# BERHAMPUR UNIVERSITY

## *Syllabus*

**for**

## M.A./M.Sc. in Mathematics

## (2-Year Programme)

**P. G. Department of Mathematics**
**Berhampur University**
**Berhampur-760007 (Orissa)**

**2024-25**

**BERHAMPUR UNIVERSITY**
**Syllabus for M.A./M.Sc. in Mathematics**
**(Applicable for Students Taking Admission from the Session 2024-25)**

## Programme Outcome:

A two years regular course M.A./M.Sc. in Mathematics will develop a breadth of understanding in Calculus, Complex analysis, Measure theory, Numerical analysis, Topology, Differential equations, Functional analysis, Optimization techniques, Number theoretic Cryptography, Graph theory and Statistics along with a depth of knowledge in algebra and analysis. The course is designed to make the students competent to solve ordinary and partial differential equations using Laplace transform and Fourier transform techniques, Eigen value problems, systems of linear differential equations, problems concerning topological spaces, continuous functions, product topologies, and quotient topologies, extension fields, roots of polynomials, complex integrals, elliptic functions. The course also includes the initial value problems by using single step methods, multi step methods, problems on interpolation, numerical differentiation and integration, measurable sets, measurable functions, problems on Green, Gauss and Stokes theorems, problems on probability distributions and generating functions, problems on Hahn-Banach theorems, problems on primitive roots, quadratic residues, and quadratic non-residues, cryptography, zero knowledge protocol and oblivious transfer, the rho method, the continued fraction method. After completion of this course the students will be capable in different competitive examinations like, TIFR, IISc, HRI, CSIR (NET & JRF), GATE, Civil services and pursue research in any national and international institutes of high repute. This course also makes the students cognizant on various features of teaching, learning, and research. Students after completion of this course are expected to operate the mathematical projects and magnify their skills in writing various research articles and to publish the same in national and international reputed journals.

# First Semester

| Sl. No | Subject Code | Subject Title | Internal | External | Credits |
|---|---|---|---|---|---|
| 1. | MATH C101 | PARTIAL DIFFERENTIAL EQUATIONS AND ITS APPLICATIONS | 30 | 70 | 4 |
| 2. | MATH C102 | TOPOLOGY | 30 | 70 | 4 |
| 3. | MATH C103 | ALGEBRA-I | 30 | 70 | 4 |
| 4. | MATH C104 | ELEMENTARY COMPLEX ANALYSIS | 30 | 70 | 4 |
| 5. | MATH C105 | NUMERICAL ANALYSIS AND ITS APPLICATIONS | 30 | 70 | 4 |
| 6. | MATH C106 | INDIAN KNOWLEDGE SYSTEM IN MATHEMATICS | 30 | 70 | 4 |

| | | | | | |
|---|---|---|---|---|---|
| **Second Semester** | | | | | |
| 7. | MATH C201 | ABSTRACT MEASURE | 30 | 70 | 4 |
| 8. | MATH C202 | ADVANCED CALCULUS | 30 | 70 | 4 |
| 9. | MATH C203 | ALGEBRA-II | 30 | 70 | 4 |
| 10. | MATH C204 | ADVANCED COMPLEX ANALYSIS | 30 | 70 | 4 |
| 11. | MATH C205 | GRAPH THEORY | 30 | 70 | 4 |
| 12. | MATH VAC206 | AN INTRODUCTION TO MATLAB | | Grade | Non-Credits |
| **Third Semester** | | | | | |
| 13. | MATH C301 | FUNCTIONAL ANALYSIS-I | 30 | 70 | 4 |
| 14. | MATH C302 | NUMBER THEORETIC CRYPTOGRAPHY - I | 30 | 70 | 4 |
| **Elective - I** | | **A Student is allowed to opt any two papers** | | | |
| 15. | MATH E303 | OPTIMIZATION TECHNIQUES-I | 30 | 70 | 4 |
| 16. | MATH E304 | ORDINARY DIFFERENTIAL EQUATIONS-I | 30 | 70 | 4 |
| 17. | MATH E305 | MATRIX TRANSFORMATIONS IN SEQUENCE SPACES-I | 30 | 70 | 4 |
| 18. | MATH E306 | FLUID DYNAMICS-I | 30 | 70 | 4 |
| 19. | MATH E307 | **ABSTRACT MEASURE AND PROBABILITY**-I | 30 | 70 | 4 |
| 20. | MATH E308 | FUZZY SETS AND FUZZY LOGIC | 30 | 70 | 4 |
| 21. | MATH E309 | MATHEMATICAL STATISTICS | 30 | 70 | 4 |
| 22. | MATH VAC310 | AN INTRODUCTION TO LATEX | Grade | Non-Credits | |
| **CBCT Course** | | **Other Department students will opt this paper** | | | |
| 23. | MATH CT300 | MATHEMATICAL METHODS | 30 | 70 | 4 |
| **Fourth Semester** | | | | | |
| 24. | MATH C401 | FUNCTIONAL ANALYSIS-II | 30 | 70 | 4 |
| 25. | MATH C402 | NUMBER THEORETIC CRYPTOGRAPHY-II | 30 | 70 | 4 |
| 26. | MATH D408 | DISSERTATION | 100 | | 4 |
| **Elective - II** | | **A Student is allowed to opt any two papers** | | | |
| 27. | MATH E403 | OPTIMIZATION TECHNIQUES-II | 30 | 70 | 4 |
| 28. | MATH E404 | ORDINARY DIFFERENTIAL EQUATIONS-II | 30 | 70 | 4 |
| 29. | MATH E405 | MATRIX TRANSFORMATIONS IN SEQUENCE SPACES-II | 30 | 70 | 4 |
| 30. | MATH E406 | FLUID DYNAMICS-II | 30 | 70 | 4 |
| 31. | MATH E407 | ABSTRACT MEASURE AND PROBABILITY- II | 30 | 70 | 4 |
| 32. | MATH AC409 | CULTURAL HERITAGE OF SOUTH ODISHA | | Grade | Non-Credits |
| **Total** | | | **2100** | | **84** |

