Shri Acharyaratna Deshbhooshan Shikshan Prasarak Mandal , Kolhapur

Mahavir Mahavidyalaya, Kolhapur (Autonomous)

Affiliated to Shivaji University, Kolhapur

DEPARTMENT OF MATHEMATICS

Three/Four- Years UG Programme

Department/Subject Specific Core or Major (DSC)

Curriculum, Teaching and Evaluation Structure

For

B.Sc. -II Mathematics

Semester-III & IV

(Implemented from academic year 2024-25 onwards)

B.Sc.- II, Semester- III Mathematics

MIN-V: Real Analysis -I

Theory: 30 hrs.

Marks-50 (Credits: 02)

Course Outcomes (COs):

On completion of the course, the students will be able to:

1. Draw and interpret Venn diagram of set relations, operations, types of a function and use Venn diagram to solve their problem.
2. Describe fundamental properties of the real number that lead to the formal development of real analysis.

UNIT	Contents	Hours Allotted
1	**Sets and Functions** **1.1** Introduction **1.2** Revision of sets **1.3** Operation on sets Union, Intersection, Complement, Relative complement, Cartesian product of sets, Relation. **1.4** Illustrative Examples **1.5** Functions Definition: Function, Domain, Co-domain, Range, Graph of function, Direct image and Inverse image of a subset under a function. **1.6** Example of direct image and inverse image of a subset. **1.7** Definitions Injective, Surjective and Bijective functions (1-1 correspondence) Inverse function. Composite function, Restriction and Extension of a function. **Mathematical Induction** **1.8** Well ordering Property of Natural Numbers **1.9** Principles of Mathematical Induction **1.10** First Version of Principal of Mathematical Induction **1.11** Second Version of Principal of Mathematical Induction. **1.12** Principles of Strong Induction **1.13** Illustrative Examples **1.14** Multiple Choice Questions	15

2	**Countable Sets** 2.1 Introduction 2.2 Definitions Equivalent sets, Countable Sets, Uncountable sets. 2.3 Examples of countable sets Sets of Natural number, Set of Integers, Set of even Natural numbers and odd natural numbers. 2.4 Proposition: Union of two disjoint countable sets is countable. 2.5 Theorems and Examples. 2.6 Illustrative Examples. **The real Numbers** 2.7 Algebraic and Order Properties of R 2.8 Algebraic properties Properties of real numbers. 2.9 Theorems 2.10 Inequalities 2.11 Arithmetic – Geometric Mena Inequality (With Proof) 2.12 Bernoulli’s Inequality (With Proof) 2.13 Illustrative Examples 2.14 Absolute Value and the Real Line Definition, Theorems, Triangle Inequality 2.15 Illustrative Example 2.16 Completeness Property of R 2.17 Applications of the Supremum Property 2.18 Interval Types of Intervals 2.19 Characterization theorem 2.20 Multiple Choice Questions	16

Recommended Books:

1. Robert G. Bartle and Donald R. Sherbert (Wiley)
2. Richard R. Goldberg

Reference Books:

1. R. R Goldberg, Oxford and IBH Publishing House, New Delhi, 1970
2. Michael Spivak, Real, Cambridge University Press.

B. Sc. Part – II Semester -III Mathematics

MIN-VI: Algebra I : 30 hrs.

Marks-50 (Credits: 02)

Course Outcomes (COs)

On completion of the course, the students will be able to:

1. Understand the importance of Row-echelon form.
2. Employ the Cayley Hamilton theorem to solve numerical problems.
3. Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix, using rank.
4. Understanding the Theorem: The intersection of any two subgroups of a group is again a subgroup.

