

Dr. C. S .RAO PG CENTRE
SRI Y.N .COLLEGE (AUTONOMOUS), NARSAPUR, W.G.Dt.,A.P.
NAAC Accredited 'A' Grade College Affiliated to AdikaviNannaya University
DEPARTMENT OF MATHEMATICS
M.Sc. MATHEMATICS I YEAR SEMESTER I
(W.e.f. 2022-2023 Admitted Batch)

M101: ALGEBRA-I

Course Outcomes: The study of M.Sc. degree programme will enable the students:

1. To discuss Normal Subgroups and Normal series like Isomorphism theorem and Automorphism.
2. To explain Structure theorem of Groups like Finitely generated Abelian group and Sylow's theorem
3. To describe Ideal's and Homomorphism, Unique Factorization domain and Euclidean domains.

UNIT-I: Normal subgroups: Normal subgroups and quotient groups-Isomorphism theorem- Automorphisms - Conjugacy and G-sets- Normal series solvable groups- Nilpotent groups.
(Section 1,2,3 and 4 of Chapter 5, Sections 1,2,3 of Chapter 6)

UNIT-II: Structure theorems of groups: Direct product- Finitely generated abelian groups- Invariants of a finite abelian group- Sylow's theorems- Groups of orders p^2 , pq .
(Sections 1 to 5 of Chapter 8)

UNIT-III: Ideals and homomorphism- Sum and direct sum of ideals, Maximal and prime ideals- Nilpotent and nil ideals- Zorn's lemma.
(Sections 1 to 6 of Chapter 10)

UNIT-IV: Unique factorization domains - Principal ideal domains- Euclidean domains- Polynomial rings over UFD.
(Sections 1 to 4 of Chapter 11)

Additional Inputs: Normal subgroups and quotient groups, Isomorphism theorem.

PRESCRIBED TEXT BOOK: Basic Abstract Algebra, Second Edition by P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul.

REFERRECE TEXT BOOK: Topics in Algrbra By I. N. Herstein.

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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS I YEAR SEMESTER I

(W.e.f. 2022-2023 Admitted Batch)

M101: ALGEBRA-I

Model Question Paper

Time: 3 hours

Max Marks: 75

SECTION – A

Answer **ALL** questions. Each question carries 15 marks.

$4 \times 15 = 60$

1. (a) If N be a normal subgroup of the group G , then prove that the mapping $\phi: G \rightarrow G/N$ defined by $x \mapsto xN$ is an epimorphism with $\text{Ker}\phi = N$.
(b) State and prove Burnside theorem.

(OR)

2. (a) Let G be a group. Then the following are true.
 - i) The set of conjugate classes of G is a partition of G .
 - ii) $|C(a)| = [G: N(a)]$.
 - iii) If G is finite, $|G| = \sum [G: N(a)]$.(b) Define an alternating group A_n . Show that the alternating group A_n is generated by the set of all 3 – cycles in S_n .

3. (a) State and prove fundamental theorem of finitely generated abelian group.
(b) State and prove Cauchy's theorem.

(OR)

4. (a) A group G is nilpotent if and only if G has a normal series $|e| = G_0 \subset G_1 \subset \dots \subset G_m = G$ such that $G_i / G_j \subset Z(G/G_{i-1})$ for all $i=1, \dots, m$.
(b) State and prove 2^{nd} and 3^{rd} Sylow theorems.

5. (a) If a ring R has unity, then every ideal I in the matrix ring R_n is of the form A_n , where A is some ideal in R .

(b) If K is an ideal in a ring R , then show that each ideal in R/K is of the form A/K where A is an ideal in R containing K .

(OR)

6. (a) f be a homomorphism of a ring R into a ring S with kernel N , then prove that $R/N \simeq \text{Im} f$.

(b) Let $f: R \rightarrow S$ be a homomorphism of Ring R into a ring S , then prove $\ker f = \{0\}$ if and only if f is 1-1.

7. (a) R is a non-zero ring with unity and I is an ideal in R such that $I \neq R$, then prove that there exists a maximal ideal M of R such that $I \subseteq M$.

(b) Prove that an irreducible element in a commutative principal ideal domain (PID) is always prime.

(OR)

8. (a) show that every Euclidean ring is a principal ideal domain

(b) State and prove Gauss lemma

SECTION – B

9. Answer any THREE questions of the following

3 × 5 = 15

(a) Define the following and give one example for each

(i) $\text{Aut}(G)$

(ii) Eisenstein Criteria of irreducibility.

(b) (i) Define invariants of a group.

(ii) Define p -group and give an example.

(c) (i) define an ideal and give two examples.

(ii) Define a principal ideal and give an example of a principal ideal ring.

(d) (i) define nilpotent ideal and give an example.

(ii) Show that every nilpotent ideal is nil. What about the converse? Justify?

(e) (i) write Zorn's lemma and give an application.

(ii) Define a Euclidean domain and give an example.



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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS I YEAR SEMESTER I

(W.e.f. 2022-2023 Admitted Batch)

M102:REAL ANALYSIS-I

Course Outcomes: The study of M.Sc. degree programme will enable the students:

1. To describe the Basic Topology and Numerical Sequences & Series.
2. To explain about Continuity like Continuity and Connectedness & Continuity and Compactness.
3. To Understand some special theorems of Differentiation like Mean value theorems and Taylor's theorem and further more learn about Differentiation of vector valued functions.

UNIT-I: Basic Topology: Finite-Countable- and Uncountable Sets- Metric spaces- Compact sets- Perfect Sets-Connected sets, The Real and Complex Number systems –Ordered sets , Fields.
(Chapter 2 of the text book)

UNIT-II: Numerical Sequences and Series: Convergent Sequences- Subsequences -Cauchy Sequences- Upper and Lower limits- Some Special Sequences- Series- Series of Non-negative Terms- The number e -The Root and Ratio tests- Power series -Summation by parts - Absolute Convergence-Addition and Multiplication of series-Rearrangements.
(Chapter 3 of the text book)

UNIT-III: Continuity: Limits of Functions- Continuous Functions- Continuity and Compactness- Continuity and Connectedness- Discontinuities- Monotonic Functions- Infinite Limits and Limits at Infinity.
(Chapter 4 of the text book)

UNIT-IV: Differentiation: The Derivative of a Real Function -Mean Value Theorems - The Continuity of Derivatives- L' Hospital's Rule- Derivatives of Higher order- Taylor's theorem- Differentiation of Vector- valued Functions.
(Chapter 5 of the text book)

Additional Inputs: The Real and Complex Number systems –Ordered sets , Fields.

PRESCRIBED TEXT BOOK: Principles of Mathematical Analysis by Walter Rudin, International Student Edition, 3rd Edition, 1985.

REFERENCE TEXT BOOK: Mathematical Analysis by Tom M. Apostol, Narosa Publishing House, 2nd Edition, 1985.

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DEPARTMENT OF MATHEMATICS
M.Sc. MATHEMATICS I YEAR SEMESTER I

(W.e.f. 2022-2023 Admitted Batch)

M102: REAL ANALYSIS-I

Model Question Paper

Time: 3 hours

Max Marks: 75

SECTION - A

Answer **ALL** questions. Each question carries 15 marks. $4 \times 15 = 60$

1. (i) Prove that Every infinite subset of a countable set A is countable
(ii) Define Metric Space. And Prove that "Every neighbourhood is an open set".
(OR)
2. Prove that "Every K- cell is compact".
3. Prove that, (i) If $|a_n| \leq c_n$ for $n \geq n_0$ where N_0 is some fixed integer, if $\sum c_n$ converges then $\sum a_n$ converges. (ii) If $a_n \geq d_n$ for $n \geq N_0$ and if $\sum d_n$ diverges then $\sum a_n$ diverges.
(OR)
4. Prove that $\lim_{n \rightarrow \infty} (1 + \frac{1}{n})^n = e$.
5. Prove that "a mapping f of a metric space X into a metric space Y is continuous on X if and only if $f^{-1}(V)$ is open in X for every open set V in Y .
(OR)
6. Prove that "if f is a continuous mapping of a compact metric space X into a metric space Y , then f is uniformly continuous on X ".
7. State and Prove Chain Rule.
(OR)
8. State and Prove Mean Value Theorem.

SECTION – B

9. Answer any three questions of the following. Each question carries 5 marks. $3 \times 5 = 15$

(i) Define Cantor Set.

(ii) State and Prove LEIBNITZ Theorem.

(iii) If $\{p_n\}, \{q_n\}$ are Cauchy sequences in a metric space, then show that $(d(p_n, q_n))$ converges

(iv) Prove that every differentiable function is continuous.

(v) Let f be defined on $[a, b]$ if f has a local maximum at a point $x \in (a, b)$ and if $f'(x)$ exists then $f'(x) = 0$.

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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS I YEAR SEMESTER I

(W.e.f. 2022-2023 Admitted Batch)

M103:DIFFERENTIAL EQUATIONS

Course Outcomes: The study of M.Sc. degree programme will enable the students:

1. To discuss the second order linear differential equations and analyze homogeneous equation with constant coefficients, undetermined coefficients and method of variation of parameters.
2. To explain Oscillation theory and Boundary value problems like Eigen values and Eigen functions.
3. To describe Power series solutions and Systems of first order equations.

UNIT-I: Second order linear differential equations: Introduction-general solution of the homogeneous equation - Use of a known solution to find another - Homogeneous equation with constant coefficients - method of undetermined coefficients - method of variation of parameters.

Chapter 3 (Sec 14-19)

UNIT-II: Oscillation theory and boundary value problems: Qualitative properties of solutions – The Sturm comparison theorem - Eigen values, Eigen functions and the vibrating string.

Chapter 4 (Sec 22-24, Appendix A)

UNIT-III: Power series solutions: A review of power series-series solutions of first order equations-second order linear equations - ordinary points-regular singular points-Gauss's hypergeometric equation.

Chapter 5 (Sec 25-30)

UNIT-IV: Systems of first order equations: Linear systems - Homogeneous linear systems with constant coefficients - Existence and Uniqueness of solutions - successive approximations - Picard's theorem - Some examples.

Chapter 7 (Sec 36-38) and Chapter 11(Sec 55-56)

Additional Inputs: Gauss's hypergeometric equation.

PRESCRIBED TEXT BOOK: George F. Simmons, Differential Equations, Tata McGraw-Hill Publishing Company Limited, New Delhi.



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M.Sc. MATHEMATICS I YEAR SEMESTER I
(W.e.f. 2022-2023 Admitted Batch)
M103:DIFFERENTIAL EQUATIONS

Model Question Paper

Time: 3 hours

Max Marks: 75

SECTION – A

Answer **ALL** questions. Each question carries 15 marks.

$4 \times 15 = 60$

1. If $y_1(x)$ and $y_2(x)$ are the linearly independent solutions of the homogeneous equation $y'' + p(x)y' + Q(x)y = 0$ on the interval $[a,b]$, then prove that $c_1y_1(x) + c_2y_2(x)$ is a solution of the differential equation. Also prove that Wronskian $W = W(y_1, y_2)$ is either identically zero or never zero on $[a,b]$.

(OR)

2. (a) Find the general solution of

$y'' - 3y' + 2y = 14 \sin 2x - 18 \cos 2x$ by the method of undetermined coefficients.

- (b) Find particular solution of $y'' + y = \operatorname{cosec} x$ by the method of variation of parameters.

3. State and prove Sturm comparison Theorem.

(OR)

4. Find the Frobenius series solution and the general solution for the differential equation $4x^2y'' - 8x^2y' + (4x^2 + 1)y = 0$.

5. (a) Find the differential equation satisfied by the function $y(x) = (1 + x)^p$ where p is any arbitrary constant, and then solve this equation by power series.

- (b) Solve the differential equation $y'' + y = 0$ by using the method of power series.

(OR)

6. Solve the Legendre differential equation.

7. (a) Solve the system

$$\frac{dx}{dt} = x + y$$

$$\frac{dy}{dt} = 4x - 2y.$$

(b) Solve the system

$$\frac{dx}{dt} = 3x - 4y$$

$$\frac{dy}{dt} = x - y.$$

(OR)

8. State and prove Picard's theorem.

SECTION – B

9. Answer any three questions of the following. Each question carries 5 marks. $3 \times 5 = 15$

(i) Explain the method of undetermined coefficients $y'' + p(x)y' + q(x)y = \sin bx$ and
Solve $y'' + 10y' + 25y = 14e^{-5x}$.

(ii) prove that 'if $q(x) < 0$ and $u(x)$ is a nontrivial solution of $u'' + q(x)u = 0$, then $u(x)$
Has at most one zero'?

(iii) Find the general solution of $(1 + x^2)y'' + 2xy' - 2y = 0$ in terms of power series in x .

(iv) Write two independent Frobenius series solution for $xy'' + 2y' + xy = 0$.

(v) Solve the linear system

$$\frac{dx}{dt} = x + y - 5t + 2$$

$$\frac{dy}{dt} = 4x - 2y - 8t - 8.$$

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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS I YEAR SEMESTER I

(W.e.f. 2022-2023 Admitted Batch)

M104: TOPOLOGY

Course Outcomes: The study of M.Sc. degree programme will enable the students:

1. To discuss the basic concepts of Sets and Functions and also know about Countable Sets & Uncountable Sets, further more about Partitions and equivalence relations.
2. To learn about Metric spaces like open sets, closed sets and continuous mappings and also learn about Euclidean and unitary spaces.
3. To describe Compactness like compact spaces, Product of spaces and discuss about some important theorems like Tychonoff's Theorem and Ascoli's theorem.

UNIT-I: Sets and Functions: Sets and Set inclusion – The algebra of sets – Functions – Products of sets – Partitions and equivalence relations – Countable sets – Uncountable sets – Partially ordered sets and lattices.

(Chapter I: Sections 1 to 8.)

UNIT-II: Metric spaces: The definition and some examples – Open sets – Closed sets – Convergence, Completeness and Baire's theorem – Continuous mappings.

(Chapter 2: Sections 9 to 13.)

UNIT-III: Metric spaces (Continued): Spaces of continuous functions – Euclidean and unitary spaces.

Topological spaces: The definition and some examples – Elementary concepts – Open bases and open sub bases – Weak topologies – The function algebras $C(X, \mathbb{R})$ and $C(X, \mathbb{C})$.

(Chapter 2: Sections 14,15 and Chapter 3: 16 to 20.)

UNIT-IV: Compactness: Compact spaces – Product of Spaces – Tychonoff's theorem and locally Compact spaces – Compactness for metric spaces – Ascoli theorem – Limit point compactness

(Chapter 4: Sections 21 to 25.)

Additional Inputs: limit point compactness.

PRESCRIBED TEXT BOOK-1: Introduction to Topology by G.F.Simmons, Mc.Graw-Hill book company.

PRESCRIBED TEXT BOOK – 2: Topology by James R. Munkers, Second edition, Pearson education Asia – Low price edition.

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M.Sc. MATHEMATICS I YEAR SEMESTER I
(W.e.f. 2022-2023 Admitted Batch)

M104: TOPOLOGY

Model Question Paper

Time: 3 hours

Max Marks: 75

SECTION – A

Answer **ALL** questions. Each question carries 15 marks. $4 \times 15 = 60$

1. (i) Let X be a non-empty set. A relation \sim in X is called circular if $x \sim y$ & $y \sim z \Rightarrow z \sim x$ & triangular if $x \sim y$ & $x \sim z \Rightarrow y \sim z$. Then prove that a relation in X is an equivalence if and only if it is reflexive & circular if and only if it is reflexive & triangular.
(ii) State Schroeder Bernstein Theorem.