**Total Credit: 84**
**C- Core Course - 1500 (Mandatory with no choice)**
**E- Elective - 500 (Mandatory with choice departmentally)**
**CT- Credits Transformation - 100 (Students of Mathematics shall opt for CBCT courses offered by other Departments)**
**VAC – Value Added Course (Non-Credits), AC - Add on Course (Non-Credits)**
**SWAYAM COURSE: All P.G. students are required to complete one SWAYAM course (Minimum 2 credits) on or before completion of 3rd Semester.**
**Dissertation – 100**
**Internal-30(Attendance-05+ Quizz-05+ Written Assesment-20)**

# DETAILED SYLLABUS

# FIRST SEMESTER

| **Sub. Code: MATH C101** | **Partial Differential Equations and its Applications** | |
|---|---|---|
| **Semester: I** | **Credit: 4** | **Core Course** |
| **Pre-requisites: Basic knowledge in ordinary and partial differential equations** | | |
| **Course Outcome:**<br>➢ To solve the Cauchy problems and wave equations with homogeneous and Nonhomogeneous equations.<br>➢ To solve Eigen value Problems and Special Functions, Boundary Value Problems of partial differential equations.<br>➢ To solve partial differential equations by applying Fourier Transforms and Laplace Transforms. | | |

**Unit-I** 10 hours

Basic Concepts and Classification of Second Order Linear Equations.

**Unit-II** 10 hours

The Cauchy Problem and Wave Equations, Method of Separation of Variables.

**Unit-III** 10 hours

Eigen value Problems and Special Functions, Boundary Value Problems.

**Unit-IV** 10 hours

Fourier Transforms and Laplace Transforms.

**Text Book:**

Tyn Myint, U. & Lokenath Debnath: Linear Partial Differential Equations for Scientists and Engineers, Birkhauser Pub. (4th Edition). Chapters: 1(1.2-1.6), 4, 5(5.1-5.7), 7, 8, 9, 12 (12.1-12.6, 12.8-12.11).

**Reference Book:**

Tyn Myint, U.: Partial Differential Equations of Mathematical Physics. (Elsevier Pub.)

| Sub. Code: MATH C102 | Topology | |
|---|---|---|
| Semester: I | Credit: 4 | Core Course |
| Pre-requisites: Basic knowledge in Sets and Functions | | |
| Course Outcome:<br>➢ To learn about different Topological spaces, Open sets, Closed sets, Connected Sets and Compact sets.<br>➢ To understand the Metric spaces, Regular and Normal Spaces. | | |

**Unit-I** 10 hours

Open sets and Limit points, Closed sets and Closure, Bases and relative Topologies.

**Unit-II** 10 hours

Connected Sets and Components, Compact and Countable compact spaces, Continuous functions, Homeomorphisms.

**Unit-III** 10 hours

$T_0$ -and $T_1$-spaces & sequence, $T_2$ Spaces, Regular and Normal Spaces, Completely regular Spaces.

**Unit-IV** 10 hours

Urysohn's lemma, Urysohn's Metrization theorem, Finite products, Product invariant properties, Metric products, Product topology.

**Text Book:**

W. J. Pervin: Foundations of General Topology, Academic Press. Chapters: 3(3.1, 3.2 and 3.4), 4(4.1 to 4.4), 5(5.1 to 5.3, 5.5 and 5.6), 8(8.1 to 8.4), 10(10.1 only).

**Reference Books:**

1. J. R. Munkers: Topology-A First Course, Prentice Hall, 1996.
2. K. D. Joshi: Introduction to General Topology, Willey Eastern Ltd., 1983.

| Sub. Code: MATH C103 | Algebra-I | |
|---|---|---|
| Semester: I | Credit: 4 | Core Course |
| Pre-requisites: Basic concepts in group theory and ring theory | | |
| Course Outcome:<br>➢ To study p- Sylow's Subgroups of a finite Group.<br>➢ To construct the maximal Ideals by using irreducible polynomials. | | |

- To learn about finite extension field, Algebraic element and transcendental numbers.

**Unit-I** 10 hours

Automorphisms, Cayley's Theorem, Permutation Groups, Another Counting Principle.

**Unit-II** 10 hours

Sylow's Theorems, More Ideals and Quotient Rings, The Field of Quotients of an Integral Domain, Euclidean Rings, A Particular Euclidean Ring.

**Unit-III** 10 hours

Polynomial Rings, Polynomial Rings over the Rational Field, Elementary Basic Concepts of Vector Space, Linear Independence and Bases.

**Unit-IV** 10 hours

Extension Fields, The Transcendence of e, Roots of Polynomials, Construction with Straightedge and Compass, More about Roots.

**Text Book:**

I. N. Herstein: Topics in Algebra, John Wiley and Sons (2nd Edition) 2002. Chapters: 2(2.8 to 2.l2), 3(3.5 to 3.10), 4(4.1, 4.2), 5(5.1 to 5.5).

**Reference Books:**

1. S. Singh end Q, Zameeraddin: Modern Algebra, Vikas Publishing House, 1590.
2. P. B .Bhattacharya. S. K. Jain and S. R. Nagpal: Basic Abstract Algebra, Cambridge University Press, 1995.

| **Sub. Code: MATH C104** | **Elementary Complex Analysis** | |
|---|---|---|
| **Semester: I** | **Credit: 4** | **Core Course** |
| **Pre-requisites: Basic concepts in complex numbers and complex functions** | | |

**Course Outcome:**

- To find an analytic functions when its real or imaginary part is known.
- To establish a linear transformation through cross ratio.
- To compute the complex integrations.

**Unit-I** 10 hours

Complex Numbers.

**Unit-II** 10 hours

Complex Functions.

**Unit-III** 10 hours

Conformality and Linear Transformations

**Unit-IV** 10 hours

Complex Integration: Fundamental theorems, Cauchy's Integral formula, Local properties of analytic functions, Complex integration continued: General form **of** Cauchy's theorem.