UNIT	Contents	Hours Allotted
1	**Matrices and relations** **1.1** Definitions: Hermitian and skew Hermitian matrices. **1.2** Properties of Hermitian and skew Hermitian matrices. **1.3** Rank of a matrix, Row-echelon Form and reduced row echelon form. **1.4** System of linear homogeneous equation and linear non-homogeneous equation. Condition for consistency, Nature of the General Solution Gaussian elimination and Gauss Jordon method (Using row-echelon form and reduced row echelon form) Examples **1.5** The characteristic equation of a matrix, Eigen values, Eigen vectors of the matrix **Cayley Hamilton Theorem** **1.6** Applications of Cayley Hamilton theorem (Examples) **1.7** Relations: Definition, Types of relations, Equivalence relation, Partial ordering relation **1.8** Example of equivalence relation and Partial ordering relations. **1.9** Digraphs of relations, matrix representation. **1.10** Composition of Relations **1.11** Transitive closure, Warhill's algorithm **1.12** Equivalence classes, Partition of a set Theorem: Let ~ be an equivalence relation on a set X. Then For every x∈X, $x \in \bar{X}$ For every x, $y \in \bar{X}, x \in \bar{Y}$ if and only if $\bar{X} = \bar{Y}$ For every x, $y \in \bar{X}$, either $\bar{X} \cap \bar{Y} = \emptyset$. Equivalence Class Theorem	16
2	**Groups** **2.1** Definition **2.2** Group and its properties **2.3** Definition of Group, Semigroup, finite **2.4** Theorem: In a group G The identity element is unique The inverse of each element in G $(a^{-1})^{-1} = a$ for all a ∈ G $(ab)^{-1} = b^{-1}a^{-1}$ For all a, b ∈G **Subgroups** **2.5** Definition **2.6** Theorem: A subset H of a group G is a subgroup of G if and only if H is closed under the binary operation of G	15

	The identity e of G is in H, For all a ∈H it is true that a^{-1} ∈ H also **2.7** Theorem: A non-empty subset H of a group G is a subgroup of G if and only if for all a, b∈ H. $a*b^{-1}$∈ H. **2.8** Theorem: The intersection of any two subgroups of a group is again a subgroup. **2.9** Definition **2.10** Theorem **2.11** Theorem **Cyclic Groups and its Properties** **2.12** Definition of cyclic group generated by an element, Cyclic subgroup of a group and example **2.13** Theorem **2.14** Order of elements of a group and their properties **2.15** Theorem: Every cyclic group is abelian. **2.16** Theorem: If a is a generator of a cyclic group G, then O(a)=O(G) **Cosets** **2.17** Definition **2.18** Theorem: If H is a subset of G, then Ha=H if and only if a ∈H Ha=Hb if and only if ab^{-1}∈H Ha is a subgroup of G if and only if a ∈H **2.19** Theorem: If H is a subgroup of G, then a one-to-one correspondence exists between any two right(left) cosets of H in G.	

Recommended Books:

Linear Algebra and Its Applications" by David C. Lay, Steven R. Lay, and Judi J. McDonald

Introduction to Linear Algebra" by Gilbert Strang

Linear Algebra Done Right" by Sheldon Axler

Reference Books:

1 Linear Algebra and Its Applications" by David C. Lay, Steven R. Lay, and Judi J. McDonald

2 Introduction to Linear Algebra" by Gilbert Strang

3 Matrix Computations" by Gene H. Golub and Charles F. Van Loa

B. Sc. Part – II Semester -III MATHEMATICS

MIN-PR-III: Mathematics Practical I (Credits: 02)

Course Outcomes - At the end of this course students will be able to:

CO1: Calculate eigenvalues and eigenvectors, and apply the Cayley-Hamilton theorem for matrix inverses.

CO2: Analyse functions, including their range, image, inverse, and types (injective, surjective, bijective).

CO3: Use mathematical induction and Bernoulli's inequality to prove and solve mathematical problems.

CO4: Understand and work with countable and uncountable sets, set operations, and properties of real numbers.

Sr.No	Title Of Experiment
1	Eigenvalues and eigen vectors
2	Cayley Hamilton theorem (Verification and finding the inverse of Matrix)
3	Range of function Image and inverse image of a subset
4	Types of Function (Injective, Surjective, Bijective, Inverse function, Composition two function)
5	Mathematical Induction
6	Bernoulli's Inequality
7	Example Of Countable Set
8	Operation On Set
9	Sets and Operations
10	Countable and Uncountable Set
11	Properties and Inequalities of Real Number

B.sc-II, Semester-IV, Mathematics

MIN-VII : Real Analysis -II

Theory: 30 hrs.