(OR)

2. Prove that, (i) Any subset of a Countable Set is Countable.
(ii) A Countable union of countable sets is countable.

3. (i) Define metric space. Prove that any metric space X each open sphere is an open set.

(ii) Let X be metric space and let A be a subset of X . If x is a limit point of A . Show that each open sphere centered on x contains an infinite number of distinct points of A .

(OR)

4. Define open set and closed set. Let (X, d) be a metric space. Let A is subset of X . Then the following hold.

(i) $b(A) = \bar{A} \cap \bar{A}^c$

(ii) $b(A)$ is a closed set.

(iii) A is closed $\Leftrightarrow b(A) \subseteq A$.

5. (i) State and prove Minkowski's inequality.

(ii) Define Topological space. Let X be a topological space and A is an arbitrary sub set of X .

Then $\bar{A} = \{x \in X \mid \text{each neighborhood of } x \text{ intersects } A\}$

i.e; $\bar{A} = \{x \in X \ni G \cap A \neq \emptyset, \text{ for any neighborhood } G \text{ of } x\}$.

(OR)

6. (i) State and Prove Lindelof's theorem.

(ii) Show that every separable metric space is second countable.

7. (i) Prove that any closed subspace of a compact space is compact.

(ii) Prove that a metric space is sequentially compact if it has the Bolzano Weierstrass property.

(OR)

8. State and prove Ascoli's theorem.

SECTION – B

9. Answer any three questions of the following. Each question carries 5 marks. **$3 \times 5 = 15$**

(i) Prove that the set of all positive rational numbers are countable.

(ii) State Cantor Intersection Theorem.

(iii) Prove that a sub set F of metric space is closed iff its complement F^c is open.

(iv) Prove that any continuous image of compact space is compact.

(v) Prove that every compact metric space is separable.



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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS I YEAR SEMESTER I

(W.e.f. 2022-2023 Admitted Batch)

M105:DISCRETE MATHEMATICS

Course Outcomes: The study of M.Sc. degree programme will enable the students:

1. To discuss lattices as partially ordered sets, some properties of lattices, lattices as algebraic systems.
2. To acquire the knowledge from Boolean forms and free Boolean algebras, values of Boolean expressions.
3. To Describe representations and minimizations of Boolean functions and to explain finite state machines, Introductory sequential circuits, equivalence of Finite state Machines.

UNIT-I:Relations and ordering: Relations- properties of binary relations in a set-Relation matrix and the graph of a relation, partition and covering of a set, equivalence relations, compatibility relation, composition of binary relations- partially ordering- Partially ordered sets - representation and associated terminology.

[2-3.1 to 2-3.9 of Chapter 2 of the Text Book]

UNIT-II:Lattices: Lattices as partially ordered sets - some properties of Lattices - Lattices as algebraic systems - sub-Lattices - direct product and homomorphism some special Lattices.

[4-1.1 to 4-1.5 of Chapter 4 of the Text Book]

UNIT-III:Boolean Algebra: Sub algebra - direct product and Homomorphism - Boolean forms and free Boolean Algebras - values of Boolean expressions and Boolean function.

[4-2.1,4-2.2,4- 3.1, 4-3.2 of Chapter 4 of the Text Book]

UNIT-IV:Representations and minimization of Boolean Function: Representation of Boolean functions – minimization of Boolean functions- Finite State Machines - Introductory Sequential Circuits - Equivalence of Finite-State Machines, Connectives – Negation , Conjunction , Disjunction , Statement formulas and Truth tables.

[4-4.1,4-4.2,4-6.1, 4-6.2 of Chapter 4 of the Text Book]

Additional Inputs: Connectives – Negation , Conjunction , Disjunction , Statement formulas and Truth tables.

PRESCRIBED TEXT BOOK:Discrete Mathematical structures with applications to Computer Science by J.P.Tremby and R. Manohar, Tata McGraw-Hill Edition.

REFERENCE TEXT BOOKS:1.Discrete Mathematics for Computer Scientists and Mathematicians by J.L.Mott, A.Kandel and T.P. Baker, Prentice-Hall India.

2. Discrete Mathematical Structures by Kolman & Busby & Sharen Ross

3. Applied Abstract Algebra by Rudolf Lidl & Gunter Pilz ,Published by Springer Verlag.

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M.Sc. MATHEMATICS I YEAR SEMESTER I
(W.e.f. 2022-2023 Admitted Batch)
M105:DISCRETE MATHEMATICS
Model Question Paper

Time: 3 hours

Max Marks: 75

SECTION – A

Answer **ALL** questions. Each question carries 15 marks.

4 × 15 = 60

- 1) Let $X = \{1, 2, 3\}$ if $R = \{(x, y) / x \in X \wedge y \in X \wedge ((x - y) \text{ is an integral non-zero multiple of } 2)\}$, $S = \{(x, y) / x \in X \wedge y \in X \wedge ((x - y) \text{ is an integral non-zero multiple of } 3)\}$
(a) Find $R \cup S$ and $R \cap S$.
(b) If $X = \{1, 2, 3, \dots\}$, What is $R \cap S$ for R and S as defined in (a)
(OR)
- 2) Let A be a given finite set and $q(A)$ its power set. Let \subseteq be the inclusion relation on the elements of $q(A)$. Draw Hasse diagrams of $(q(A), \subseteq)$ for (a) $A = \{a\}$; (b) $A = \{a, b\}$;
(c) $A = \{a, b, c\}$ (d) $A = \{a, b, c, d\}$
- 3) Let (L, \leq) be a lattice. For any $a, b, c \in L$ show that the following holds:
 $a \leq c \Leftrightarrow a \oplus (b * c) \leq (a \oplus b) * c$
(OR)
- 4) Show that in a lattice (L, \leq) , for any $a, b, c \in L$, the distributive inequalities hold:
 $a \oplus (b * c) \leq (a \oplus b) * (a \oplus c)$
 $a * (b \oplus c) \geq (a * b) \oplus (a * c)$
- 5) Write the following Boolean expression in an equivalent sum of products canonical form in three variables x_1, x_2 and x_3 (a) $x_1 * x_2$ (b) $x_1 \oplus x_2$ (c) $(x_1 \oplus x_2)' * x_3$

(OR)

6) Obtain the values of the Boolean forms $x_1 * (x_1' \oplus x_2)$, $x_1 * x_2$ and $x_1 \oplus (x_1 * x_2)$ over the ordered pairs of the two-element Boolean algebra.

7) Prove that if for some integer k , $p_{k+1} = p_k$, then $p_k = p$ and conversely.

(OR)

8) Find the value of the function $f_{\alpha, \beta} : B^n \rightarrow B$ for $x_1 = a, x_2 = 1, x_3 = b$ where $a, b, 1$ are the elements of the Boolean algebra and $\alpha(x_1, x_2, x_3)$ is the expression $\alpha(x_1, x_2, x_3) = (x_1 \oplus x_2)' * x_3$.

SECTION – B

9. Answer any three questions of the following. Each question carries 5 marks. $3 \times 5 = 15$

(i) Draw Hasse diagram of the set $x = \{2, 3, 6, 12, 24, 36\}$ and the relation \leq such that $x \leq y$ if x divides y

(ii) Write some properties of lattices

(iii) Define subalgebra, Direct product and Homomorphism.

(iv) Obtain the product of sums canonical forms of the Boolean expression $x_1 * x_2$

(v) Write about finite state machines.



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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS I YEAR SEMESTER II

(W.e.f. 2022-2023 Admitted Batch)

M201:ALGEBRA-II

Course Outcomes: The study of M.Sc. degree programme will enable the students:

- 1.To discuss about Rings of Fractions and Algebraic Extensions of Fields.
- 2.To explain Normal and Separable extensions like Splitting fields, Multiple roots and Finite fields.
- 3.To discuss about Galois theory and it's applications to classical problems like cyclic extensions, Roots of Unity and Cyclotomic polynomials.

UNIT-I: Rings of fraction: Rings of fraction-Rings with Ore condition, Algebraic extensions of fields: Irreducible polynomials and Eisenstein criterion- Adjunction of roots- Algebraic extensions-Algebraically closed fields.

(Sections 1&2of chapter 12, section 1 to 4 of Chapter 15)

UNIT-II: Normal and separable extensions: Splitting fields- Normal extensions- Multiple roots- Finite fields- Separable extensions.

(Sections 1 to 5 of Chapter 16)

UNIT-III: Galois theory: Automorphism groups and fixed fields- Fundamental theorem of Galois theory-Fundamental theorem of Algebra.

(Sections 1 to 3 of Chapter 17)

UNIT-IV: Applications of Galioes theory to classical problems: Roots of unity and cyclotomic polynomials- Cyclic extensions- Polynomials solvable by radicals - Ruler and Compass constructions.

(Sections 1 to 3 and 5 of Chapter 18)

Additional Inputs: Rings of fraction,Rings with Ore condition

PRESCRIBED TEXT BOOK: Basic Abstract Algebra , Secound Editionby P.B. Bhattacharya, S.K. Jainand S.R. Nagpaul

REFERENCE TEXT BOOK: Topics in Algrbra By I. N. Herstein.

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DEPARTMENT OF MATHEMATICS
M.Sc. MATHEMATICS I YEAR SEMESTER II

(W.e.f. 2022-2023 Admitted Batch)

M201:ALGEBRA-II

Model Question Paper

Time: 3 hours

Max Marks: 75

1. (a) (i) state and prove Gauss lemma.
(ii) let F is contained in E is contained in K be fields. If $[K:E] < \infty$ and $[E:F] < \infty$ then
(i) $[K:F] < \infty$
(ii) $[K:F] = [K:E][E:F]$

(OR)

- (b) Let $E = F(u_1, u_2, \dots, u_r)$ be a finitely generated extension of F such that each $u_i, i = 1, 2, \dots, r$ is algebraic over F then prove that each E is finite over F and hence an Algebraic extension of F .

2. (a) Let F be a field. Then show that there exists an algebraically closed field K containing F as a subfield.
(b) Let E be a finite extension of a field. Then the following are equivalent.
i) $E = F(\alpha)$ for some $\alpha \in E$.
ii) There are only a finite number of intermediate fields between F and E .
3. (a) Let F be an field. Then there exist an algebraically closed field K containing F as a subfield.
(b) State and prove uniqueness of splitting field.

(OR)

4. (a) Let $f(x)$ be an irreducible polynomial over F . Then $f(x)$ multiple root if and only if $f'(x) = 0$.
(b) If $f(x) \in F[x]$ is irreducible over F , roots of $f(x)$ have the same multiplicity.

5. Let H be a finite subgroup of the group of Automorphism of a field E . Then $[E: E^H] = |H|$.

(OR)

6. State and prove fundamental theorem of Galois theory.

7. $\phi_n(x) = \prod_{\omega} (x - \omega)$, ω primitive n th root in \mathbb{C} , is an irreducible polynomial of degree $\phi(n)$ in $\mathbb{Z}[x]$.

(OR)

8.a) Let F be a field and let n be a positive integer. Then there exists a primitive n th root of unity in some extension E of F if and only if either $\text{char } F = 0$ or $\text{char } F \nmid n$.

b) If p is a prime number and if a subgroup G of S_p is a transitive group of permutations containing a transposition (a, b) then $G = S_p$.

SECTION – B

9. Answer any three questions of the following. Each question carries 5 marks. $3 \times 5 = 15$

a) Let $f(x) = a_0 + a_1x + \dots + a_{n-1}x^{n-1} + x^n \in \mathbb{Z}[x]$ be a monic polynomial. If $f(x)$ has a root $a \in \mathbb{Q}$, then $a \in \mathbb{Z}$ and $a|a_0$.

b) the degree of the extension of the splitting field of $x^3 - 2 \in \mathbb{Q}[x]$ is 6.

c) Show that the multiplicative group of non zero elements of a finite field is cyclic.

d) If E is a finite extension of a field F , then prove that $|G(E/F)| \leq [E:F]$.

e) Show that if $a > 0$ is constructible, then \sqrt{a} is constructible.



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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS I YEAR SEMESTER II

(W.e.f. 2022-2023 Admitted Batch)

M202:REAL ANALYSIS-II

Course Outcomes: The study of M.Sc. degree programme will enable the students:

1. To describe the Riemann stieltjes Integral and Sequences and Series of the functions like Uniform convergence, Uniform convergence and Continuity and Integration further more know about Equicontinuous families of functions, the stone wierstrass theorem.
2. To explain the concept of Power Series and Functions of Several Variables like linear transformations ,the contraction principle and the inverse function theorem.
3. To learn about the the Implicit function theorem,the Rank theorem and further more about Derivatives of higher order and Differentiation of integrals.

UNIT-I: Riemann-Stieltjes Integral: Definition and existence of the Riemann Stieltjes Integral, Properties of the Integral, Integration and Differentiation, the fundamental theorem of calculus– Integral of Vector- valued Functions, Rectifiable curves.

(Chapter 6)

UNIT-II: Sequences and Series of the Functions: Discussion on the Main Problem, Uniform Convergence, Uniform Convergence and Continuity, Uniform Convergence and Integration, Uniform Convergence and Differentiation, Equicontinuous families of Functions, the Stone- Weierstrass Theorem. (Chapter 7)

UNIT-III: Power Series: (A section in Chapter 8 of the text book) , the exponential and logarithmic functions. Functions of Several Variables: Linear Transformations, Differentiation, The Contraction Principle, The Inverse Function theorem.

(First Four sections of chapter 9 of the text book)

UNIT-IV: Functions of several variables Continued: The Implicit Function theorem, The Rank theorem, Determinates, Derivatives of Higher Order, Differentiation of Integrals.

(5 th to 9 th sections of Chapter 9 of the text book)

Additional Inputs: The exponential and logarithmic functions.

PRESCRIBED TEXT BOOK: Principles of Mathematical Analysis by Walter Rudin, International Student Edition, 3 rd Edition, 1985.

REFERENCE TEXT BOOK: Mathematical Analysis by Tom M. Apostol, Narosa Publishing House, 2 nd Edition, 1985.

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DEPARTMENT OF MATHEMATICS
M.Sc. MATHEMATICS I YEAR SEMESTER II
(W.e.f. 2022-2023 Admitted Batch)
M202: REAL ANALYSIS-II
Model Question Paper

Time: 3 hours

Max Marks: 75

SECTION – A

Answer **ALL** questions. Each question carries 15 marks.

$4 \times 15 = 60$

1. (i) Prove that , $f \in R(\alpha)$ on $[a, b]$ if and only if for every $\varepsilon > 0$ there exists a partition P such that $U(P, f, \alpha) - L(P, f, \alpha) < \varepsilon$.
(ii) Prove that ,If f is monotonic on $[a, b]$ and if α is continuous on $[a, b]$,then $f \in R(\alpha)$.
(OR)
2. (i)State and prove integration by parts formula.
(ii) Prove that ,If γ' is continuous on $[a, b]$, then γ is rectifiable , and $A(\gamma) = \int_a^b |\gamma'(t)| dt$.
3. (i) State and prove Cauchy's criterion for uniform convergence of sequence of function.
(ii) State and prove Weirstrass M- Test.
(OR)
4. (i) State and prove Stone-Weirstrass Theorem.
(ii) Prove that there exists a real continuous function on the real line which is nowhere differentiable.
5. i) State and prove Abel's Theorem.
(ii) State and prove Taylor's Theorem

(OR)

6. (i) State and prove contraction principle.
(ii) Suppose that f maps a convex open set $E \subset \mathbb{R}^n$, f is differentiable in E , and there is a real number M such that $\|f'(x)\| \leq M$ for every $x \in E$. Then $|f(b) - f(a)| \leq M|b - a|$ for all $a \in E, b \in E$.