**Text Book:**

Lars V. Ahlfors: Complex Analysis, McGraw-Hill International Editions (3rd Edition). Chapters: 1, 2, 3 (2.1 to 2.4, 3.1 to 3.3), 4 (4.1 to 4.4).

| **Sub. Code: MATH C105** | **Numerical Analysis and its Applications** | |
|---|---|---|
| **Semester: I** | **Credit: 4** | **Core Course** |
| **Pre-requisites: Basic knowledge in interpolation and approximation, numerical integration and differentiation.** | | |
| **Course Outcome:**<br>➢ To obtain the interpolating polynomial by using different methods.<br>➢ To solve numerical integration by using various numerical methods.<br>➢ To solve the ordinary differential equations (IVP) by single and multi step methods. | | |

**Unit-I** 10 hours

Interpolation & Approximation: Introduction, Lagrange and Newton interpolations, finite difference operators, Interpolating Polynomials using finite differences, Hermite Interpolation, Piecewise and spline interpolation.

**Unit-II** 10 hours

Interpolation and Approximation (contd.): Bivariate interpolations, Approximation, least square approximation, uniform approximation, Rational approximation, choice of the method.

**Unit-III** 10 hours

Differentiation and Integration: Introduction, Numerical differentiation, Optimum choice of step length, extrapolation method, partial differentiation, Numerical Integration,

Methods based on interpolation. Methods based on undetermined coefficients, Composite Integration methods, Romberg Integration, Double integration.

**Unit-IV** 10 hours

Ordinary Differential Equations, Initial Value Problems: Introduction, Differential Equations, Numerical methods, single step methods, stability analysis of single step methods, Multi step methods.

**Text Book:**

M. K. Jain, S. R. K. Iyengar and R. K. Jain: Numerical Methods for Science and Engineering Computations ($4^{th}$ Edition), New Age International Publishers, 2003. Chapters: 4, 5, 6(6.1 to 6.6).

| **Sub. Code: MATH C106** | **Indian Knowledge System In Mathematics** | |
|---|---|---|
| **Semester: I** | **Credit: 4** | **Core Course** |
| **Pre-requisites: Some ideas about the Indian Mathematicians and their Biography.** | | |
| **Course Outcome:**<br>➢ To identify the Ancient Indian Mathematicians.<br>➢ To learn about the pioneering contributions of Indian Mathematicians. | | |

**Unit-I** 10 hours

Mathematical Thought in Vedic India: The Vedas and mathematics, The Sulaba-sutras, The Jyotisa-vedanga; The Genre of Medieval Mathematics: Chapters on mathematics in siddhantas, The Bakhshali Manuscript, The Ganita-sara-sangraha

**Unit-II** 10 hours

The Development of "Canonical" Mathematics: Mathematicians and society, The "standard" texts of Bhaskara (II), The School of Madhava in Kerala: Background, Lineage, Infinite series and other mathematics.

**Unit-III** 10 hours

Congruences for $p(n)$ and $\tau(n)$: Historical Background, Elementary Congruences for $\tau(n)$, Ramanujan's Congruence $p(5n+4) \equiv 0 \pmod 5$, Ramanujan's Congruence $p(7n+5) \equiv 0 \pmod 7$, The Parity of $p(n)$.

**Unit-IV** 10 hours

The Rogers-Ramanujan Continued Fraction: Definition and Historical Background, The Convergence, Divergence, and Values of R(q), The Rogers-Ramanujan Functions, Identities for R(q), Modular Equations for R(q).

**Text Books:**

1. Kim Plofker: Mathematics in India, Princeton University Press, 2008, Chapters: 2(2.1, 2.2, 2.4), 5(5.1, 5.2, 5.3), 6(6.1, 6.2), 7(7.1, 7.2, 7.3).
2. Bruce C. Berndt: Number theory in the spirit of Ramanujan, Student Mathematical Library, Volume 34, American Mathematical Society, Providence, Rhode Island, Chapters: 2(2.1, 2.2, 2.3, 2.3, 2.4, 2.5), 7(7.1, 7.2, 7.3, 7.4, 7.5).

**Reference Books:**

1. Eric Temple Bell: Men of Mathematics, Simon and Schuster, Reissue Edition, 1986.
2. C.D. Olds: Continued Fraction, Random House and the I.W. Singer Company**.**

# SECOND SEMESTER

| **Sub. Code: MATH C201** | **Abstract Measure** | |
|---|---|---|
| **Semester: II** | **Credit: 4** | **Core Course** |
| **Pre-requisites: Sets, Functions, Differentiation and Integration.** | | |
| **Course Outcome:**<br>➢ To identify the measurable sets and measurable functions.<br>➢ To learn about Lebesgue Integrable functions. | | |

**Unit-I** 10 hours

Introduction, Outer Measure, Measurable sets and Lebesgue Measure, A non-Measurable set, Measurable functions, Littlehood's three Principles.

**Unit-II** 10 hours

The Lebesgue Integral.

**Unit-III** 10 hours

Differentiation and Integration.

**Unit-IV** 10 hours

The classical Banach Spaces.

**Text Book:**

H. L. Royden: Real Analysis (MacMillan Pub.) Chapters: 3, 4, 5, 6.

| **Sub. Code: MATH C202** | **Advanced Calculus** | |
|---|---|---|
| **Semester: II** | **Credit: 4** | **Core Course** |
| **Pre-requisites: Limit, Continuity and Differentiability of real valued functions.** | | |
| **Course Outcome:** | | |

- To understand the derivatives for functions of several variables, Differentiations of transformations and Inverse of transformations.
- To exhibit the set function, transformation of multiple Integrals.

**Unit-I** 10 hours

Derivatives for Functions on $R^n$ - Differentiation of composite functions, Taylors Theorem.

**Unit-II** 10 hours

Transformations, Linear function and transformations, Differentials of transformations, Inverse of transformations.

**Unit-III** 10 hours

Implicit function theorems, functional dependence, set function, transformation of multiple Integrals.

**Unit-IV** 10 hours

Curves and Arc length, surfaces and surface area, Integrals over curves and surface, Differential forms, Theorem of Green, Gauss and stokes, exact form and closed form.