Marks-50 (Credits: 02)

Course Outcomes (COs)

On completion of the course, the students will be able to:

1. Find the sequence of partial sums of an infinite series.
2. Determine if an infinite series is convergent or divergent by selecting the appropriate test the following: (a) test for divergence; (b) integral test; (c) p-series test; (d) the comparison test; (e) alternating series test; (f) absolute convergence test; (g) D'Alembert's ratio test; (h) Cauchy root test (i) Raabe's Test
3. Determine if an infinite series converges absolutely or conditionally.

UNIT	Contents	Hours Allotted
1	**Sequence of Real Numbers** Sequence and operations on sequence 1.1 sequence 1.2 subsequence of sequence 1.3 Illustrative example 1.4 Limit of sequence 1.5 Convergent sequence Definition, Example, Theorems. 1.6 Illustrative Examples 1.7 Bounded sequence Theorem: The sequence of real numbers $\{s_n\}$ is convergent, then $\{s_n\}$ is bounded. 1.8 Monotone sequence Definition, Theorems. 1.9 Operations on Convergent Sequence Theorems and operations of Convergent sequence. 1.10 Exercise **1 Limit Superior, Inferior and Cauchy Sequence** 1.11 Limit superior 1.12 Limit Inferior 1.13 Illustrate Examples 1.14 Cauchy Sequence 1.15 Theorem: If X = $\{s_n\}$ is a convergent sequence of real number, then $\{s_n\}$ is Cauchy sequence. 1.16 Theorem: A Cauchy sequence of real number is bounded. 1.17 Cauchy convergent criterion Theorem: A sequence of real numbers is convergent if and only if it is a Cauchy sequence 1.15 [C,1] Summability of sequence 1.16 Illustrative Examples 1.17 Exercise 1.18 Objective Questions	

2	**Infinite Series** 2.1 Introduction 2.2 Convergent and Divergent Series 2.3 Illustrative examples 2.4 Cauchy's General Principle of Convergence 2.5 Positive Term Series 2.6 Geometric Series 2.7 P-Series 2.8 Comparison Test for Positive term Series.Comparison test (First Type) 2.9 Limit form of Comparison test 2.10 Comparison test (second type) 2.11 Illustrative 2.12 Cauchy's Root Test 2.13 Illustrative Example 2.14 D'Alembert's Ratio Test 2.15 Illustrative Example 2.16 Raabe's Test 2.17 Illustrative Example **Series with Arbitrary Terms** 2.18 Introduction 2.19 Alternating series 2.20 Leibnitz Test 2.21 Illustrative Example 2.22 Absolute Convergence and conditional Convergence 2.23 Illustrative Example 2.22 Exercise 2.25 Objective Questions	15

Recommended Books:
Principle of real analysis: S. C. Malik, Introduction to Real Analysis: Robert G. Bartle Wiley.
Mathematical Analysis : Savita Arora.

Reference Books:

"Principles of Mathematical Analysis" by Walter Rudin

"Real Analysis: Modern Techniques and Their Applications" by Gerald B. Folland

B. Sc. Part –II Semester –IV Mathematics

MIN-VIII: Algebra -II

Theory: 30 hrs.

Marks-50 (Credits: 02)

Course Outcomes (Cos)

On completion of the course, the students will be able to:

1. Define the index and subgroup, corollary and understand Theorem.
2. The intersection of any two normal subgroups of a group is also a normal subgroup
3. Understand the various equation
4. Factor Group or Quotient Group and examples

UNIT	Contents	Hours Allotted
1	**Lagrange's Theorem and its Consequences** 1.1 Introduction 1.2 Lagrange's Theorem 1.3 Index of a Subgroup 1.4 Illustrative Examples 1.5 Consequence of Lagrange's Theorem 1.6 Exercise 1.7 Multiple Choice Questions. **Normal Subgroup and Properties** 1.8 Introduction 1.9 Normal Subgroup 1.10 Illustrative Examples 1.11 Result Related to Normal Subgroups 1.12 Center of Group 1.13 Normalizer of an Element 1.14 Factor Group 1.15 Exercise 1.16 Multiple Choice Questions	15
2	**Homomorphism and Isomorphism of Groups** 2.1 Introduction 2.2 Homomorphism 2.3 Illustrative Examples 2.4 Kernel of Homomorphism 2.5 Exercise 2.6 Permutation Groups 2.7 Multiple choice question **Ring** 2.8 Introduction 2.9 Rings 2.10 Illustrative Example 2.11 Integral Domain 2.12 Exercise 2.13 Homomorphism and Isomorphism of Ring 2.14 Subrings 2.15 Ideals	15