7. Prove that ,(i) If I is the identity operator on R^n ,then

$$\det[I] = \det(e_1, \dots, e_n) .$$

(ii) If $[A]_1$ is obtained from $[A]$ by interchanging two columns ,thend $\det[A]_1 = -\det[A]$.

(OR)

8. Suppose f is defined in an open set $E \subset R^2$, suppose that $D_1f, D_{21}f, \text{ and } D_2f$ exist at every point of E ,and $D_{21}f$ is continuous at some point $(a, b) \in E$.

SECTION – B

9. Answer any three questions of the following. Each question carries 5 marks. **$3 \times 5 = 15$**

- (i) Suppose $\{f_n\}$ is a sequence of functions defined on E ,and suppose $|f(x)| \leq M_n, x \in E, n = 1,2,3, \dots \dots$. Then prove that $\sum f_n$ coversges uniformly on E if $\sum M_n$ converges.
- (ii) If $f \in R(\alpha)$ & $g \in R(\alpha)$ on $[a, b]$, then prove that $fg \in R(\alpha)$.
- (iii) Let B be the uniform closure of an algebra of bounded functions .Then B is a uniformly closed algebra.
- (iv) If $[A]$ and $[B]$ are n by n matrices , then prove that $\det([B][A]) = \det[B] \det[A]$.
- (v) State contraction principle and Inverse function theorem.



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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS I YEAR SEMESTER II

(W.e.f. 2022-2023 Admitted Batch)

M203:COMPLEX ANALYSIS-I

Course Outcomes: The study of M.Sc. degree programme will enable the students:

1. To discuss the elementary properties and examples of Analytic functions like Power series and Mobius transformations.
2. To study complex integration and analyze Riemann-Stieltjes integrals, Cauchy theorem and Integral formula.
3. To describe classification of Singularities, Residues and argument principle.

UNIT-I:Elementary properties and examples of analytic functions: Power series- Analytic functions- Analytic functions as mappings, Mobius transformations.

(1,2,3 of chapter-III)

UNIT-II:Complex Integration: Riemann- Stieltjes integrals- Power series representation of analytic functions- zeros of an analytic functions- The index of a closed curve.

(1,2,3,4 of chapter-IV)

UNIT-III:Cauchy's theorem and integral formula- the homotopic version of Cauchy's theorem and simple connectivity- Counting zeros; the open mapping theorem.

(5,6,7 of chapter-IV)

UNIT-IV: Singularities: Classifications of singularities- Residues- The argument principle, The Maximum Modulus Theorem: The Maximum Principle- Schwarz's Lemma

(1,2,3 of chapter-V ,1,2 of chapter-VI)

Additional Inputs:The Maximum Modulus Theorem: The Maximum Principle- Schwarz's Lemma

PRESCRIBED TEXT BOOK: Functions of one complex variables by J.B.Conway : Second edition, Springer International student Edition, Narosa Publishing House, New Delhi.

REFERENCE TEXT BOOK: A first course in complex analysis with applications by Dennis G.Zill and Patrick Shanahan.

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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS I YEAR SEMESTER II

(W.e.f. 2022-2023 Admitted Batch)

M203: COMPLEX ANALYSIS-I

Model Question Paper

Time: 3 hours

Max Marks: 75

SECTION – A

Answer **ALL** questions. Each question carries 15 marks.

4 × 15 = 60

1. (a) Let G be an open connected set in \mathbb{C} . If $f: G \rightarrow \mathbb{C}$ is differentiable with $f'(z) = 0$ for all z in G , prove that f is constant.
(b) Let u and v be two real valued continuous functions defined on a region G . If u and v have continuous first order partial derivatives, satisfying $u_x = v_y$ and $u_y = v_x$, then prove that the function $f: G \rightarrow \mathbb{C}$ defined by $f(z) = u(z) + iv(z)$ is analytic in G .
(OR)
2. (a) Define cross ratio. If z_2, z_3, z_4 are distinct points and T is any Mobius transformation, Prove that $(Z, Z_2, Z_3, Z_4) = (TZ_1, TZ_2, TZ_3, TZ_4)$ for any point Z_1 .
(b) State and prove the symmetry principles.
3. (a) State and prove Leibniz 's theorem.
(b) Let r be a rectifiable curve and suppose that f is a function continuous on $\{r\}$, prove
That $\left| \int_r f \right| \leq \int |f| |dz| \leq V(r) \sup \left\{ \left| \frac{f(z)}{z} \right| \in \{r\} \right\}$.
(OR)
4. State and prove Fundamental theorem of Algebra.
5. State and prove Cauchy's Integral formula second version.
(OR)
6. (a) State and prove the open mapping theorem.
(b) State and prove Morera's Theorem.
7. (a) State and prove Casorati-Weirstrass theorem.

(b) Show that $\int_0^{\infty} \frac{\log x}{1+x^2} = 0$.

(OR)

8. (a) State and prove Rouché's Theorem.

(b) Obtain the Laurent Series Expansion for the function $f(z) = \frac{1}{(z-1)(z-2)}$ following annuli i) $a(0;0,1)$ ii) $ann(0;1,2)$ iii) $ann(0;2,\infty)$

SECTION – B

9. Answer any three questions of the following. Each question carries 5 marks. **3 × 5 = 15**

(i) If $u(x, y) = e^x \cos x(x, y) \in C$, prove that u is harmonic in C

And find its harmonic conjugate.

(ii) Prove that any Möbius transformation has at most two fixed points

(iii) Define $\gamma: [0, 2\pi] \rightarrow C$ by $\gamma(t) = \exp(int)$ where n is some integer. Show

$$\text{That } \int_{\gamma} \frac{dz}{z} = 2\pi in.$$

(iv) Find all entire functions such that $f(x) = e^x$ for all $x \in R$.

(v) Evaluate $\int_0^{\infty} \frac{\sin x}{x} dx = \frac{\pi}{2}$.



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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS I YEAR SEMESTER II

(W.e.f. 2022-2023 Admitted Batch)

M204:LINEAR ALGEBRA

Course Outcomes: The study of M.Sc. degree programme will enable the students:

1. To Explain elementary canonical forms, annihilating polynomials, invariant subspaces.
2. To Describe direct –sum decompositions, invariant direct-sums.
3. To Acquire the knowledge in the Jordan forms, computation of invariant factors, semi simple operators.

UNIT-I:Elementary Canonical Forms : Introduction – Characteristic Values – Annihilating Polynomials –invariant subspaces – Simultaneous Triangulation – Simultaneous Diagonalization.

(Sections 6.1,6.2,6.3,6.4,6.5 of chapter-6)

UNIT-II: Direct – sum Decompositions – invariant direct sums – the primary decomposition theorem – cyclic subspaces and Annihilators – cyclic decompositions and the rational form.

(Sections 6.6,6.7,6.8 of chapter-6 and Sections 7.1,7.2 of chapter - 7)

UNIT-III: The Jordan Form – Computation of Invariant Factors – Semi Simple Operators, Linear Transformations.(Sections 7.3,7.4,7.5 of chapter - 7)

UNIT-IV: Bilinear Forms : Bilinear Forms – Symmetric Bilinear Forms – Skew Symmetric Bilinear Forms– Group Preserving Bilinear Forms.

(Sections 10.1,10.2,10.3,10.4 of chapter - 10)

Additional Inputs : Linear Transformations.

PRESCRIBED TEXT BOOK: Linear Algebra second edition By Kenneth Hoffman and Ray Kunze, PrenticeHall of india Private Limited, New Delhi.

REFERENCE TEXT BOOK: SCHAUM'S outlines by MURRAY,R.SPIEGEL, JOHN SCHILLER, R.ALU SRINIVASAN.

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DEPARTMENT OF MATHEMATICS
M.Sc. MATHEMATICS I YEAR SEMESTER II
(W.e.f. 2022-2023 Admitted Batch)

M204:LINEAR ALGEBRA

Model Question Paper

Time: 3 hours

Max Marks: 75

SECTION – A

Answer **ALL** questions. Each question carries 15 marks.

4 × 15 = 60

1. Let T be a linear operator on the finite dimensional space V . Let c_1, c_2, \dots, c_k be the distinct characteristic values of T and let w_i be the If $w = w_1 + w_2 + \dots + w_k$ then dimension of $w = \dim w_1 + \dim w_2 + \dots + \dim w_k$ infact if β_i is an ordered basic for w_i then $\beta = \beta_1 + \beta_2 \dots + \beta_k$ is an ordered basic for w .

(OR)

2. Let T be a linear operator on an n -dimensional $V.S V(F)$. The characteristic equation and minimal polynomials for T have same roots except for multiplicities.
3. State and prove primary decomposition theorem.

(OR)

4. Let T be a linear operator on the finite dimensional vector space V and W_1, \dots, W_k are subspaces of V and E_1, \dots, E_k are projections corresponding to the linear operator T . Then a necessary and sufficient condition that each subspace W_i be invariant under T is that T is commutes with each of the projections E_i .
5. let M be an $m \times m$ matrix with entries in the polynomial algebra $F[x]$. Then M is equivalent to a matrix N which is in normal form.

(OR)

6. Find all rational canonical for with minimal polynomial $m(t) = (t - 1)^3$ and characteristic polynomial $\Delta(t) = (t - 1)^7$.

7. Let V be a finite dimensional vector space over the field F . Let f be a symmetric bilinear form on V which has a rank r then there is an ordered basis $\mathfrak{B} = \{\beta_1, \beta_2 \dots \beta_n\}$ for V such that
- The matrix of f in the ordered basis \mathfrak{B} is diagonal.
 - $f(\beta_j, \beta_j) = \begin{cases} 1 & \text{if } j = 1, 2, \dots, r \\ 0 & \text{if } j > r \end{cases}$

(OR)

8. Let f be a non-degenerate bilinear form on a finite dimensions vector space V . The set of all linear operators on V which preserves f is a group under the operation of composition.

SECTION – B

9. Answer any three questions of the following. Each question carries 5 marks. **3 × 5 = 15**

(i) Prove that similar matrices have the same characteristic Polynomial.

(ii) Let E_1, E_k be linear operators on the space V such that $E_1 + \dots + E_k = I$. Then prove that if $E_i E_j = 0$ for $i \neq j$, then $E_i^2 = E_i$ for each i .

(iii) Define a Smith Normal form and give an example.

(iv) Define a bilinear form and give an example.

(v) Let V be a finite-dimensional vector space over the field F and f a symmetric bilinear form on V . For each subspace W of V , let X be the set of all vectors α in V such that $f(\alpha, \beta) = 0$ for every β in W . Show that X is a subspace.



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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS I YEAR SEMESTER II

(W.e.f. 2022-2023 Admitted Batch)

M205:PROBABILITY THEORY & STATISTICS

Course Outcomes: The study of M.Sc. degree programme will enable the students:

1. It gives insight about the concepts, definitions and theorems of Probability and analyze the Probability distributions like Binomial, Poisson and Normal distributions.
2. Describe correlation and regression analysis concepts.
3. Understand the concepts of sampling and explain the large sample test.

UNIT-I:Sample Space & Events, Axioms of Probability, Some theorems on Probability, Boole's inequality, Conditional probability, Multiplication theorem on probability, Independent events, Multiplication theorem on probability for Independent Events, Extension of Multiplication theorem on probability to n events, Pair-wise Independent Events, Baye's theorem

[Section 3.8 to 3.15 , Page no: 3.2 to 3.98 & Section 4.2, Page no: 4.4 to 4.20]

UNIT-II:Distribution function, Discrete Random variables, Continuous random variables, Mathematical Expectation, Expected value of function of a random variable, Properties of Expectation, Properties of variance, Covariance, Moment Generating Function, Characteristic function, Binomial Distribution, Poisson Distribution, Normal Distribution, Uniform Distribution, Random Experiment, Mutually exclusive events, Exhaustive number of cases, Population, Level of significance and Degrees of freedom.

[Section 5.2 to 5.4, Page no: 5.2 to 5.31, Section 6.2 to 6.6, Page no: 6.1 to 6.22, Section

7.1, 7.3(7.3.1 & 7.3.2 only), Page no: 7.2 to 7.6, Page no: 7.9 to 7.15, Section 8.4, 8.5, Page

no: 8.4 to 8.47, Section 9.2.1 to 9.2.11 and 9.2.14, 9.3, Page no: 9.2 to 9.12, 9.14 to 9.28, and 9.3 to 9.37]

UNIT-III:Correlation: Introduction, meaning of correlation, scatter diagram, Karl Pearson's Coefficient of Correlation, Rank Correlation, Linear and Curvilinear Regression:Introduction, linear regression, curvilinear regression

[Section 10.1 to 10.4(10.4.1, 10.4.2 only & in 10.7 –10.7.1 only), Page no: 10.1 to 10.16 and 10.23 – 10.25, Section 11.1 to 11.3, Page no: 11.1 to 11.19]

UNIT-IV:Large Sampling theory: Introduction, types of sampling, parameters and statistic, tests of significance, procedure for testing of hypothesis, tests of significance for large samples.

[Section 14.1 – 14.6, Page no: 14.1 to 14.22]

Additional Inputs : Random Experiment, Mutually exclusive events, Exhaustive number of cases, Population, Level of significance and Degrees of freedom.

PRESCRIBED TEXT BOOK: Fundamentals of Mathematical Statistics, S.C.Gupta, V.K.Kapoor Eleventh Thoroughly Revised Edition Published by: Sultan Chand & Sons, NEW-DELHI.

REFERENCE TEXT BOOK: Statistical methods by S.P Gupta.

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M.Sc. MATHEMATICS I YEAR SEMESTER II
(W.e.f. 2022-2023 Admitted Batch)
M205: PROBABILITY THEORY & STATISTICS
Model Question Paper

Time: 3 hours

Max Marks: 75

SECTION – A

Answer **ALL** questions. Each question carries 15 marks.

$4 \times 15 = 60$

1. (a) State and prove addition theorem of probability.
(b) The probability that a contractor will get a plumbing contract is $\frac{2}{3}$ and the probability that he will not get an electric contract is $\frac{5}{9}$. If the probability of getting at least one contract is $\frac{4}{5}$, what is the probability that he will get both the contracts?
(OR)
2. (a) State and prove Bayes' theorem.
(b) In a bolt factory, machines A, B, C manufacture respectively 25%, 35%, and 40% .Of the total of their output 5%, 4%, and 2% are known to be defective bolts. A bolt is drawn at random from the product and is found to be defective. What are the probabilities that it was manufactured by
i) Machine A ii) Machine B and
iii) Machine C
3. (a) Derive the moment generating function of Binomial distribution. Hence find the mean and variance of Binomial distribution.