**Text Book:**

R. C. Buck: Advanced Calculus (3rd Edition), McGraw Hill. Chapters: 3(3.3 to 3.3), 7(7.2 to 7.7), 8(8.2 to 8.6), 9(9.2, 9.4, 9.5).

| **Sub. Code: MATH C203** | **Algebra-II** | |
|---|---|---|
| **Semester: II** | **Credit: 4** | **Core Course** |
| **Pre-requisites: Basic knowledge in Linear transformation and inner product spaces** | | |

**Course Outcome:**

- To understand the basic knowledge of Golois Group and solvability by radicals.
- To gain the knowledge about the triangular, Nilpotent and Jordan Form of the linear transformation.
- To know the Application of Hermitian, Unitary and normal Transformations.

**Unit-I** 10 hours

Dual Spaces, Inner Product Spaces, The Elements of Galois Theory, Solvability by Radicals.

**Unit-II** 10 hours

The Algebra of Linear Transformation, Characteristic Roots, Matrices.

**Unit-III** 10 hours

Canonical Forms 1 Triangular Form, Nilpotent Transformations, Jordan Form.

**Unit-IV** 10 hours

Trace and Transpose Determinants, Hermitian, Unitary and normal Transformations.

**Text Book:**

I. N. Herstein: Topics in Algebra, John Wiley and Sons (2nd Edition), 2002.
Chapters: 4(4.3, 4.4), 5(5.6, 5.7), 6(6.1 to 6.6, 6.8 to 6.10).

**Reference Books:**

1. S. Singh end Q, Zameeraddin: Modern Algebra, Vikas Publishing House, 1590.
2. P. B.Bhattacharya, S. K. Jain and S. R. Nagpal: Basic Abstract Algebra, Cambridge University Press, 1995.

| **Sub. Code: MATH C204** | **Advanced Complex Analysis** | |
|---|---|---|
| **Semester: II** | **Credit: 4** | **Core Course** |
| **Pre-requisites: Knowledge in Power series and special functions.** | | |
| **Course Outcome:**<br>➢ To learn about various types of power series expansions and some special functions. | | |

**Unit-I** 10 hours

Complex Integration Calculus of Residues.

**Unit-II** 10 hours

Series and Product development: Power series expansion, partial fraction and factorization.

**Unit-III** 10 hours

Series and product development continued: Entire function, Riemann Zeta Function.

**Unit-IV** 10 hours

Elliptic Functions: Simple periodic functions and Double periodic functions, Elliptic Functions, Weierstrass Theory.

**Text Book:**

Lars V. Ahlfors: Complex Analysis, McGraw-Hill International Editions (3rd Edition). Chapters: 4 (4.5), 5(5.1 to 5.4), 7(7.1 to 7.3).

| **Sub. Code: MATH C205** | **Graph Theory** | |
|---|---|---|
| **Semester: II** | **Credit: 4** | **Core Course** |
| **Pre-requisites: Basic knowledge in graphs** | | |
| **Course Outcome:**<br>➢ To learn about various types of graphs and trees.<br>➢ To understand the colouring of the graphs. | | |

Unit-I 10 hours

Introduction to Graphs.

Unit-II 10 hours

Trees and Connectivity.

Unit-III 10 hours

Euler Tours and Hamiltonian Cycles: Euler Tours, Hamiltonian graphs, Planar Graphs: Plane and Planar Graphs, Euler's Formula, Kuratowski's Theorem.

Unit-IV 10 hours

Colouring.

**Text Book:**

John Clark and D. A. Holton: A First Look at Graph Theory, World Scientific and Allied Publishers. Chapters: 1, 2, 3(3.1, 3.3), 5(5.1, 5.2 & 5.4), 6.

**Reference Book:**

N. Deo: Graph Theory and Applications to Engineering, Anil Computer Sciences, Prentice Hall of India.

| **Sub. Code: MATH VAC206** | **An Introduction to MATLAB** | |
|---|---|---|
| **Semester: II** | **Credit: Nil** | **Non-Credits Course** |
| **Pre-requisites: Basic knowledge of computer** | | |
| **Course Outcome:**<br>➢ To analyze and design systems. | | |

**Unit-I** 10 hours

Introduction: Matrices and arrays.

**Unit-II** 10 hours

Basic functions and commands.

**Unit-III** 10 hours

Simulink: image processing, machine learning, parallel computing and more similar concepts.

**Unit-IV** 10 hours

Modelling and Simulations.

**Text Book:**

MATLAB Programming, The MathWorks, Inc.(Pub.), Chapters: 1, 2, 3, 4, 5 and 6.

| **Sub. Code: MATH SC207** | **SWAYAM COURSE** | |
|---|---|---|
| **Semester: II** | **Credit: 4** | **Core Course** |
| **Students will have to opt any one of the Course from Mathematics Discipline from SWAYAM PORTAL** | | |
| **Course Outcome:**<br>➢ To learn about Mathematical Concepts and its Applications<br>➢ To acquire the knowledge of Mathematical Sciences | | |

# THIRD SEMESTER

| **Sub. Code: MATH C301** | **Functional Analysis-I** | |
|---|---|---|
| **Semester: III** | **Credit: 4** | **Core Course** |
| **Pre-requisites: Basic knowledge in linear space and different types of functions** | | |
| **Course Outcome:**<br>➢ To learn about Normed spaces and Banach spaces<br>➢ To acquire the knowledge of Application of Uniform Boundedness Principle, Closed Graph and Open Mapping Theorem. | | |

**Unit-I** 10 hours

Normed spaces, Continuity of linear maps.

**Unit-II** 10 hours

Hahn-Banach Theorems, Banach spaces.

**Unit-III** 10 hours

Uniform Boundedness Principle, Closed Graph and Open Mapping Theorems, Bounded Inverse Theorem.

**Unit-IV** 10 hours

Spectrum of a Bounded operator, Duals and Transposes.