	2.16 Examples of subrings that are not Ideals 2.17 Exercise 2.18 Multiple Choice Questions	

Recommended Books:

1. Shanti Narayan: Analytical Solid Geometry, S. Chand and Company Ltd, New Delhi, 1998.

Reference Books:

1. Algebra 2 Practice Workbook by Holt McDougal

2. Algebra 2 by McGraw-Hill Education

3. Algebra and trigonometry by Ron Larson

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B. Sc. Part – II Semester -IV MATHEMATICS
MIN Mathematics Practical IV (Credits: 02)

Course Outcomes - At the end of this course students will be able to:

CO1: Assess sequence convergence using various tests, including comparison, Cauchy's root, and ratio tests.
CO2: Understand group theory concepts like cyclic subgroups, permutation groups, and homomorphisms.
CO3: Analyze bounded sequences and summability to determine sequence behavior.
CO4: Explore and compare subrings, ideals, normal subgroups, and factor groups.

Practical:

Sr,No	Title of experiment
1	Limit of a sequence (using definition)
2	Convergence of sequence
3	Comparison test and Cauchy's root test
4	D'Alembert's ratio test and Rabbi's test
5	Examples on Group and Order of an element
6	Cyclic Subgroup
7	Permutation group
8	Homomorphism and Kernel
9	Bounded sequence
10	[C.I] Summability
11	Comparing Subrings and Ideals
12	Exploring Normal Subgroups and Factors Groups

Suggested methods of Teaching:	
1.	Offline Traditional Board Teaching
2.	Power Point Presentation
3.	Online Teaching on platform of Zoom or Google Meet

Scheme of Course Evaluation		
1.	End Semester Examination (ESE)	40
2.	Continuous Internal Evaluation (CIE)	10
3.	**Total Marks**	**50**

Suggested techniques for Continuous Internal Evaluation (10 Marks)	
1.	Seminar
2.	Field Report
3.	Assignments
4.	Open book test
5.	Offline / online MCQ test
6.	Visit/Tour report
7.	Surprise test
8.	Formula Test

End Semester Examination Question Paper Pattern (40 Marks) Theory

Q. No.	**Nature /Type of Question**	**Marks**	**Total**
1.	Multiple Choice Question (06)	Each for 01 Marks	**06**
2.	Write definition or Formulas (5)	Each for 02 Marks	**10**
3.	Solve the following question Any 3 out of 5	Each for 04 Marks	**12**
4.	Solve the following question A Or B	Each for 06 Marks	**06**
5.	Solve the following question A Or B	Each for 06 Marks	**06**
	Total		**40**

Practical Examination

(A) The practical examination will be conducted on one day for three hours per day per batch of the practical examination.

(B) Each candidate must produce a certificate from the Head of the Department in her/his college, stating that he/she has completed in a satisfactory manner the practical course on lines laid down from time to time by Academic Council on the recommendations of Board of Studies and that the journal has been properly maintained. Every candidate must have recorded his/her observations in the laboratory journal and have written a report on each exercise performed. Every journal is to be checked and signed periodically by a member of teaching staff and certified by the Head of the Department at the end of the semister. Candidates must produce their journals at the time of practical examination.

Question Paper Pattern (25 Marks) Semisterwise Practical Exam		
Semister	**Nature / Type of Question**	**Marks**
I	Solve any one question out of Two	**10**
	Solve any Two question out of four	**10**
	Certified Journal & Oral	**05**
	Total Marks (For Semister I)	**25**
II	Solve any one question out of Two	**10**
	Solve any Two question out of Four	**10**
	Certified Journal & Oral	**05**
	Total Marks (For Semister II)	**25**
Total Marks		**50**