(b) Fit a Poisson distribution to the following data:

Number of mistakes per page	0	1	2	3	4	Total
Number of pages	109	65	22	3	1	200

(OR)

4. (a) The distribution of monthly income of 500 workers may be assumed to be normal with mean of Rs.2000 and a standard deviation of Rs. 200. Estimate the number of workers with incomes
(i) Exceeding Rs.2300 per month

(ii) Between Rs. 1800 and Rs.2300 per month.

(b) If X is uniformly distributed with mean 1 and variance $\frac{4}{3}$, then find $P(X < 0)$.

5. Calculate the Karl Pearson's correlation coefficient for the following heights of fathers(X) and their sons(Y):

X	65	66	67	67	68	69	70	72
Y	67	68	65	68	72	72	69	71

(OR)

6. (a) Prove that if one of the regression coefficients is greater than unity, the other must be less than unity.

(b) Obtain the equations of two lines of regression for the following data. Also obtain the estimate of X for $Y = 70$.

X	65	66	67	67	68	69	70	72
Y	67	68	65	68	72	72	69	71

7. (a) A random sample of 500 pineapples was taken from a large consignment and 65 were found to be bad. Show that the S.E. of the proportion of bad ones in a sample of this size is 0.015 and deduce that the percentage of bad pineapples in the consignment almost certainly lies between 8.5 and 17.5.

(b) Twenty people were attacked by a disease and only 18 survived. Will you reject the hypothesis that the survival rate, if attacked by this disease, is 85% in favour of the hypothesis that it is more, at 5% level.

(OR)

8. A company has the head office at Kolkata and a branch at Mumbai. The personal director wanted to know if the workers at the two places would like the introduction of a new plan of work and a survey was conducted for this purpose. Out of a sample of 500 workers at , 62% favoured the new plan. At Mumbai out of a sample 400 workers, 41% were against the new plan. Is there any significant difference between the two groups in their attitude towards the new plan at 5% level?

SECTION – B

9. Answer any three questions of the following. Each question carries 5 marks.

3 × 5 = 15M

(i) From a city population, the probability of selecting (a) a male or a smoker is $\frac{7}{10}$, (b) a male smoker is $\frac{2}{5}$, and (c) a male, if a smoker is already selected is $\frac{2}{3}$. Find the probability of selecting a smoker, if a male is first selected.

(ii) A problem in Statistics is given to three students A, B and C whose chances of solving it are $\frac{1}{2}$, $\frac{3}{4}$, and $\frac{1}{4}$ respectively. What is the probability that the problem will be solved if all of them try independently.

(iii) A random variable X has the following probability function:

Values of X, x	0	1	2	3	4	5	6	7
P(x)	0	K	2k	2k	3k	k^2	$2k^2$	$7k^2 + k$

(a) Find k , and (b) Evaluate $P(X < 6)$, $P(X \geq 6)$.

(iv) Prove that correlation coefficient is lies between ± 1 .

(v) Explain the procedure for testing of hypothesis.

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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS II YEAR SEMESTER III

(W.e.f. 2022-2023 Admitted Batch)

M301: FUNCTIONAL ANALYSIS

Course Outcomes: The study of M.Sc. degree programme will enable the students:

1. To discuss the Banach spaces definition with examples, continuous linear transformation, the Hahn- Banach theorem and the natural imbedding of N in N^{**} .
2. To discuss Hilbert spaces the definition and some simple properties, orthogonal complements and orthonormal sets.
3. To explain Finite- dimensional spectral theory Matrices, determinants and the spectrum of an operator and the spectral theorem.

UNIT-I Banach spaces: the definition and some examples, continuous linear transformation, the Hahn-Banach theorem, the natural imbedding of N in N^{**} , The open mapping theorem.
(Sections 46 – 50 of chapter 9)

UNIT-II The conjugate of an operator, **Hilbert spaces:** The definition and some simple properties, orthogonal complements, orthonormal sets.
(Sections 51 of chapter 9 and Sections 52- 54 of chapter 10)

UNIT-III The Conjugate space H^* , the ad joint of an operator, Self- ad joint operators, Normal and Unitary operators, Projections.
(Sections 55 - 59 of chapter 10)

UNIT-IV Finite- dimensional spectral theory: Matrices, determinants and the spectrum of an operator, the spectral theorem, A survey of the situation.
(Sections 60 - 63 of chapter - 11)

PRESCRIBED TEXT BOOK: Introduction to Topology and Modern Analysis by G.F.Simmons, McGraw Hill Book Company, Inc-International student ed.

REFERENCE TEXT BOOK: First course in functional analysis by Casper-Goffman, George pedrick.

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DEPARTMENT OF MATHEMATICS
M.Sc. MATHEMATICS II YEAR SEMESTER III
(W.e.f. 2022-2023 Admitted Batch)
M301: FUNCTIONAL ANALYSIS
Model Question Paper

Time: 3 hours

Max Marks: 75

SECTION – A

Answer **ALL** questions. Each question carries 15 marks.

4 × 15 = 60

1. a) Define a Banach Space. Prove that the real linear space \mathbb{R}^n is a Banach Space.
b) In a Banach Space B, prove that the vector addition and scalar multiplication are jointly continuous.
(OR)
2. a) State and prove Hahn-Banach theorem.
b) Prove that the mapping $X \rightarrow F_x: N \rightarrow N^{**}$ where $F_x(f) = f(x), \forall f \in N^*$ is an isometric isomorphism of N into N^{**} .
3. a) State and prove open mapping theorem.
b) State and prove uniform boundedness theorem.
(OR)
4. a) If M and N are two closed linear subspaces of a Hilbert space H such that $M \perp N$ then $M + N$ is also a closed linear subspace of H.
b) State and prove Bessel's Inequality (finite case).
5. a) Prove that the mapping $y \rightarrow f_y$ is a norm preserving mapping of H into H^* where $f_y(x) = \langle x, y \rangle$ for all $x \in H$.
b) If T is an operator on a Hilbert space H for which $\langle Tx, x \rangle = 0$ for all $x \in H$, then prove that $T = 0$ on H.

(OR)

6. a) If T is an operator on a Hilbert space H then prove that the following conditions are all equivalent to one another .
- (i) $T^*T = I$
 - (ii) $\|Tx\| = \|x\|$
 - (iii) $(Tx, Ty) = (x, y) \forall x, y$.
- b) Prove that a closed linear subspace M of H is invariant under T an operator T on H if and Only if M^\perp is invariant under T^* .
7. a) Prove that two matrices of A_n are similar if and only if they are the matrices of a single operator on H relative to (possibly) different bases.
- b) Prove that an operator T on H is singular if and only if $\theta \in \sigma(T)$.
- (OR)
8. State and prove Spectral theorem.

SECTION – B

9. Answer any **THREE** of the following. Each Question carries 5 marks. **3 × 5 = 15M**
- a) Prove that every normal linear space is a metric space.
 - b) State and prove Schwartz inequality.
 - c) Define an orthogonal set in a Hilbert space H and given an example.
 - d) Define Eigen value and Eigen vector.
 - e) Let T be an operator on a Hilbert space H be such that adjoint T^* of T is a polynomial in T , then prove that T is Normal.

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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS II YEAR SEMESTER III

(W.e.f. 2022-2023 Admitted Batch)

M302:LEBESGUE THEORY

Course Outcomes: The study of M.Sc. degree programme will enable the students:

1. To discuss Algebra of sets, Lebesgue measure, Outer measure, Measurable set and Lebesgue measure etc.
2. To discuss the Riemann integral, the Lebesgue integral of a bounded function over a set of finite measures etc.
3. To discuss Differentiation of monotonic functions, functions of bounded variation, differentiation of an integral, absolute continuity, L_p - Spaces the Holder's and Minkowski inequalities etc.

UNIT-I :Algebra of sets, Lebesgue measure, Outer measure, Measurable set and Lebesgue measure, a non-measurable set, measurable function, Little woods's Three principles.(Chapter 3)

UNIT-II :The Riemann integral, the Lebesgue integral of a bounded function over a set of finite measures, the integral of a non-negative function, the general Lebesgue integral convergence in measure. (Chapter 4)

UNIT-III : Differentiation of monotonic functions, functions of bounded variation, differentiation of an integral, absolute continuity. (Chapter 5)

UNIT-IV : L_p - Spaces the Holder's and Minkowski inequalities, convergence and completeness

(Chapter 6)

PRESCRIBED TEXT BOOK: H.L.Royden, Real Analysis, Macmillan Publishing Company, New York, Third Edition, 1988.

REFERENCE TEXT BOOK: Real Analysis by H.L.Roydan, P.M.Fitzpatrick

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M.Sc. MATHEMATICS II YEAR SEMESTER III
(W.e.f. 2022-2023 Admitted Batch)
M302: LEBESGUE THEORY

Model Question Paper

Time: 3 hours

Max Marks: 75

SECTION – A

Answer **ALL** questions. Each question carries 15 marks.

$4 \times 15 = 60$

1. Define measurability of a set and prove that the set of all measurable sets m is a σ -algebra.
(OR)
2. Every Borel set is measurable. In particular each open set and each closed set is measurable.
3. State and prove Lebesgue convergence theorem
(OR)
4. State and prove bounded convergence theorem
5. State and prove Fatou's lemma and hence prove the monotone convergence theorem.
(OR)
6. State and prove Vitali Lemma.
7. State and prove Minkowski Inequality in L^p
(OR)
8. State and prove Riesz – Fischer theorem.

SECTION – B

9. Answer any **THREE** of the following. Each Question carries 5 marks. **$3 \times 5 = 15M$**

- a) Define the outer measure of a set and prove that if E_1 and E_2 are measurable then $E_1 \cup E_2$ is measurable.
- b) Describe the invariance property.
- c) Define convergence in measure.
- d) If f and g are non negative measurable functions, then show that $\int_E cf = c \int_E f$, $c > 0$ and
$$\int_E (f + g) = \int_E f + \int_E g.$$
- e) State bounded convergence theorem and monotone convergence theorem.



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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS II YEAR SEMESTER III

(W.e.f. 2022-2023 Admitted Batch)

M303: ANALYTICAL NUMBER THEORY

Course Outcomes: The study of M.Sc. degree programme will enable the students:

1. To discuss basic concepts of arithmetical functions and dirichlet multiplication like Mobius function $\mu(n)$, Euler quotient function $\varphi(n)$, Mangoldt function $\Lambda(n)$, Multiplicative functions, Liouville's function $\lambda(n)$, Divisor functions $\sigma_\alpha(n)$ - and Generalized convolutions.
2. To explain Averages of arithmetical functions, big oh notation, Euler's summation formula, The average order of $d(n)$, The average order of the divisor functions $\sigma_\alpha(n)$, The average order of $\varphi(n)$, application to the distribution of lattice points visible from the origin and applications to $\mu(n)$ and $\Lambda(n)$.
3. To discuss some elementary theorems on the distributions of prime numbers chebyshev's function $\psi(x)$ and $\vartheta(x)$, Relations connecting $\vartheta(x)$ and $\pi(x)$, Some equivalent forms of the prime number theorem, Shapiro's Tauberian theorem, Definition and basic properties of congruences, Euler-Fermat theorem, Polynomial congruences modulo p . Lagrange's theorem and it's applications, Chinese remainder Theorem and it's applications etc.

UNIT-I: ARITHMETICAL FUNCTIONS AND DIRICHLET MULTIPLICATION :-Introduction – The Mobius function $\mu(n)$.-The Euler quotient function $\varphi(n)$ -A relation connecting φ and μ - A product formula for $\varphi(n)$ -The Dirichlet product of arithmetical functions- Dirichlet inverses and the Mobius inversion formula- The mangoldt function $\Lambda(n)$ - multiplicative functions- multiplicative function and Dirichlet multiplication – The inverse of a completely multiplicative function- Liouville's function $\lambda(n)$ - The divisor functions $\sigma_\alpha(n)$ - Generalized convolutions.

(Sections 2.1 – 2.14 of chapter 2)

UNIT-II : AVERAGES OF ARITHMETICAL FUNCTIONS:- Introduction- The big oh notation.

Asymptotic equality of functions – Euler’s summation formula – Some elementary asymptotic formulas – The average order of $d(n)$ -The average order of the divisor functions $\sigma_\alpha(n)$ - The average order of $\varphi(n)$ -An application to the distribution of lattice points visible from the origin– the average order of $\mu(n)$ and $\Lambda(n)$ – The partial sums of a Dirichlet product- Applications to $\mu(n)$ and $\Lambda(n)$ – Another identity for the partial sums of a Dirichlet product.

(Sections 3.1 – 3.12 of chapter 3)

UNIT-III :SOME ELEMENTARY THEOREMS ON THE DISTRIBUTION OF PRIME NUMBERS:-

Introduction – chebyshev’s function $\psi(x)$ and $\vartheta(x)$ - Relations connecting $\vartheta(x)$ and $\pi(x)$ – Some equivalent forms of the prime number theorem - Inequalities for $\pi(n)$ and p_n – Shapiro’s Tauberian theorem – Applications of Shapiro’s theorem – An asymptotic formula for the partial sums $\sum_{p \leq x} (1/p)$ - The partial sums of the Mobius function- Selberg’s asymptotic formula.

(Sections 4.1 to 4.9 and 4.11 of Chapter 4)

UNIT-IV : CONGRUENCES :- Definition and basic properties of congruences – Residue classes and complete residue systems – linear congruences – Reduced residue systems and the Euler-Fermat theorem – Polynomial congruences modulo p . Lagrange’s theorem –Applications of Lagrange’s theorem – Simultaneous linear congruences. The Chinese remainder Theorem- Applications of the Chinese remainder Theorem – Polynomial congruences with prime power moduli.

(Sections 5.1 – 5.9 of chapter 5)

Additional Input: Selberg’s asymptotic formula.

PRESCRIBED TEXT BOOK : Introduction to Analytic Number Theory – By T.M.APOSTOL – Springer Verlag New York, Heidelberg – Berlin – 1976.

REFERENCE TEXT BOOK: Analytical Number Theory: An Introductory course by Harold G.Diamond and Paul T.Bateman.

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M303: ANALYTICAL NUMBER THEORY

Model Question Paper

Time: 3 hours

Max Marks: 75

SECTION – A

Answer **ALL** questions. Each question carries 15 marks.

4 × 15 = 60

1. Define Euler totient function and prove if $n \geq 1$ then $\sum_{d|n} \phi(d) = n$ and also prove $\phi(p^\alpha) = p^\alpha - p^{\alpha-1}$ for prime p and $\alpha \geq 1$.
(OR)
2. Define Multiplicative function and prove both g and $f * g$ are multiplicative then f is also multiplicative.
3. State and prove Euler summation formula.
(OR)
4. Prove that for $x \geq 2$ we have $\sum_{p \leq x} \left[\frac{x}{p} \right] \log p = x \log x + O(x)$ where the sum is extended over all primes $\leq x$.
5. Let p_n denote the n^{th} prime then the following asymptotic relations are logically equivalent
$$\lim_{x \rightarrow \infty} \frac{\pi(x) \log x}{x} = 1$$
$$\lim_{x \rightarrow \infty} \frac{\pi(x) \log \pi(x)}{x} = 1$$
$$\lim_{x \rightarrow \infty} \frac{p_n}{n \log n} = 1$$

(OR)
6. For $n \geq 1$ the n^{th} prime p_n satisfies the inequalities
$$\frac{1}{6} n \log n < p_n < 12 \left(n \log n + n \log \frac{12}{e} \right)$$
7. State and prove Lagrange's theorem.
(OR)
8. State and prove Chinese remainder theorem.