**Text Book:**

B. V. Limayee: Functional Analysis, New Age International Ltd. (2nd Edition). Chapters: 5, 6, 7(Except Banach Limits), 8, 9(Except Divergence of Fourier Series of continuous Functions and Matrix Transformations and Summability Methods), 10, 11, 12 (12.1 to12.6) and 13 (13.1 to 13.5).

| **Sub. Code: MATH C302** | **Number Theoretic Cryptography-I** | |
|---|---|---|
| **Semester: III** | **Credit: 4** | **Core Course** |
| **Pre-requisites: Basic knowledge in number theory** | | |
| **Course Outcome:**<br>➢ To able time estimates for doing arithmetic, Divisibility and Euclidean algorithm.<br>➢ To able the factoring large number, to find the quadratic residues in Finite fields.<br>➢ To solve the some cryptosystems problems with enciphering matrices.<br>➢ To solve the cryptosystems problems by using RSA. | | |

**Unit-I** 10 hours

Time estimates for doing arithmetic, Divisibility and Euclidean algorithm, Congruences, Some applications to factoring.

**Unit-II** 10 hours

Finite fields, Quadratic residues and Reciprocity.

**Unit-III** 10 hours

Some simple Cryptosystems, Enciphering Matrices.

**Unit-IV** 10 hours

The idea of public key Cryptography, RSA.

**Text Book:**

Neal Koblitz: A Course In number theory and Cryptography, Springer Verlag, GTM No. 114; (1987). Chapters: 1, 2, 3, 4(4.1 and 4.2).

**Reference Book:**

J. Menezes, P. C. Van Oorchot and Scoff A. Vanstone: Hand Book of Applied Cryptography, CRC Press (1997).

| Sub. Code: MATH E303 | Optimization Techniques-I | |
|---|---|---|
| Semester: III | Credit: 4 | Core Course |
| Pre-requisites: Basic knowledge in operation research | | |
| Course Outcome:<br>➢ To solve the integer programming problems by applying different type of methods.<br>➢ To solve the game theory problems by using linear programming, graphical methods and dominance principal. | | |

**Unit-I** 10 hours

Integer Programming: Gomory's Algorithm for pure integer linear programs, Gomory's mixed integer- continuous variable algorithm, Branch and Bound methods.

**Unit-II** 10 hours

Kuhn-Tucker optimality conditions: Some theorems, Kuhn-Tucker first order necessary optimality conditions, Second order optimality condition, Lagranges method.

**Unit-III** 10 hours

Convex programming problem, Sufficiency of Kuhn-Tucker conditions, Legrangian saddle point and duality, duality for convex programs.

**Unit-IV** 10 hours

Game Theory : Game theory problem, Two person zero sum Game, Finite matrix Game, Graphical method for 2xn and mx2 matrix games, Some theorems, Dominance principal.

**Text Book:**

N. S. Kambo: Mathematical Programming, Affiliated EWP Ltd. New Delhi. Chapters: 6(6.4 to 6.6), 7(7.1 to 7.4), 8, 16.

| Sub. Code: MATH E304 | Ordinary Differential Equations-I | |
|---|---|---|
| Semester: III | Credit: 4 | Elective Course |
| Pre-requisites: Derivative and Differential equations with solutions. | | |

**Course Outcome:**

- To solve the linear differential equations of higher order with variable coefficients and constant coefficients.
- To learn the existence and uniqueness of solutions of first order ordinary differential equations with initial conditions and systems of first order ordinary differential equations with constant coefficients.

**Unit-I** 10 hours

Basic Concepts and Linear Equations of the First Order.

**Unit-II** 10 hours

Linear Differential Equations of Higher Order.

**Unit-III** 10 hours

Systems of Linear Differential Equations, Systems of First Order Equations, Existence and Uniqueness Theorems, Fundamental Matrix Non Homogeneous Linear Systems, Systems of Linear Differential Equations, Continued Linear Systems with Constant Coefficients, Linear System with Periodic Coefficients.

**Unit-IV** 10 hours

Equations with Deriving Arguments, Existence and Uniqueness of Solutions.

**Text Book:**

S. G. Deo. V. Lakhimikantbam, V. Raghavendra: Text Book of Ordinary Differential Equations (2nd Edition), Tata-Mc Graw-Hill Publishing Company Ltd. New Delhi. Chapters: 1, 2(except 2.10), 4, 5, 11.

| **Sub. Code: MATH E305** | **Matrix Transformations in Sequence Spaces-I** | |
|---|---|---|
| **Semester: III** | **Credit: 4** | **Elective Course** |
| **Pre-requisites: Knowledge in Infinite series, sequence of real numbers** | | |

**Course Outcome:**

- To learn about different types of limitation methods for matrix transformations.
- To understand various matrices such as Norlund and Riesz Musos, Scbur Matrices, Cesaro and Holder Matrices, etc.

**Unit-I** 10 hours

Limitation Methods: Limitation methods, Examples of Limitation Methods, Matrix Limitation Methods, Norlund and Riesz Musos.

**Unit-II** 10 hours

Limitation Methods: Scbur Matrices: Consistency of Matrix Methods.

**Unit-III** 10 hours

Some particular Limitation Matrices: Norlund Mean, Cesaro and Holder Matrices.

**Unit-IV** 10 hours

Hausdorff Methods, Abels method, Tauberin Theorem, Banach Limits, Strongly Regular Matrices, Counting function.

**Text Book:**

G. N. Peterson: Regular Matrix Transformation, McGraw-Hill Publishing Company. Chapters: 1, 2, 3(3.1 to 3.3).

| **Sub. Code: MATH E306** | **Fluid Dynamics-I** | |
|---|---|---|
| **Semester: III** | **Credit: 4** | **Elective Course** |
| **Pre-requisites: Ordinary and Partial differential equations with solutions** | | |
| **Course Outcome:**<br>➢ To study different types of fluids and various governing equations of it.<br>➢ To solve equations of the flow of viscous compressible and incompressible fluids. | | |

**Unit-I** 10 hours

Kinematics of Fluids, Methods describing Fluid motion. Legarangian and Eulerian Methods. Translation Rotation and Rate of Deformation. Streamlines, Pathlines and Streaklines. The Material derivative and Acceleration Vorticity in Polar and Orthogonal Curvilinear Coordinates.

**Unit-II** 10 hours

Fundamental equations of the flow of viscous compressible fluids, Equations of continuity, motion and energy is Cartesian coordinate systems.

**Unit-III** 10 hours

The equation of state. Fundamental equations of continuity, motion and energy in Cylindrical and Spherical coordinates.

