of the Exa	mination
12	Inter	nal Continuous Assessme	ent: 40%	Semester End Examination: 60%
13	Conti	nuous Evaluation throug	.	
15		izzes, Class Tests, present	-	
	-	ets, role play, creative writ		
		is, fore plug, creative with		
	assign	ments, etc.		
	assign (at lea	uments, etc. (st 3)		
		1st 3)		
			Marks	
	(at lea	1st 3)	Marks	
	(at lea	1st 3)	Marks 10	
	(at lea Sr. No.	est 3) Particulars		
	(at lea Sr. No. 1	Particulars Objective question test	10	
	(at lea Sr. No. 1 2 3	Particulars Objective question test Overall performance Viva	10 05 05	
	(at lea Sr. No. 1 2 3 Pap	Particulars Objective question test Overall performance Viva er pattern of the Test (Of	10 05 05	
	(at lea Sr. No. 1 2 3 Pap Mod	Particulars Objective question test Overall performance Viva er pattern of the Test (Of le):	10 05 05 ffline	
	(at lea Sr. No. 1 2 3 Pap Mod Q1:	Particulars Objective question test Overall performance Viva er pattern of the Test (Of le): (Attempt any 5 from 8) M	10 05 05 ffline	
	(at lea Sr. No. 1 2 3 Pap Mod Q1:	Particulars Objective question test Overall performance Viva er pattern of the Test (Of le):	10 05 05 ffline	
	(at lea Sr. No. 1 2 3 Pap Mod Q1: choi	Particulars Objective question test Overall performance Viva er pattern of the Test (Of le): (Attempt any 5 from 8) M ce questions. (10 marks: 5	10 05 05 ffline	
	(at lea Sr. No. 1 2 3 Pap Moo Q1: choi Dur	Particulars Objective question test Overall performance Viva er pattern of the Test (Of le): (Attempt any 5 from 8) M ce questions. (10 marks: 5 ation: 1Hrs	10 05 05 ffline	
	(at lea Sr. No. 1 2 3 Pap Moo Q1: choi Dur Whi	Particulars Objective question test Overall performance Viva er pattern of the Test (Of le): (Attempt any 5 from 8) M ce questions. (10 marks: 5 ation: 1Hrs le setting the question	10 05 05 ffline ultiple- $\times 2$)	
	(at lea Sr. No. 1 2 3 Pap Mod Q1: choi Dur Whit pap	Particulars Objective question test Overall performance Viva er pattern of the Test (Of le): (Attempt any 5 from 8) M ce questions. (10 marks: 5 ation: 1Hrs	10 05 05 ffline ultiple- $\times 2$)	
14	(at lea Sr. No. 1 2 3 Pap Moo Q1: choi Dur Whi pap and	Particulars Objective question test Overall performance Viva er pattern of the Test (Of le): (Attempt any 5 from 8) M ce questions. (10 marks: 5 ation: 1Hrs le setting the question er, four MCQs in module MCQs in module 2.	10 05 05 ffline ultiple- $\times 2$)	
14	(at lea Sr. No. 1 2 3 Pap Moo Q1: choi Dur Whi pap and Form	Particulars Objective question test Overall performance Viva er pattern of the Test (Of le): (Attempt any 5 from 8) M ce questions. (10 marks: 5 ation: 1Hrs le setting the question er, four MCQs in module MCQs in module 2. at of Question Paper:	10 05 05 ffline ultiple- $\times 2$)	
14	(at lea Sr. No. 1 2 3 Pap Moc Q1: choi Dur Whi pap and Form Scho	Particulars Objective question test Overall performance Viva er pattern of the Test (Of le): (Attempt any 5 from 8) M ce questions. (10 marks: 5 ation: 1Hrs le setting the question er, four MCQs in module MCQs in module 2. at of Question Paper: eme of examination:	10 05 05 ffline ultiple- × 2) e 1	ations of three hours duration

Q. No. 1	choice questions (four from module 1 and four from module 2) (OC1, OC2 and OC 3)	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 Journ	(OC3 and OC4)		

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

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