SECTION – B

9. Answer any **THREE** of the following. Each Question carries 5 marks.

3 × 5 = 15M

(a) State and prove Generalized inversion formula.

(b) If $x \geq 1$ then prove that $\sum_{n \leq x} \frac{1}{n^s} = \frac{x^{1-s}}{1-s} + \mathcal{O}(x^{-s})$ if $s > 0, s \neq 1$.

(c) For $x > 0$ then prove that $0 \leq \frac{\varphi(x)}{x} - \frac{\vartheta(x)}{x} \leq \frac{(\log x)^2}{2\sqrt{x} \log 2}$.

(d) Solve the congruence $5x \equiv 3 \pmod{24}$.

(e) State and prove Wilson's theorem.



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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS II YEAR SEMESTER III

(W.e.f. 2022-2023 Admitted Batch)

M304:PARTIAL DIFFERENTIAL EQUATIONS

Course Outcomes: The study of M.Sc. degree programme will enable the students:

1. To discuss about basics of partial differential equations and method of solutions of $dx/P = dy/Q = dz/R$ and know about pfaffian differential forms and equations and their solutions in three variables.
2. To describe linear & non-linear equations of the first order and solving the orthogonal surfaces and compatible systems of first order equations further more about some methods like,charpit's method,jacobi's method.
3. To solve the second order partial differential equations and discuss about solutions f linear hyperbolic equations and explaining method of separation of variables,monger's method and further more about Laplace equation and some elementary solutions and solving boundary value problems and more about wave equation and elementary solution in one dimensional form.

UNIT I: Introduction, Methods of Solution of $dx/P = dy/Q = dz/R$, Orthogonal trajectories of a system of curves on a surface, Pfaffian Differential forms and equations, Solutions of Pfaffian differential equations in three variables, Cauchy's problem for first order partial differential equations.

(Sections 3 to 6 of Chapter 1, Sections 1 to 3 of Chapter 2)

UNIT II: Linear Equations of the first order, Integral surfaces, orthogonal surfaces, non linear partial differential equations of the first order, Cauchy's method of characteristics, Compatible systems of first order equations, Charpit's Method, Special types of first order equations, Jacobi's method.

(Sections 4 to 13 of Chapter 2)

UNIT III: Partial Differential Equations of the second order, Their origin, Linear partial Differential equations with constant and variable coefficients, Solutions of linear hyperbolic equations, Method of separation of variables, Monger's method.

(Sections 1 to 5 and Sections 8,9,11 of Chapter 3)

UNIT IV: Laplace Equation, elementary solutions, families of equipotential surfaces, Boundary value problems, Method of separation of variables of solving Laplace equation, problems with axial symmetry, Kelvin's inversion theorem, The wave equation, Elementary solution in one dimensional form, Riemann-Volterra solution of one dimensional wave equation, The theory of Green's function for Laplace's equation.

(Sections 1 to 8 of Chapter 4 and Sections 1 to 3 of Chapter 5)

Additional Inputs: The theory of Green's function for Laplace's equation

PRESCRIBED TEXT BOOK: Elements of Partial Differential Equations by I.N.Sneddon, Mc Graw Hill, International Edition, Mathematics series.

REFERENCE BOOK: Fritz John, Partial Differential Equations, Narosa Publishing House, New Delhi, 1979

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(W.e.f. 2022-2023 Admitted Batch)
M304: PARTIAL DIFFERENTIAL EQUATIONS
Model Question Paper

Time: 3 hours

Max Marks: 75

SECTION – A

Answer **ALL** questions. Each question carries 15 marks.

4 × 15 = 60

1. Find the integral curves of the equations $\frac{dx}{y(x+y)+az} = \frac{dy}{x(x+y)-az} = \frac{dz}{z(x+y)}$.

(OR)

2. A necessary and sufficient condition that there exists between two functions $u(x, y)$ and $v(x, y)$ a relation $F(u, v) = 0$, not involving x or y explicitly is that $\frac{\partial(u,v)}{\partial(x,y)} = 0$.

3. Find the surface which is orthogonal to the one- parameter system $z = cxy(x^2 + y^2)$ and which passes through the hyperbola $x^2 - y^2 = a^2, z = 0$.

(OR)

4. Show that the equations $xp - yq = x$

$x^2p + q = xz$ are compatible and find their solution.

5. Reduce the equation

$$y^2 \frac{\partial^2 z}{\partial x^2} - 2xy \frac{\partial^2 z}{\partial x \partial y} + x^2 \frac{\partial^2 z}{\partial y^2} = \frac{y^2}{x} \frac{\partial z}{\partial x} + \frac{x^2}{y} \frac{\partial z}{\partial y} \quad \text{to canonical form, and hence solve it.}$$

(OR)

6. Solve the equation $rq^2 - 2pqs + tp^2 = pt - qs$.

7. Show that the surface $x^2 + y^2 + z^2 = cx^{\frac{2}{3}}$ can form a family of equipotential surfaces, and find the general form of the corresponding potential function.

(OR)

8. State and prove Kelvin's Inversion theorem.

SECTION – B

9. Answer any **THREE** of the following. Each Question carries 5 marks. $3 \times 5 = 15M$

(a) Eliminate the arbitrary function f from the equation $z = xy + f(x^2 + y^2)$.

(b) Find the general integral of the linear partial differential equation $z(xp - yq) = y^2 - x^2$.

(c) Prove that a pfaffian differential equation in two variables always possesses an integrating factor.

(d) Explain Charpit's method.

(e) Find the D-Alembert's Solution for one dimensional wave equation.



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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS II YEAR SEMESTER III

(W.e.f. 2022-2023 Admitted Batch)

M305.1 – LATTICE THEORY

UNIT-I: Partially Ordered sets – Diagrams – Special subsets of a poset – length – lower and upper bounds – the minimum and maximum condition – the Jordan Dedekind chain conditions – dimension functions.

(Sections 1 – 9 of Chapter 1)

UNIT-II: Algebras – lattices – the lattice theoretic duality principle – semi lattices – lattices as posets – diagrams of lattices – semi lattices, ideals – bound elements of Lattices – atoms and dual atoms – complements, relative complements, semi complements – irreducible and prime elements of a lattice – the homomorphism of a lattice – axioms systems of lattices.

(Sections 10 - 21 of Chapter 2).

UNIT-III: Completer lattices – complete sub lattices of a completer lattice – conditionally complete lattices – lattices – compact elements, compactly generated lattices – sub algebra lattice of an algebra – closure operations – Galois connections, Dedekind cuts – partially ordered sets as topological spaces..

(Sections 22 - 29 of Chapter 3)

UNIT-IV: Distributive lattices – infinitely distributive and completely distributive lattices – modular lattices – characterization of modular and distributive lattices by their sub lattices – distributive sublattices of modular lattices – the isomorphism theorem of modular lattices, covering conditions- meet representations in modular and distributive lattices – some special subclasses of the class of modular lattices – preliminary theorems – modular lattices of locally finite length– the valuation of a lattice, metric and quasi metric lattices – complemented modular lattices.

(Sections 30 – 40 of Chapter 4)

PRESCRIBED TEXT BOOK: Introduction to Lattice Theory by Gabor Szasz, Academic Press, New York.

REFERENCE TEXT BOOK :General Lattice theory by G.Gratzer, Academic Press, New York.

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M.Sc. MATHEMATICS II YEAR SEMESTER III
(W.e.f. 2022-2023 Admitted Batch)
M305.1: LATTICE THEORY
Model Question Paper

Time: 3 hours

Max Marks: 75

SECTION – A

Answer **ALL** questions. Each question carries 15 marks.

4 × 15 = 60

- 1) Define Partly Ordered Set. State maximum and minimum condition for partly ordered set. Give an example of a poset satisfying minimum condition but failing to satisfy maximum condition.

(OR)

- 2) State and prove Kuratowski-Zorn Lemma.
3) In a lattice L if we define the order relation " \leq " by $a \leq b \Leftrightarrow a \wedge b = a$ for all $a, b \in L$, show that every finite subset $\{a_1, a_2, a_3, \dots, a_n\}$ of L has an infimum and supremum.

(OR)

- 4) i) In a complemented lattice, show that every join prime element except the least one is an atom.

ii) Show that, if a homomorphism of a lattice has a kernel, then the kernel is an ideal of the lattice.

- 5) (i) Prove that every order preserving mapping of a complete lattice into itself has a fix element. (ii) Show that, if we affix bound elements to a conditionally complete lattice, then we obtain a complete lattice.

(OR)

- 6) Show that every lattice is isomorphic to some sub-lattice of a complete lattice.

7) If H is a non-void subset of a modular lattice L . For the sublattice H of L generated by H to be distributive, it is necessary and sufficient that for every finite distributive, it is necessary and

sufficient that for every finite subsystem $\{x_1, x_2, \dots, x_m, y_1, y_2, \dots, y_n\}$ of H $\bigcup_{j=1}^m x_j \cap \bigcap_{k=1}^n y_k = \bigcup_{j=1}^m (x_j \cap \bigcap_{k=1}^n y_k)$

(OR)

8) (i) Show that a lattice is distributive if and only if every triplet of its elements has a median.
(ii) Show that every element of a distributive lattice has at most one irredundant meet

representation.

SECTION – B

9) Answer any three of the following .Each question carries 5 marks. **3 × 5 = 15**

- (a) Define a Lattice. Give two examples.
- (b) Show that every uniquely complemented lattice is weakly complemented.
- (c) Define the concepts of (i) an atom (ii) a dual atom and (iii) an atomic lattice
- (d) Show that every complete lattice is bounded.
- (e) A lattice L is modular if and only if every triplet a, b, c of L satisfies $a \cup (b \cap (a \cup c)) = (a \cup b) \cap (a \cup c)$



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M.Sc. MATHEMATICS II YEAR SEMESTER III

(W.e.f. 2022-2023 Admitted Batch)

M305.2: COMMUTATIVE ALGEBRA

Course Outcomes: The study of M.Sc. degree programme will enable the students:

1. To explain the concepts of Rings and ring homomorphism, ideals, quotient rings, prime ideals and Maximal ideals, nil radical and Jacobson radical.
2. To study Modules and module homomorphisms, Sub modules and quotient modules, operations on submodules, direct sum and product, finitely generated modules and exact sequences.
3. To discuss the topics Local Properties, Extended and Contracted ideals in rings of fractions and Primary decompositions.

UNIT-I :Rings and ring homomorphism, ideals, quotient rings, zero divisors, Nilpotent elements, units, prime ideals and Maximal ideals, nil radical and Jacobson radical, operations on ideals, Extensions and contractions.

UNIT-II :Modules and module homomorphisms, Sub modules and quotient modules, operations on submodules, direct sum and product, finitely generated modules, exact sequences, Tensor product of modules, Restriction and extension of scalars, Exactness properties of the tensor product, algebras, tensor product of algebras.

UNIT-III :Local Properties, Extended and Contracted ideals in rings of fractions.

UNIT-IV : Primary decompositions, *Integral Dependence* (Content and extent of chapters 1 to 4 of the prescribed text book)

Additional Inputs: Integral Dependence.

PRESCRIBED TEXT BOOK: Introduction to commutative algebra, M.F.ATIYAH and I.G.MACDONALD,

Addision – Wesley publishing Company, London.**REFERENCE TEXT BOOK:** Commutative Algebra book by Hideyuki Matsumura.

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(W.e.f. 2022-2023 Admitted Batch)
M305.2: COMMUTATIVE ALGEBRA
Model Question Paper

Time: 3 hours

Max Marks: 75

SECTION – A

Answer **ALL** questions. Each question carries 15 marks. **$4 \times 15 = 60$**

1. Prove that the nilradical of A is the intersection of all the prime ideals of A .
(OR)
2. Let $A \neq 0$ be a ring then prove that the following are equivalent
 - i) A is a field
 - ii) The only ideals in A are (0) & (1)
 - iii) Every homomorphism of A into a non-zero ring B is injective.
3. a) State and prove Nakayamas lemma.
b) Let M be a finitely generated A -module and N be a submodule of M . Let I be an ideal of A contained in the Jacobson radical of A then $M=IM+N$ implies $M=N$.
(OR)
4. a) If L contains M contains N are A -modules then $(L/N) \cong (L/M)$
b) If M_1, M_2 are submodules of M then $M_1+M_2/M_1 \cong M_2/M_1 \cap M_2$.
5. Let M be an A -module then the following are equivalent
 - (i) $M=0$
 - (ii) $M_p=0$ for all prime ideals p of A
 - (iii) $M_m=0$ for all maximal ideals m of A .

(OR)

6. Prove that the operation S^{-1} commutes with formation of finite sums Products intersections and radicals.
7. a) State and prove First uniqueness theorem.
- b) Let I be a p -primary, x is an element of A then
- (i) $x \in I$ then $(I:x)=(1)$.
 - (ii) if $x \notin I$ then $(I:x)$ is p -primary and therefore $r(I:x) = p$.
 - (iii) if $x \notin p$ then $(I:x)=I$.

(OR)

8. Let S be a M.C.S of A and q be a primary ideal then
- (i) $S \cap P \neq \emptyset \Rightarrow S^{-1}q = S^{-1}P$
 - (ii) $S \cap P = \emptyset \Rightarrow S^{-1}q$ is $S^{-1}p$ - primary and its contraction in A is q .

SECTION – B

9. Answer any three of the following. Each question carries 5 marks. **3 × 5 = 15**
- a) $x \in R$ iff $1-xy$ is a unit in $A \forall y \in A$.
 - b) Every ring $A \neq 0$ has atleast one maximal ideal.
 - c) Let M be a finitely generated A -Module and let I be an ideal of A such that $IM=M$ then there exists $x \cong 1 \pmod I$ such that $xM=0$.
 - d) Show that $S^{-1}A$ is a flat A -module.
 - e) Let q be a primary ideal in a ring A then $r(q)$ is the smallest prime ideal Containing q .

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(W.e.f. 2022-2023 Admitted Batch)

M305.3: COMPLEX ANALYSIS - II

UNIT-I: The maximum modulus theorem: The maximum principle – Schwarz's lemma – convex function's and hadamard's three circles theorem – Phargmem – Lindelof theorem.

(1,2,3,4 of chapter-VI)

UNIT-II: Compactness and Convergence in the Space of Analytic Functions: The space of continuous function $C(G, \Omega)$ – Spaces of Analytic functions – spaces of meromorphic functions – The Riemann Mapping Theorem – Weierstrass factorization theorem – Factorization of sine functions. .

(1,2,3,4,5,6 of chapter-VII)

UNIT-III: Runge's Theorem : Runge's Theorem – Simple connectedness – Mittag – Leffler's Theorem, Analytic Continuation and Riemann Surfaces, Schwarz Reflection Principle – Analytic Continuation Along A Path – Mordant's Theorem..

(1,2,3 of chapter-VIII and 1,2,3 of chapter IX)

UNIT-IV: Harmonic Functions : Basic properties of Harmonic functions – Harmonic functions on a disk. Jensen's formula, the genus and the order of an entire function Hadamard's factorization theorem. .

(1,2, of chapter-X and 1,2,3 of chapter XI)

PRESCRIBED TEXT BOOK: Functions of one complex variables by J.B.Conway : Second edition, Springer International student Edition, Narosa Publishing House, New Delhi





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M 305.4- SEMI GROUPS- I

UNIT-I: Basic definition, monogenic semigroups, ordered sets, semilattices and lattices, binary relations, equivalences and congruences.