**Unit-IV** 10 hours

2-D and 3-D in viscid incompressible flow. Basic equations and concepts of flow. Circulation theorems, Velocity potential, Rotational and Irrotational flows. Integration of the equations of motion. Bernoulli's Equation, The momentum theorem and the moment of momentum theorem. Laplace's equations in different coordinate systems. Stream function in 2-D motion.

**Text Book:**

S. W. Yuan: Foundations of Fluid Mechanics, Prentice-Hall of India. Chapters: 3, 5 (5.1 to 5.6), 7 (7.1 to 7.9).

| **Sub. Code: MATH E307** | **Abstract Measure and Probability-I** | |
|---|---|---|
| **Semester: III** | **Credit: 4** | **Elective Course** |
| **Pre-requisites: Basic concept in Probability and set theory** | | |
| **Course Outcome:**<br>➢ To introduce the Measures on Boolean semi-Algebra and σ-algebra.<br>➢ To understand the several Distributions such as Binomial Distribution, Poisson Distribution and Normal Distribution and several Approximations to such Distribution. | | |

**Unit-I** 10 hours

Sets and Events, Probability on Foslesn Algebra, Probability Diminutions and Elementary Random Variables, Repeated Trials and Statistical Independence, Poisson Approximation to the Binomial Distribution, Normal Approximation to Binomial Distribution.

**Unit-II** 10 hours

Multivariate Normal Approximation to Multinomial Distribution, some applications of the normal approximation. Independent simple Random variables and central limit theorem, Conditional probability, Law of large numbers An application of the law of large numbers to a problem is Analysis.

**Unit-III** 10 hours

σ-algebra and Borel spaces, Monotone classes, Measures on Boolean semi-Algebra and Algebra Extension of Measure to σ-Algebra, Uniqueness of extensions of measures.

**Unit-IV** 10 hours

Extension and completion of measures, measures on matrix spaces, probability contents,

the lebesgue measure on the Real line, Elementary properties of Borel Maps, Borel Maps into Matrix Spaces, Borel Maps on measure Spaces.

**Text Book:**

K. R. Parthsarathy: Introduction to probability and measure, MacMillan Company. Chapters: 1, 2, 3 (22, 23, 24).

| **Sub. Code: MATH E308** | **Fuzzy Sets and Fuzzy Logic** | |
|---|---|---|
| **Semester: III** | **Credit: 4** | **Core Course** |
| **Pre-requisites: Sets, Functions and Relations** | | |
| **Course Outcome:**<br>➢ To introduce Fuzzy sets versus crisp sets, types of Fuzzy set.<br>➢ To learn about Fuzzy Arithmetic, Fuzzy numbers, Fuzzy Relation. | | |

## Unit-I

10 hours

From Classical (CRISP) sets to Fuzzy sets: Fuzzy sets: Basic types, Basic concept. Fuzzy sets versus crisp sets: Additional properties of α-cuts, Representations of fuzzy sets, extension principle of fuzzy sets.

## Unit-II

10 hours

Operations on Fuzzy sets: Types of operations, Fuzzy complements, Fuzzy intersections: t-norms, Fuzzy unions: t-conorms, Combinations of Operations, Aggregation operations.

## Unit-III

10 hours

Fuzzy Arithmetic: Fuzzy numbers, linguistic variables, Arithmetic operations on Intervals and Fuzzy numbers, Lattice of Fuzzy numbers, Fuzzy equations.

## Unit-IV

10 hours

Fuzzy Relation: Crisp versus Fuzzy relations, Projections and cylindric extensions, Binary Fuzzy relations, Binary relations on a single set, Fuzzy equivalence relations, compatibility relations and ordering relations, Fuzzy morphisms, Sup-i compositions of Fuzzy relations, Inf-$w_i$ compositions of Fuzzy relations.

**Text Book:**

George J. Klir & Bo Yuan: Fuzzy sets and Fuzzy Logic: Theory and Applications, Prentice Hall PTR under Saddle River, New Jersey 07458.

**Reference Books:**

1. S. K. Pundir and R. Pundir: Fuzzy sets and their applications, A Pragati Editions, 8th Editions.
2. A. K. Bhargava: Fuzzy set theory fuzzy logic and their applications, S. Chand & Co, New Delhi.

| **Sub. Code: MATH E309** | **Mathematical Statistics** | |
|---|---|---|
| **Semester: III** | **Credit: 4** | **Core Course** |
| **Pre-requisites: Basic knowledge in probability theory** | | |
| **Course Outcome:**<br>➢ To solve the probability problems of discrete and continuous random variables.<br>➢ To solve the probability problems of probability distribution and generating functions. | | |

**Unit-I** 10 hours

Elements of Theory of Probability : Classical definition of probability, Theorems on probability of union of events, Conditional probability : Theorem of compound probability, Independence of events, The Bayes Theorem, Statistical and empirical definition of probability, Geometric probability, Axiomatic definition of probability, Conditional probability (Axiomatic definition of probability).

**Unit-II** 10 hours

Probability distribution on R: Random variables, probability distribution of a random variables, discrete and continuous random variables, independent random variables, lebesgue-stieltjes integrals, Integration of a random variables.

**Unit-III** 10 hours

Some characteristic of probability distribution: Expectation, Moments, some inequalities concerning moments, Different measures of central tendency, measures of dispersion, Measures of skewness and kurtosis, some probability inequalities.

**Unit-IV** 10 hours

Generating functions: probability generating function, Moment generating function, Factorial generating function, Cummulant generating function, characteristic function, Exercises, Some discrete distribution on R: The discrete uniform distribution, the Bernoulli distribution, the binomial distribution, The hypergeometric distribution, The Poisson distribution, The geometric distribution, The negative binomial distribution, The power series distribution.

**Text Book:**

Parimal Mukhopadhyay: Mathematical Statistics, Books and Allied (P) Ltd. Kolkata. Chapters: 1, 2, 3, 4 and 5.