UNIT-II :Free semigroups, Ideals and Rees' congruences, Lattices of equivalences and congruences. Green's equivalences, the structure of D-classes, regular semigroups.

UNIT-III :Simple and 0-simple semigroups, Principal factors, Rees' theorem, Primitive idempotents.

UNIT-IV :Congruences on completely 0-simple semi groups, The lattice of congruences on a completely 0-simple semigroup, Finite congruence free semigroups.

Contents of the syllabus-Chapters 1,2 and 3 of the text book.

PRESCRIBED TEXT BOOK: An introduction to semi group theory by J.M. Howie, 1976, Academic press, New York.



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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS II YEAR SEMESTER IV

(W.e.f. 2022-2023 Admitted Batch)

M401:MEASURE THEORY

Course Outcomes: The study of M.Sc. degree programme will enable the students:

1. To discuss Convergence and Completeness, Measure spaces, Measurable functions, Integration, General convergence Theorems.
2. To discuss Signed Measures, The Raydon-Nikodym Theorem, the L_p spaces, Outer Measure and Measurability, The Extension theorem, The Lebesgue - Stieltjes Integral and Product measures.
3. To discuss Integral Operators, Inner Measure, Extension by sets of measure zero, caratheodory outer measure and Hausdroff Measure.

UNIT- I : Convergence and Completeness, Measure spaces, Measurable functions, Integration, General convergence Theorems. [Section 3 of Chapter 6,

Section 1 to 4 of Chapter 11 of the text book]

UNIT- II : Signed Measures, The Raydon-Nikodym Theorem, the L_p spaces. [Sections 5 to 7 of Chapter 11 of the text book]

UNIT- III : Outer Measure and Measurability, The Extension theorem, The Lebesgue - Stieltjes Integral, Product measures. [Sections 1 to 4 of Chapter 12 of the text book]

UNIT- IV : Integral Operators, Inner Measure, Extension by sets of measure zero, caratheodory outer measure, Hausdroff Measure.

[Sections 5 to 9 of Chapter 12 of the text book]

PRESCRIBED TEXT BOOK: Real Analysis by H. L. Royden, Macmillan Publishing Co. Inc. 3 rd Edition, New York, 1988.

REFERENCE TEXT BOOK: Real Analysis by H.L.Roydan, P.M.Fitzpatrick

**Dr. C. S .RAO PG CENTRE
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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS II YEAR SEMESTER IV

(W.e.f. 2022-2023 Admitted Batch)

M401: MEASURE THEORY

Model Question Paper

Time: 3 hours

Max Marks: 75

SECTION – A

Answer **ALL** questions. Each question carries 15 marks.

4 × 15 = 60

1. a) Prove that a normed linear space X is complete if and only if every absolutely summable series is summable.
b) Let (X, \mathcal{B}) be measurable space and f be an extended real valued function defined on X then prove that the following statements are equivalent.
 - (i) $\{x / f(x) < \alpha\} \in \mathcal{B}$ for each α .
 - (ii) $\{x / f(x) \leq \alpha\} \in \mathcal{B}$ for each α .
 - (iii) $\{x / f(x) > \alpha\} \in \mathcal{B}$ for each α .
 - (iv) $\{x / f(x) \geq \alpha\} \in \mathcal{B}$ for each α .

(OR)

2. a) State and prove Fatous lemma.
b) If (X, \mathcal{B}, μ) is any measure space then there exist a complete measure space $(X, \mathcal{B}_0, \mu_0)$ such that
 - i) $\mathcal{B} \subseteq \mathcal{B}_0$
 - ii) If $B \in \mathcal{B}$ then $\mu(B) = \mu_0(B)$
 - iii) $E \in \mathcal{B}_0$ iff $E = A \cup B$ then $B \in \mathcal{B}$ and $A \subseteq C$ for some $C \in \mathcal{B}$ with $\mu(C) = 0$.

3. a) Let E be a measurable set such that $0 < \gamma(E) < \infty$. Then prove that there is a positive set A contained in E with $\gamma(A) > 0$.

b) State and prove Hahn Decomposition theorem.

(OR)

4. State and prove Riesz representation theorem.

5. a) Prove that the class \mathfrak{B} of μ^* measurable sets is a σ - algebra.

b) Let μ be a measure on an algebra \mathcal{G} and μ^* be a outer measure induced by μ and E is any set then for any $\epsilon > 0 \exists$ a set $A \in \mathcal{G}_\sigma$ with $E \subseteq A$ and $\mu^*(A) \leq \mu^*(E) + \epsilon$ also there is a set $B \in \mathcal{G}_{\sigma\delta}$ with $E \subseteq B$ and $\mu^*(E) = \mu^*(B)$.

(OR)

6. state and prove Tonelli theorem.

7. a) Let E and F be two disjoint sets. Then prove that

$$\begin{aligned} \mu_*(E) + \mu_*(F) &\leq \mu_*(E \cup F) \leq \mu_*(E) + \mu^*(F) \\ &\leq \mu^*(E \cup F) \leq \mu^*(E) + \mu^*(F). \end{aligned}$$

b) Suppose that $\mu^*(E) < \infty$. Then prove that E is measurable if and only if $\mu_*(E) = \mu^*(E)$.

(OR)

8. If μ^* is a caratheodory outer measure with respect to Γ then prove that every function in Γ is μ^* - measurable.

SECTION – B

9. Answer any three of the following. Each question carries 5 marks. **3 × 5 = 15**

a). Prove that every σ - finite measure is saturated.

b). Show that the Hahn decomposition need not be unique.

c). Show that if γ is a signed measure such that γ is mutually singular with respect to μ and $\gamma \ll \mu$ then $\gamma = 0$.

d). Let B be a μ^* measurable set with $\mu^*(B) < \infty$. Prove that $\mu_*(B) = \mu^*(B)$.

e). Give an example for an algebra of sets which is not an σ - algebra of sets. Justify.



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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS II YEAR SEMESTER IV

(W.e.f. 2022-2023 Admitted Batch)

M402: NUMERICAL ANALYSIS

Course Outcomes: The study of M.Sc. degree programme will enable the students:

1. To perform the iterations for the smallest root by using Bisection method, Regulafalsi method, Newton- Raphson method, Mullers method, Chebyshev method, Multipoint iterative method and secant method.
2. To discuss the iterations for the smallest root by using Guass elimination method, Triangularization method, Cholesky method, Lagrange and Newton's divided difference interpolation, sterling and Bessel interpolation, Hermite interpolation, piecewise and Spline Interpolation method.
3. To find the smallest root by using Gauss Legendre Integration method, Euler's method, Taylor series method, Runge kutte second and forth order methods.

UNIT I :Transcendental and polynomial equations: Introduction, Bisection method, Iteration methods based on first degree equation; Secant method, Regulafalsi method, Newton- Raphson method, Iteration method based on second degree equation; Mullers method, Chebyshev method, Multipoint iterative method, Rate of convergence of secant method, Newton Raphson method,

(Section 1 of the Text Book pages 1 to 52 above specified methods only)

UNITII : System of linear algebraic equation: Direct methods, Guass elimination method, Triangularization method, Cholesky method, Partition method, Iteration method: Gauss seidel Iterative method, OR method.

(Section 2 of the Text Book pages 53 to 169 above specified methods only)

UNIT III : Interpolation and Approximation: Introduction, Lagrange and Newton's divided difference interpolation, Finite difference operators, sterling and Bessel interpolation, Hermite interpolation, piecewise and Spline Interpolation, least square approximation.

(Section 3 of the Text Book pages 210 to 300 above specified methods only)

UNIT IV : Numerical Differentiation: methods based on Interpolation, methods based on Finite difference operators Numerical Integration: methods based on Interpolation, Newton's cotes methods, methods based on Undetermined coefficients, Gauss Legendre Integration method, Numerical methods ODE: Single step methods: Euler's method, Taylor series method, Runge kutte second and forth order methods, Multistep methods: Adam Bash forth method, Adam Moulton methods, Milne-Simpson method.

(Section 4 of the Text Book pages 320 to 495 above specified methods only)

PRESCRIBED TEXT BOOK: Numerical Methods for Scientific and Engineering computation by M.K. Jain, S.R.K. Iyengar, R.K. Jain, New Age Int. Ltd., New Delhi.

REFERENCE TEXT BOOK: Introduction to Numerical Analysis, by S.S. Sastry, Prentice Hall Flied.

DEPARTMENT OF MATHEMATICS
M.Sc. MATHEMATICS II YEAR SEMESTER IV
(W.e.f. 2022-2023 Admitted Batch)
M402: NUMERICAL ANALYSIS
Model Question Paper

Time: 3 hours

Max Marks: 75

SECTION – A

Answer **ALL** questions. Each question carries 15 marks.

4 × 15 = 60

1. Perform five iterations of the bisection method to obtain the smallest positive root of the equation $x^3 - 5x + 1 = 0$.

(OR)

2. Perform four iterations of the Newton-Raphson method to find the smallest positive root of the equation $x^4 - x - 10 = 0$.

3. Solve the system of equations $\begin{bmatrix} 1 & 2 & 3 \\ 2 & 8 & 22 \\ 3 & 22 & 82 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 5 \\ 6 \\ -10 \end{bmatrix}$ using the Cholesky method.

Also determine A^{-1} .

(OR)

4. Find the inverse of the matrix $A = \begin{bmatrix} 2 & 1 & 1 & -2 \\ 4 & 0 & 2 & 1 \\ 3 & 2 & 2 & 0 \\ 1 & 3 & 2 & -1 \end{bmatrix}$ using partition method. Hence, solve the system of equation $AX = b$, where $b = [-10, 8, 7, -5]^T$

x	f(x)	f'(x)
2	29	50

5. Construct the

3	105	105
---	-----	-----

 Hermite interpolation polynomial that fits the data

Interpolate $f(x)$ at $x = 2.5$.

(OR)

6. Obtain the cubic spline approximation for the function defined by the data

x	0	1	2	3
$f(x)$	1	2	33	244

with $M(0) = 0, M(3) = 0$. Hence find an estimate of $f(2.5)$.

7. Evaluate the integral $= \int_1^2 \frac{2x dx}{1+x^4}$, using the Gauss-Legendre 1-point, 2-point and 3-point quadrature rules. Compare with the exact solution $I = \tan^{-1}(4) - \left(\frac{\pi}{4}\right)$.

(OR)

8. Given the initial value problem $u' = -2tu^2, u(0) = 1$ estimate $u(0.4)$ using
(i) modified Euler-cauchy method, and

(ii) Heun method with $h = 0.2$. compare the results with the exact solution $u(t) = \frac{1}{1+t^2}$.

SECTION – B

9. Answer any Three of the following. Each question carries 5 marks. **3 × 5 = 15**

a) Perform two iterations of the Chebyshev method to find an appropriated value of $1/7$. Take the initial approximation as $x_0 = 0.1$

b) Solve the equations $10x_1 - x_2 + 2x_3 = 4$

$$x_1 + 10x_2 - x_3 = 3$$

$$2x_1 + 3x_2 + 20x_3 = 7$$

Using the Gauss elimination method.

c) Show that (i) $\delta = \nabla(1 - \nabla)^{-1/2}$ (ii) $\mu = \left(\frac{1+\delta^2}{4}\right)^{1/2}$

d) Find the approximate value of $I = \int_0^1 \frac{dx}{1+x}$ using Trapezoidal rule. Obtain a bound for the error.

The exact value of $I = \ln 2 = 0.693147$ correct to six decimal places.

e) For the matrix $A = \begin{bmatrix} 1 & 2 & -2 \\ 1 & 1 & 1 \\ 1 & 3 & -1 \end{bmatrix}$, find all the eigen values.

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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS II YEAR SEMESTER IV

(W.e.f. 2022-2023 Admitted Batch)

M403:GRAPH THEORY

Course Outcomes: The study of M.Sc. degree programme will enable the students:

1. To understand the basic concepts of graphs and about trees & fundamental circuits.
2. To discuss about cutsets & cut vertices and planar & dual graphs, further more ,to learn about the matrix representation of graphs like, Incidence, Circuit,Path and Adjacency matrices of graphs.
3. To explain about the concepts of coloring , covering and partitioning of graphs and at the end of the chapter we learn about graph theory in operation research.

UNIT-I: Basic concepts, Paths and Circuits, Trees and Fundamental Circuits.

[Chapters 1, 2, 3 of the text book]

UNIT-II: Cut Sets and Cut Vertices: Cut sets, Some properties of a cut set, All cut sets in a graph, Fundamental circuits and cut sets, Connectivity and Separability, Network Flows, 1- Isomorphism, 2-Isomorphism; Planar and Dual Graphs: Combinatorial Vs Geometric graphs, Planar graphs, Kuratowski's Two graphs, Different Representations of Planar Graphs, Detection of Planarity, Geometric Dual, Combinational Duals of a Graph,

[Chapter 4 and Sections 5.1 to 5.7 of Chapter 5 of the text book]

UNIT-III: Matrix Representation of graphs: Incident matrix of a Graph, Sub Matrices of $A(G)$, Circuit Matrix, Fundamental Circuit Matrix and Rank of B , An Applications to a Switching Network, Cut set matrix, Relationship among A_f , B_f and C_f , Path Matrix and Adjacency Matrix, Directed Graphs: What is a digraph? Some types of digraph, Matrices A, B & C of digraphs.

[Chapter 7 & 9.1, 9.2, 9.8 of chapter-9 of the text book]

UNIT-IV: Coloring, Covering and Partitioning: Chromatic Number, Chromatic Partitioning, Chromatic Polynomial, Matchings, Coverings, The four color Problem; Graph Theory in Operation Research: Transport networks, Extensions of Max-flow Min cut theorem, Minimal cost flows.

[Chapter 8 and Sections 14.1 to 14.3 of Chapter 14 of the text book]

Additional Inputs: Directed Graphs: What is a digraph? Some types of digraph, Matrices A, B & C of digraphs.

PRESCRIBED TEXTBOOK: Graph Theory with applications to Engineering and computer Science by Narsingh Deo; Prentice-Hall of India.

REFERENCES: 1. Graph Theory with applications by Bond JA and Murthy USR, North Holland, New York.
2. Introduction to Graph Theory by Douglas B. West. Prentice Hall of India.

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DEPARTMENT OF MATHEMATICS
M.Sc. MATHEMATICS II YEAR SEMESTER IV
(W.e.f. 2022-2023 Admitted Batch)

M403: GRAPH THEORY

Model Question Paper

Time: 3 hours

Max Marks: 75

SECTION – A

Answer **ALL** questions. Each question carries 15 marks.

4 × 15 = 60

1. a) Explain Konigsberg Bridge Problem.
b) (i) Define Euler Graph
(ii) Prove that the number of vertices of odd degree in a graph is always even.
(OR)
2. a) Prove that in a complete graph with n vertices there are $(n - 1)/2$ edge disjoint Hamiltonian circuits, if n is odd number ≥ 3 .
b) (i) Define Binary Tree
(ii) Prove that a tree with n vertices has $(n - 1)$ edges.
3. a) (i) Define cut set and give an example
(ii) Prove that every circuit has an even number of edges in common with any cut set.
b) Define 1-Isomorphism.
(OR)
4. a) Prove that a graph has a dual if and only if it is planar.
b) In any simple connected planar graph with f regions, n vertices and e edges ($e > 2$) then prove that
(i) $e \geq \frac{3}{2} f$
(ii) $e \leq 3n - 6$.
5. a) (i) Define Incidence Matrix.
(ii) Define fundamental circuit matrix.

b) Let B and A be, respectively, the circuit matrix and the incidence matrix (of a self-loop free graph) whose columns are arranged using the same order of edges. Then prove that, every row of B is orthogonal to every row A , that is, $AB^T = BA^T = 0 \pmod{2}$.