**Reference Books:**


1. Robert V. Hogg and Allen T. Craig: Introduction to mathematical statistics, Pearson Education Asia, Indian Branch :482 F.I.E Pratapgaanj, Delhi 110092
2. John E. Freund and Ronald E. Walpole: Mathematical statistics, Prentice Hall India Pvt. Ltd. New Delhi-110001.


| **Sub. Code: MATH VAC310** | **An Introduction to LATEX** | |
|---|---|---|
| **Semester: III** | **Credit: Nil** | **Non-Credits Course** |
| **Pre-requisites: Knowledge about computer programming.** | | |
| **Course Outcome:**<br>➢ To be capable to write a research article in LaTeX. | | |

**Unit-I** 10 hours

Basics: Introduction to LaTeX, Text, Symbols and Commands, Document layout and organization, displayed text.

**Unit-II** 10 hours

Mathematical formulas, Graphics inclusion and color.

**Unit-III** 10 hours

Floating tables and figures, User customizations.

**Unit-IV** 10 hours

Beyond the Basics: Document management, Postscript and PDF, Bbliographic data bases and BiBTeX, Presentation material.

**Text Book:**

Helmut Kopka & Patrick W. Daly: A Guide to LATEX and Electronic Publishing (Fourth Edition), Addison-Wesley Longman Ltd. Chapters: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 14, 15.

| **Sub. Code: MATH CT300** | **Mathematical Methods** | |
|---|---|---|
| **Semester: III** | **Credit: 4** | **CBCT Course** |
| **Pre-requisites: knowledge of sets, functions, limit, differentiation, Interpolation** | | |
| **Course Outcome:**<br>➢ To solve functions using limit, differentiation.<br>➢ To obtain the interpolating polynomial by using different methods. | | |

- To solve numerical integration by using various numerical methods.

**Unit-I** 10 hours

Transcendental and polynomial equations: Introduction, Bisection method, Iteration methods based on first degree equation, Rate of convergence of Secant method, Regula-Falsi method, Newton-Raphson method; System of Linear Algebraic equations: Introduction, Direct methods, Cramer Rule, Gauss elimination method, Gauss-Jordan elimination method.

**Unit-II** 10 hours

Interpolation & Approximation: Introduction, Lagrange and Newton interpolations, finite difference operators, Interpolating Polynomials using finite differences, Hermite Interpolation, Piecewise and spline interpolation.

**Unit-III** 10 hours

Limit and Continuity of real valued functions.

**Unit-IV** 10 hours

The Derivatives, Maxima and Minima.

**Text Books:**


1. M. K. Jain, S. R. K. Iyengar and R. K. Jain: Numerical Methods for Science and Engineering Computations (4th Edition), New Age International Publishers, 2003. Chapters: 2(2.1 to 2.3, 2.5), 3(3.1, 3.2), 4(4.1 to 4.6).
2. Shanti Narayan and M. D. Raisinghania: Elements of Real Analysis, S. Chand & Company Pvt. Ltd., New Delhi. Chapter: 8(8.1 to 8.21), 9(9.1 to 9.6), 11(11.1 to 11.4).


# FOURTH SEMESTER

| **Sub. Code: MATH C401** | **Functional Analysis-II** | |
|---|---|---|
| **Semester: IV** | **Credit: 4** | **Core Course** |
| **Pre-requisites: Basics concepts in convergence of sequence and inner product spaces.** | | |
| **Course Outcome:**<br>➢ To learn the Weak and Weak *convergence Reflexivity.<br>➢ To Normal, Unitary and Self-Adjoint Operators. | | |

**Unit-I** 10 hours

Weak and Weak *convergence Reflexivity.

**Unit-II** 10 hours

Inner product spaces, Orthonormal sets.

**Unit-III** 10 hours

Approximation and Optimization Projection and Riesz Representation Theorems.

**Unit-IV** 10 hours

Bounded Operators and Adjoints, Normal, Unitary and Self-Adjoint Operators.

**Text Book:**

B. V. Limayee: Functional Analysis, New Age International Ltd. (2nd Edition). Chapters: 15, 16 (16.1 to 16.3), 21, 22, 23, 24, 25 and 26 (26.1 to 26.5).

| **Sub. Code: MATH C402** | **Number Theoretic Cryptography-II** | |
|---|---|---|
| **Semester: IV** | **Credit: 4** | **Core Course** |
| **Pre-requisites: Basic ideas of RSA, Factorization in finite fields, primes.** | | |
| **Course Outcome:**<br>➢ To solve the Discrete log problems by using Silver-Pihlog-Samir method and Knapsack problems.<br>➢ To find the factor of large number. | | |

**Unit-I** 10 hours

Discrete log, Knapsack.

**Unit-II** 10 hours

Zero knowledge protocols and oblivions transfer, pseudo primes.

**Unit-III** 10 hours

The rho method, Fermat factorization and factor bases.

**Unit-IV** 10 hours

The continued fraction method, The quadratic sieve method.
**Indian Knowledge System**: Contributions of Indian Mathematician Srinivas Ramanujan on continued fraction.

**Text Book:**

Neal Koblitz: A Course on number theoretic Cryptography, Springer Verlag, GTM No. 114 (1987). Chapters: 4(4.3, 4.4, 4.5), 8.

**Reference Book:**

J. Menezes. P. C. Van Oorschot and Scott A. Vanstone: Hand Book of Applied Cryptography, CRC Press (1997).

| **Sub. Code: MATH D408** | **Dissertation** | |
|---|---|---|
| **Semester: IV** | **Credit: 4** | **Core Course** |
| **Pre-requisites: All semester theory.** | | |
| **Course Outcome:**<br>➢ To acquire knowledge for writing research proposal for pursuing higher studies in mathematics. | | |

**Course Details:**

| Chapter | Contents | Hours |
|---|---|---|
| 1 | Literature Review | 15 |
| 2 | Learning objectives | 15 |
| 3 | Dissertation work | 50 |
| 4 | Report writing in proper format | 20 |
| | Total | 100 |

**NB: 1. The students will be informed regarding their supervisors. Each student has to work for at least 100 hours for writing his/her dissertation under the guidance.**

**2. The research work will be submitted in the form of a dissertation before one week of last theory examination/as instructed by HOD. The student has to present his/her work in power point before the External examiner and internal examiners for evaluation.**

| **Sub. Code: MATH E403** | **Optimization Techniques-II** | |
|---|---|---|
| **Semester: IV** | **Credit: 4** | **Core Course** |
| **Pre-requisites: Basic knowledge in operation research** | | |
| **Course Outcome:**<br>➢ To solve the quadratic programs by using Wolfe's algorithm, Beales Algorithm, Fletchers method.<br>➢ To solve the non linear programs by using Frank-Wolfe's method, Reduced gradient method and Kelley's cutting method.<br>➢ To solve the Geometric programming. | | |

**Unit-I** 10 hours

Quadratic program, Wolfe's algorithm, Beales Algorithm, Fletchers method.