(OR)

6. a) prove that, (i) $B_f = [I_\mu | A_c^T \cdot A_t^{-1T}]$
(ii) $C_f = A_t^{-1} \cdot A_f$.

b) Prove that in a connected graph, the distance between two vertices v_i and v_j (for $i \neq j$) is k , if and only if k is the smallest integer for which the i, j th entry in X^k is non-zero. That is, $[X^k]_{ij} \neq 0$.

7. a) Prove that a graph with atleast one edge is 2-chromatic if and only if it has no circuit of odd length.

b) Prove that the vertices of every planar graph can be properly colored with five colors.

(OR)

8. a) Let a and b be two nonadjacent vertices in a graph G . Let G' be a graph obtained by adding an edge between a and b . Let G'' be a simple graph obtained from G by fusing the vertices a and b together and replacing sets of parallel edges with single edges. Then prove that,

$$P_n(\lambda) \text{ of } G = P_n(\lambda) \text{ of } G' + P_{n-1}(\lambda) \text{ of } G''.$$

b) State and Prove Max Flow Min Cut Theorem.

SECTION – B

9. Answer any three of the following. Each question carries 5 marks.

3 × 5 = 15

a) Prove that a graph G with n vertices, $n - 1$ edges, and no circuits is connected.

b) Prove that the complete graph of five vertices is non planar.

c) Define Circuit matrix and give an example.

d) Prove that every tree with two or more vertices is 2-chromatic.

e) Explain Multi Commodity Flow.

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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS II YEAR SEMESTER IV

(W.e.f. 2022-2023 Admitted Batch)

M404: LINEAR PROGRAMMING

Course Outcomes: The study of M.Sc. degree programme will enable the students:

1. To study the concepts of formulation of Linear Programming problems, Graphical solution, General formulation and Simplex Method.
2. To solve the problems by using the methods two-phase, Big-M, degeneracy, Concept of Duality in Linear Programming, Comparison of solutions of the Dual and its primal.
3. Mathematical formulation of Assignment problem, Reduction theorem, Hungarian Assignment Method, Travelling salesman problem, Mathematical formulation of Transportation problem, North West corner rule, Lowest cost entry method, Vogel's approximation methods,

UNIT I : Definition of O.R, Decision method of O.R, Methodology of O.R, Application of O.R, Concept of Dual Simplex method, Formulation of Linear Programming problems, Graphical solution of Linear Programming problem, General formulation of Linear Programming problems, Standard and Matrix forms of Linear Programming problems, Simplex Method.

[Sections 3.1 to 3.7 of Chapter 3 and Section 5.4 of Chapter 5 of the text book]

UNIT II :Two-phase method, Big-M method, Method to resolve degeneracy in Linear Programming problem, Alternative optimal solutions. Solution of simultaneous equations by simplex Method, Inverse of a Matrix by simplex Method, Concept of Duality in Linear Programming, Comparison of solutions of the Dual and its primal.

[Sections 5.5, 5.7, 5.8, 5.12, 5.13 of Chapter 5 and Sections 7.1, 7.7 of Chapter 7]

UNIT III : Mathematical formulation of Assignment problem, Reduction theorem, Hungarian Assignment Method, Travelling salesman problem, Formulation of Travelling Salesman problem as an Assignment problem, Solution procedure.

[Sections 12.1 to 12.4, 12.9 of Chapter 12 of the text book]

UNIT IV : Mathematical formulation of Transportation problem, Tabular representation, Methods to find initial basic feasible solution, North West corner rule, Lowest cost entry method, Vogel's approximation methods, Optimality test, Method of finding optimal solution, Degeneracy in transportation problem, Method to resolve degeneracy, Unbalanced transportation problem.

[Sections 11.1 to 11.5 and 11.8 to 11.12 of Chapter 11 of the text book]

Additional Inputs: Definition of O.R, Decision method of O.R, Methodology of O.R, Application of O.R, Concept of Dual Simplex method.

PRESCRIBED TEXT BOOKS: S. D. Sharma, Operations Research.

REFERENCE BOOKS:

[1] Kanti Swarup, P. K. Gupta and Manmohan, Operations Research.

[2] H. A. Taha, Operations Research – An Introduction.

DEPARTMENT OF MATHEMATICS
M.Sc. MATHEMATICS II YEAR SEMESTER IV

(W.e.f. 2022-2023 Admitted Batch)

M404: LINEAR PROGRAMMING

Model Question Paper

Time: 3 hours

Max Marks: 75

SECTION – A

Answer **ALL** questions. Each question carries 15 marks. **4 × 15 = 60**

1. Solve the following Linear Programming Problem by using Graphical Method.

$$\text{Max } Z = 3x_1 + 4x_2$$

Subject to the Constraints

$$4x_1 + 2x_2 \leq 80$$

$$2x_1 + 5x_2 \leq 180$$

$$\text{and } x_1, x_2 \geq 0.$$

(OR)

2. Solve the following Linear Programming Problem by using Simplex Method.

$$\text{Max } Z = 7x_1 + 5x_2$$

Subject to the Constraints

$$x_1 + 2x_2 \leq 6$$

$$4x_1 + 3x_2 \leq 12$$

$$\text{and } x_1, x_2 \geq 0.$$

3. Use Big-M Method to solve the following Linear Programming Problem.

$$\text{Min } Z = 2x_1 + x_2$$

Subject to the Constraints

$$3x_1 + x_2 = 3$$

$$4x_1 + 3x_2 \geq 6$$

$$x_1 + 2x_2 \leq 3$$

$$\text{and } x_1, x_2 \geq 0.$$

(OR)

4. Apply the principle of Duality to solve the following Linear Programming Problem.

$$\text{Max } Z = 3x_1 + 4x_2$$

Subject to the Constraints

$$x_1 - x_2 \leq 1$$

$$x_1 + x_2 \geq 4$$

$$x_1 - 3x_2 \leq 3 \text{ and } x_1, x_2 \geq 0.$$

5. Solve the following Assignment Problem.

	JOBS				
	J ₁	J ₂	J ₃	J ₄	J ₅
MACHINES	130	160	190	200	175
M ₁	120	135	160	175	130
M ₂	110	140	170	185	155
M ₃	50	50	80	110	80
M ₄	35	55	80	105	70

(OR)

6. Solve the following Travelling Salesman problem so as to minimize the cost per cycle.

	TO ITEM				
	A	B	C	D	E
FROM ITEM	∞	4	7	3	4
A	4	∞	6	3	4
B	7	6	∞	7	5
C	3	3	7	∞	7
D	4	4	5	7	∞

7. Obtain an optimum solution to the following Transportation Problem.

	<i>D</i>	<i>E</i>	<i>F</i>	<i>G</i>	Available
<i>A</i>	11	13	17	14	250
<i>B</i>	16	18	14	10	300
<i>C</i>	21	24	13	10	400
Requirement	200	225	275	250	

(OR)

8. Solve the following Transportation Problem.

	<i>D</i>	<i>E</i>	<i>F</i>	Supply
<i>A</i>	6	4	1	50
<i>B</i>	3	8	7	40
<i>C</i>	4	4	2	60
Demand	20	95	35	

SECTION – B

9. Answer any **Three** of the following. Each question carries 5 marks.

3 × 5 = 15

(a) Explain the concept of Degeneracy in Linear Programming Problem.

(b) Obtain the basic feasible solution of the system

$$x_1 + 2x_2 + x_3 = 10$$

$$x_1 + 3x_2 + 6x_3 = 12$$

(c) Describe briefly the general rules for converting any primal into its dual.

(d) Explain an Unbalanced Assignment Problem.

(e) Explain North-West Corner Rule method in Transportation Problem.



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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS II YEAR SEMESTER IV

(W.e.f. 2022-2023 Admitted Batch)

M405: DISCRETE DYNAMICAL SYSTEMS

Course Outcomes: The study of M.Sc. degree programme will enable the students:

1. To discuss about Phase Portraits, Periodic Points and Stable Sets, Sarkovskii's theorem, Differentiability and its Implications.
2. To explain the concepts of Parameterized Families of Functions and Bifurcations; The Logistic Function Part I, The Logistic Function Part II Topological Conjugacy, The Logistic Function Part III and Newton's method.
3. Be able to write and understand the basic proofs of Numerical solutions of Differential Equations, The Dynamics of Complex functions, Quadratic Family and Mandelbrot Set.

UNIT I : Phase Portraits, Periodic Points and Stable Sets, Sarkovskii's theorem, Differentiability and its Implications [Hyperbolic, Attractive and Repelling Periodic Points]

[Chapters 1,4,5,6]

UNIT II : Parameterized Families of Functions and Bifurcations; The Logistic Function Part I [Cantor Sets], Symbolic Dynamics and Chaos.

[Chapters 7,8,9]

UNIT III : The Logistic Function Part II Topological Conjugacy, The Logistic Function Part III [Period Doubling Cascade], Newton's Method

[Chapters 10,11,12]

UNIT IV : Numerical solutions of Differential Equations, The Dynamics of Complex functions [Newton's Method in Complex Plane], the Quadratic Family and Mandelbrot Set

[Chapters 13, 15 and Sections 14.3, 14.5]

PRESCRIBED TEXT BOOK : Richard M. Holmgren, A First Course in Discrete Dynamical Systems, Springer Verlag.

REFERENCE TEXT BOOK: Introduction to Dynamical Systems by Michael Brin and Garrett Stuck.

DEPARTMENT OF MATHEMATICS
M.Sc. MATHEMATICS II YEAR SEMESTER IV
(W.e.f. 2022-2023 Admitted Batch)
M405: DISCRETE DYNAMICAL SYSTEMS

Model Question Paper

Time: 3 hours

Max Marks: 75

SECTION – A

Answer **ALL** questions. Each question carries 15 marks.

$4 \times 15 = 60$

1. (a) Define fixed point and prove that if $I = [a, b]$ be a closed interval and $f: I \rightarrow I$ be a continuous function then f has a fixed point in I . (b) Define stable set and prove that the stable set of distinct periodic points do not intersect. (OR)
2. State and prove Sarkovskii's Ordering Theorem.
3. (a) Define Saddle-node Bifurcation with suitable example. (b) Define Cantor set and prove that the Cantor Middle- α Set is a Cantor set. (OR)
4. Let $f: X \rightarrow X$ be a topologically transitive and suppose that periodic points of f are dense in X . If X is infinite then f exhibits sensitive dependence on initial conditions.
5. Let D and E be metric spaces, $f: D \rightarrow D$, $g: E \rightarrow E$ and $\tau: D \rightarrow E$ be a topological conjugacy of f and g then (a) $\tau^{-1}: E \rightarrow D$ is a topological conjugacy.
(b) The periodic points of f are dense in D if and only if the periodic points of g are dense in E .
(c) f is chaotic on D if and only if g is chaotic on E . (OR)
6. (a) Let $f(x) = ax^2 + bx + c$ and $q(x) = x^2 - A$ where $A = (b^2 - 4ac)$ then $\tau(x) = 2ax + b$ is a topological conjugacy from $N_f(x)$ to $N_q(x)$.
(b) Prove that the function $\Psi: \Lambda \rightarrow \Sigma_2$ is topological conjugacy.

7. (a) Let f be a differentiable complex function and p be a fixed point of f . If $|f'(p)| < 1$, then the stable set of p contains a neighbourhood of p .
- (b) Let $f(z) = az$ where 'a' is complex number whose module is not 1 and note that 0 is the only fixed point of f and investigate the orbit of z_0 when $z_0 \neq 0$.

(OR)

8. Let $f(z) = e^{i\theta}z$ and z_0 is a nonzero complex number. Show that
- (a) z_0 is a periodic point of f if θ is a rational multiple of π .
- (b) If θ is a rational multiple of π then z_0 is not a periodic point of f and its orbit is dense in the circle containing z_0 .

SECTION – B

9. Answer any **Three** of the following. Each question carries 5 marks. **3 × 5 = 15**
- (a) Define Discrete Dynamical system and give three examples.
- (b) Define Shift map and prove that shift map is continuous
- (c) If D and E be metric spaces, $f: D \rightarrow D$, $g: E \rightarrow E$ and $\tau: D \rightarrow E$ be a topological conjugacy of f and g prove that f is topological transitive on D iff g is topological transitive on E .
- (d) Define attracting periodic point and repelling periodic point.
- (e) Prove that $h(x) = rx(1 - x)$ is chaotic on Λ when $4 < r \leq 2 \pm \sqrt{5}$.



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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS II YEAR SEMESTER IV

(W.e.f. 2022-2023 Admitted Batch)

M405.2 : OPERATOR THEORY

UNIT I :Banach fixed point theorem- application of Banach's theorem to linear equations - application of Banach's theorem to differential equations-application of Banach's theorem to integral equations.

[Chapter 5 of the text book]

UNIT II:Approximation in normed spaces-Uniqueness, strict convexity-uniform approximation
Chebyshev polynomials – Splines.

[Sections 6.1 to 6.4 and 6.6 of Chapter 6 of the text book]

UNIT III :Spectral theory in finite dimensional Normed spaces-basic concepts-spectral properties of bounded linear operators-further properties of Resovent and spectrum-use of complex analysis in spectral theory.

[Sections 7.1 to 7.5 of Chapter 7 of the text book]

UNIT IV:Compact linear operator of normed spaces-Further properties of compact linear operators Spectral properties of compact linear operators on normed spaces-further spectral properties of compact linear operators.

[Sections 8.1 to 8.4 of Chapter 8 of the text book.]

PRESCRIBED TEXT BOOK:

Introductory Functional Analysis and Applications by Kreyszig, John Wiley and Sons, Delhi, 2001.



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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS II YEAR SEMESTER IV

(W.e.f. 2022-2023 Admitted Batch)

M405.3 - ADVANCED DIFFERENTIAL EQUATIONS

UNIT I :Boundary value problems: Preliminaries – Sturm – Liouville Problem – Green's function –

Application of Boundary Value Problem – Picard's theorem.

[Chapter 7 of prescribed text book.]

UNIT II :Oscillations of second order equations: Fundamental results – Sturm's Comparisons theorem

– Elementary linear oscillations – Comparisons theorem of Hille – Wintner – oscillations of $x'' + a(t)x = 0$.

[Chapter 8 of prescribed text book.]

UNIT III :Stability of linear and nonlinear systems: preliminaries – Elementary critical points – system of equations with constant coefficients – Linear equation with constant coefficients – Lyapunov stability – stability of quasi linear systems – second order linear differential equations.

[Chapter 9 of prescribed text book.]

UNIT IV :Equations with deviating arguments: Preliminaries – equations with constant delay – Equations

with piecewise constant delay – a few other types of delay equations.

[Chapter 11 of prescribed text book.]

PRESCRIBED TEXT BOOK:

S.G. Deo, V. Lakshmikantham and V. Raghavendra: Text book of ordinary Differential equations, Second edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 1997.



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DEPARTMENT OF MATHEMATICS

M.Sc. MATHEMATICS II YEAR SEMESTER IV

(W.e.f. 2022-2023 Admitted Batch)

M405.4 NONLINEAR FUNCTIONAL ANALYSIS

UNIT-I :Various forms of continuity- Geometry in normed spaces and duality mapping, Nemytskii,

Hammerstein and Urysohn operators.

Chapter 1 of the textbook

UNIT-II :Gateaux and Frechet derivative, Properties of derivative, Taylor's theorem, Inverse function

theorem and Implicit function theorem, Sub differential of convex functions.

Chapter 2 of the text book

UNIT-III :Banach's contraction principle and its generalization, Nonexpansive mappings, Fixed point theorems of Brouwer and Schauder.

Sections 4.1 to 4.3 of Chapter 4 of the text book.

UNIT-IV:Fixed point theorems for multifunctions, common fixed point theorems, Sequences of contractions, generalized contractions and fixed points.

Sections 4.4 to 4.6 of Chapter 4 of the textbook.

PRESCRIBED TEXT BOOK:

Joshi, Mohan C., and Ramendra K. Bose. Some topics in nonlinear functional analysis. John Wiley & Sons, 1985.



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University**

DEPARTMENT OF MATHEMATICS

ANALYTICAL SKILLS
(W.e.f. 2022-2023 Admitted Batch)

UNIT – 1 : Data Analysis

The data given in a Table, Graph, Bar Diagram, Pie Chart, Venn diagram or a passage is to be analyzed and the questions pertaining to the data are to be answered.

UNIT – 2 : Sequence and Series

Analogies of numbers and alphabets completion of blank spaces following the pattern in A:b::C:d relationship odd thing out; Missing number in a sequence or a series.

UNIT – 3: Arithmetic ability

Algebraic operations BODMAS, Fractions, Divisibility rules, LCM&GCD (HCF).

Date, Time and Arrangement Problems: Calendar Problems, Clock Problems, Blood Relationship.

Quantitative aptitude: Averages, Ration and proportion, Problems on ages, Time-distance – speed.

Reference Books:

1. Quantitative Aptitude for Competitive Examination by R S Agrawal, S.Chand publications.
2. Quantitative Aptitude and Reasoning by R V Praveen, PHI publishers.
3. Quantitative Aptitude : Numerical Ability (Fully Solved) Objective Questions, Kiran Prakashan, Pratogitaprakasan, Kic X, Kiran Prakasan publishers
4. Quantitative Aptitude for Competitive Examination by Abhijit Guha, Tata Mc Graw hill publications.
5. Old question Paper of the exams conducted by (Wipro, TCS, Infosys, Etc) at their recruitment process, source-Internet.

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DEPARTMENT OF MATHEMATICS
M.Sc. MATHEMATICS I YEAR SEMESTER I
(W.e.f. 2022-2023 Admitted Batch)

Analytical Skills
Model Question Paper

Time: 2Hrs

Max Marks: 50

Answer ALL the questions. Each question carries ONE mark.

50 x 1 =50M

SECTION-A(Unit-I)

I. Study the following table carefully and answer the questions given below.

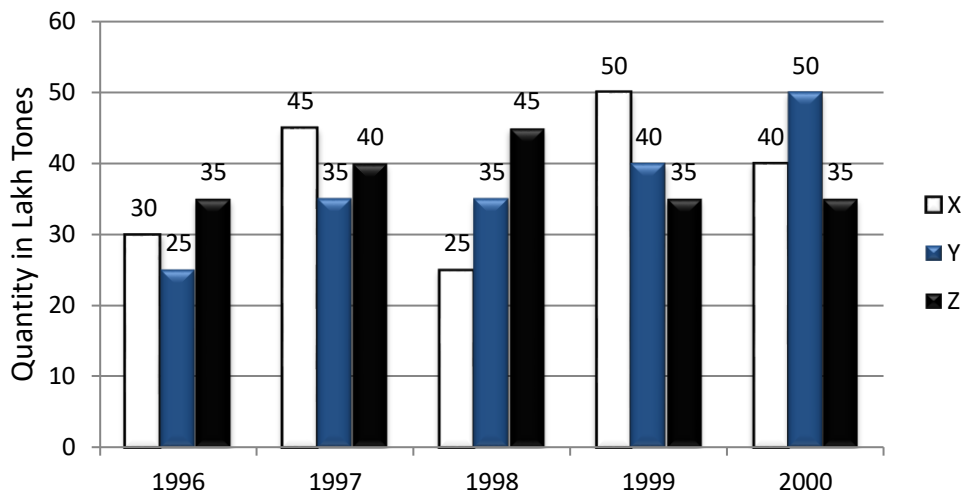
Classification of 100 students based on the marks obtained by them in Physics and Chemistry in an Examination

Marks out of 50 \ Subject	40 and Above	30 and Above	20 and Above	10 and Above	0 and Above
Physics	9	32	80	92	100
Chemistry	4	21	66	81	100
Average	7	27	73	87	100

- The number of students scoring less than 40% marks in aggregate is:
(a) 13 (b) 19 (c) 20 (d) 27 (e) 34
- If at least 60% marks in Physics are required for pursuing higher studies in Physics, how many students will be eligible to pursue higher studies in Physics?
(a) 27 (b) 32 (c) 34 (d) 41 (e) 68
- What is the difference between the number of students passed with 30 as cut-off marks in Chemistry and those passed with 30 as cut-off marks in aggregate?
(a) 3 (b) 4 (c) 5 (d) 6 (e) 7
- The percentage of the number of students getting at least 60% marks in Chemistry over those getting at least 40% marks in aggregate, is approximately:
(a) 21% (b) 27% (c) 29% (d) 31% (e) 34%
- If it is known that at least 23 students were eligible for a symposium on Chemistry, the minimum qualifying marks in Chemistry for eligibility to Symposium would lie in the range :
(a) 40 -50 (b) 30-40 (c) 20-30 (d) Below 20 (e) Cannot be determined

II. The bar graph provided below gives the data of the production of paper (in lakh tones) by three different companies X,Y and Z over the years. Study the graph and answer the questions that follow.

Production of Paper (in lakh tones) by three companies X,Y and Z over the years



6. What is the difference between the production of Company Z in 1998 and Company Y in 1996?
 (a) 2,00,000 tons (b) 20,00,000 tons (c) 20,000 tons (d) 2,00,00,000 tons
 (e) None of these
7. What is the ratio of the average production of Company X in the period 1998-2000 to the average production of Company Y in the same period?
 (a) 1 : 1 (b) 15 : 17 (c) 23 : 25 (d) 27 : 29 (e) None of these
8. What is the percentage increase in the production of Company Y from 1996 to 1999?
 (a) 30% (b) 45% (c) 50% (d) 60% (e) 75%
9. The average production for five years was maximum for which company?
 (a) X (b) Y (c) Z (d) X and Y both (e) X and Z both
10. In which year was the percentage of production of Company Z to the production of Company Y the maximum?
 (a) 1996 (b) 1997 (c) 1998 (d) 1999 (e) 2000

SECTION-B(Unit-II, III, IV & V)

11. 1 : 1 :: 25 : ?
 (a) 26 (b) 125 (c) 240 (d) 625
12. 5 : 100, 4 : 64 :: 4 : 80, 3 : ?
 (a) 26 (b) 48 (c) 54 (d) 60
13. WONDER PES
 CLUSTER MTF
 MUSCLE ?
 (a) LRK (b) NSM (c) TBD (d) VDF
14. $\frac{2}{3}, \frac{4}{7}, ?, \frac{11}{21}, \frac{16}{31}$
 (a) $\frac{5}{9}$ (b) $\frac{6}{11}$ (c) $\frac{7}{13}$ (d) $\frac{9}{17}$
15. 2, 1, 2, 4, 4, 5, 6, 7, 8, 8, 10, 11, ?

- (a) 9 (b) 10 (c) 11 (d) 12
16. 10, 18, 28, 40, 54, 70, ?
 (a) 85 (b) 86 (c) 87 (d) 88
17. 2, 8, 16, 128, ?
 (a) 2042 (b) 2046 (c) 2048 (d) 2056
18. ab_d_aaba_na_badna_b
 (a) andaa (b) babda (c) badna (d) bdanb
19. abca_bcaab_ca_bbc_a
 (a) ccaa (b) bbaa (c) abac (d) abba
20. mnonopqopqrs_ _ _ _ _
 (a) mnopq (b) oqrst (c) pqrst (d) qrstu
21. $\frac{3\frac{1}{4} - \frac{4}{5} \text{ of } \frac{5}{6}}{4\frac{1}{3} \div \frac{1}{5} - \left(\frac{3}{10} + 21\frac{1}{5}\right)} =$
 (a) $\frac{1}{6}$ (b) $2\frac{7}{12}$ (c) $15\frac{1}{2}$ (d) $21\frac{1}{2}$
22. $\frac{(0.1667)(0.8333)(0.3333)}{(0.2222)(0.6667)(0.1250)}$ is approximately equal to :
 (a) 2 (b) 2.40 (c) 2.43 (d) 2.50
23. Find the H.C.F of $2^3 \times 3^2 \times 5 \times 7^4$, $2^2 \times 3^5 \times 5^2 \times 7^6$, $2^3 \times 5^3 \times 7^2$
 (a) 980 (b) 400 (c) 500 (d) 680
24. Which of the following is a pair of co-primes?
 (a) (16, 62) (b) (18, 25) (c) (21, 35) (d) (23, 92)
25. What was the day of the week on 16th July, 1776?
 (a) Monday (b) Wednesday (c) Tuesday (d) Saturday
26. Find the angle between the hour hand and the minute hand of a clock when the time is 3.25.
 (a) $55\frac{1}{2}^\circ$ (b) $47\frac{1}{2}^\circ$ (c) $35\frac{1}{2}^\circ$ (d) $25\frac{1}{2}^\circ$
27. The angle between the minute hand and hour hand of a clock when the time is 8 : 30 is :
 (a) 80° (b) 75° (c) 60° (d) 105°
28. How many times in a day, are the hands of a clock in straight line but opposite in direction?
 (a) 20 (b) 22 (c) 24 (d) 48
29. Looking at a portrait of a man, Harish said , “His mother is the wife of my father’s son . Brothers and sisters I have none”. At whose portrait was Harsh looking?
 (a) His son (b) His cousin (c) His uncle
 (d) His nephew (e) None of these
30. D the son-in-law of B, is the brother-in-law of A who is the brother of C. How is A related to B?

- (a) Brother (b) Son (c) Father
(d) Data inadequate (e) None of these
31. The average weight of 10 oarsmen in a boat is increased by 1.8kg when one of the crew, who weighs 53kg is replaced by a new man. Find the weight of the new man.
(a) 55Kg (b) 71kg (c) 85kg (d) 95kg
32. A batsman makes a score of 87 runs in the 17th innings and thus increases his average by 3. Find his average after 17th inning.
(a) 38 (b) 40 (c) 45 (d) 39
33. The average score of a cricketer for ten matches is 38.9 runs. If the average for the first six matches is 42, then find the average for the last four matches.
(a) 33.25 (b) 33.5 (c) 34.25 (d) 35
34. A motorist travels to a place 150km away at an average speed of 50 km/hr and returns at 30 km / hr. His average speed for the whole journey in km / hr is :
(a) 35 (b) 37 (c) 37.5 (d) 40
35. If $A : B = \frac{1}{2} : \frac{1}{8}$, $B : C = \frac{1}{3} : \frac{5}{9}$ and $C : D = \frac{5}{6} : \frac{3}{4}$, then the ratio $A : B : C : D$ is :
(a) 4 : 6 : 8 : 10 (b) 6 : 4 : 8 : 10 (c) 6 : 8 : 9 : 10 (d) 8 : 6 : 10 : 9
36. The ratio of the number of boys and girls in a college is 7 : 8. If the percentage increase in the number of boys and girls be 20% and 10% respectively, what will be the new ratio?
(a) 8 : 9 (b) 17 : 18 (c) 21 : 22 (d) Cannot be determined
37. Sachin is younger than Rahul by 4 years. If their ages are in the respective ratio of 7 : 9, how old is sachin?
(a) 16 years (b) 18 years (c) 28 years
(d) Cannot be determined (e) None of these
38. In 10 years, A will be twice as old as B was 10 years ago. If A is now 9 years older than B, the present age of B is:
(a) 19 Years (b) 29 Years (c) 39 Years (d) 49 Years
39. A cyclist covers a distance of 750m in 2 min 30 sec. What is the speed in km/hr of the cyclist?
(a) 18 km /hr (b) 20 km /hr (c) 22 km /hr (d) 25 km
40. A train covers a distance of 10 km in 12 minutes. If its speed is decreased by 5 km / hr the time taken by it to cover the same distance will be :
(a) 10 min (b) 11 min 20 sec (c) 13 min (d) 13 min 20 sec
41. The difference between a number and its two-fifth is 510. What is 10% of that number?
(a) 12.75 (b) 85 (c) 204 (d) None of these

42. A scored 30% marks and failed by 15 marks. B scored 40% marks and obtained 35 marks more than those required to pass. The pass percentage is :
 (a) 33% (b) 38% (c) 43% (d) 46%
43. Alfred buys an old scooter for Rs.4700 and spends Rs.800 on its repairs. If he sells the scooter for Rs.5800, his gain percent is :
 (a) $4\frac{4}{7}\%$ (b) $5\frac{5}{11}\%$ (c) 10% (d) 12%
44. The cash difference between the selling prices of an article at a profit of 4% and 6% is Rs.3. The ratio of the two selling prices is :
 (a) 51 : 52 (b) 52 : 53 (c) 51 : 53 (d) 52 : 55
45. A, B and C jointly thought of engaging themselves in a business venture. It was agreed that A would invest Rs.6500 for 6 months, B, Rs.8400 for 5 months and C, Rs.10,000 for 3 months. A wants to be the working member for which he was to receive 5% of the profits. The profit earned was Rs.7400. Calculate the share of B in the profit.
 (a) Rs.1900 (b) Rs.2660 (c) Rs.2800 (d) Rs.2840
46. A sum of Rs.12,500 amounts to Rs.15,500 in 4 years at the rate of simple interest. What is the rate of interest?
 (a) 3% (b) 4% (c) 5% (d) 6% (e) None of these
47. Rs.800 becomes Rs.956 in 3 years at a certain rate of simple interest. If the rate of interest is increased by 4%, what amount will Rs.800 become in 3 years?
 (a) Rs.1020.80 (b) Rs.1025 (c) Rs.1052
 (d) Data inadequate (e) None of these
48. Reena and Shaloo are partners in a business. Reena invests Rs. 35,000 for 8 months and Shaloo invests Rs.42,000 for 10 months. Out of a profit of Rs.31,750, Reena's share is :
 (a) Rs.9471 (b) Rs.12,628 (c) Rs.18,040 (d) Rs.18,942
49. A sum of money invested at compound interest amounts to Rs.800 in 3 years and to Rs. 840 in 4 years. The rate of interest per annum is :
 (a) $2\frac{1}{2}\%$ (b) 4% (c) 5% (d) $6\frac{2}{3}\%$
50. Find the compound interest on Rs.15,625 for 9 months at 16% per annum compounded quarterly.
 (a) Rs.1851 (b) Rs.1941 (c) Rs.1951 (d) Rs.1961