**Unit-II** 10 hours

Dual quadratic program, Complementarity problem.

**Unit-III** 10 hours

Nonlinear programming methods: Frank-Wolfe method, Reduced Gradient method, Kelley's cutting plane method.

**Unit-IV** 10 hours

Geometric programming: Proto type primal and dual Geometric Programs, Reduction to proto type Geometric program, Dynamic Programming: Principle of optimality, Reliability of system in series, Height of projectile, Cargo-Loading problem, Inventory problem.

**Text Book:**

N. S. Kambo: Mathematical Programming , Affiliated EWP Pvt Ltd, New Delhi. Chapters: 10(10.1 to 10.5, 10.8), 11(11.1 to 11.3), 12 (12.1 to 12.2), 15 (15.1 to 15.5).

| **Sub. Code: MATH E404** | **Ordinary Differential Equations -II** | |
|---|---|---|
| **Semester: IV** | **Credit: 4** | **Elective Course** |
| **Pre-requisites: Basic knowledge in ordinary differential equations and its solutions** | | |
| **Course Outcome:**<br>➢ To analyze the stability of Nonlinear Systems of first order ordinary differential equations.<br>➢ To explain the oscillatory solutions of Nonlinear Differential Equations. | | |

**Unit-I** 10 hours

Analysis and Methods of Nonlinear Differential Equations.

**Unit-II** 10 hours

Boundary Value Problems.

**Unit-III** 10 hours

Oscillations of Second Order Equations.

**Unit-IV** 10 hours

Stability of Linear and Nonlinear, Systems: Elementary Critical Points, System of Equations with constant coefficients, linear Equations with constant coefficients, Stability of Linear and Nonlinear Systems (continued) Lyapunov stability, stability of Quasi-linear systems, Second Order Linear Differential Equations.

**Text Book:**

S. G. Deo. V. Lakhsmikantham, V. Raghavendra: Text Book of Ordinary Differential Equations (2nd Edition), Tata Mc Graw Hill Publishing Company Ltd. New Delhi. Chapters: 6, 7, 8, 9.

| **Sub. Code: MATH E405** | **Matrix Transformations in Sequence Spaces -II** | |
|---|---|---|
| **Semester: IV** | **Credit: 4** | **Elective Course** |
| **Pre-requisites: Convergent and divergent of sequence and series.** | | |
| **Course Outcome:**<br>➢ To demonstrate the universal Tauberian Theorem, some special types of matrices.<br>➢ To understand the summability theory. | | |

**Unit-I** 10 hours

Strongly Regular Matrices: Some Matrices of a special Type, A universal Tauberian Theorem.

**Unit-II** 10 hours

Bounded sequence, Uniformly limitable sequence, Intersection of Bounded Convergence Fluids.

**Unit-III** 10 hours

Set of Matrices, Bounds on Limits of sequences, Matrix Norms, Pairs of consistent matrices.

**Unit-IV** 10 hours

Matrix and linear transformations Algebras of matrices, Summability, Tauberian theorems.

**Text Books:**

1. O. M. Peterson: Regular Matrix Transformations, Chapters: 3 (8.4 and 3.5), 4.
2. I. J. Maddox: Elements of Functional Analysis, Cambridge University Press, Chapter: 7.

| **Sub. Code: MATH E406** | **Fluid Dynamics-II** |
|---|---|

| Semester: IV | Credit: 4 | Elective Course |
|---|---|---|
| **Pre-requisites: Basic ideas in nonlinear ODE and PDE** | | |
| **Course Outcome:**<br>➢ To understand nonlinear Navier-Stokes equations of motion and its solutions.<br>➢ To learn about the various types of flow of fluid through different mediums. | | |

## Unit-I

10 hours

Laminar Sow of viscous incompressible fluids, Similarity' of flows, The Reynolds number, Flow between parallel flat plates, Couette flow, plane Poiseuille flow, Steady flow in pipes, The Hagen-Poiseuille flow, Flow between two coaxial cylinders*.

## Unit-II

10 hours

Flow between two Coaxial rotating cylinders. Steady flow around a sphere Theory of very slow motion. Unsteady motion of a flat plate.

## Unit-III

10 hours

The laminary boundary layer. Properties of Navier-Stokes equations. The boundary layer, equations in 2-D flow. The boundary layer along a flat plate. Boundary layer on a surface with pressure gradient, Momentum integral theorems for the boundary layer.

## Unit-IV

10 hours

Von Karman-Pohlhausen method. Boundary layer for axially symmetrica' flow. Separation of boundary layer flow. Boundary layer control. Separation prevention by boundary layer suction, The origin of turbulence. Reynolds modification of the Navier-Stokes equations for trubulent flow. Reynolds equations and Reynolds stresses, PrandtPs mixing length theory. The universal velocity profile near a wall. Turbulent flow in pipes, Turbulent boundary layer over a smooth flat plate.

**Text Book:**

S. W. Yuan: Foundations of Fluid Mechanics, Prentice-Hall of India. Chapters: 8 (8.1 to 8.3, 8.7 to 8.8), 9, 10.

| Sub. Code: MATH E407 | Abstract Measure and Probability -II | |
|---|---|---|
| **Semester: IV** | **Credit: 4** | **Elective Course** |
| **Pre-requisites: Vector spaces, Integration and differentiation,** | | |
| **Course Outcome:**<br>➢ To know about Riemann and Lebesgue Integrals of different functions and probability measure on Rn. | | |

- To understand the convolution theory on Lp spaces.

**Unit-I** 10 hours

Integration of non-negative Functions, Integration of Borel Functions, Riemann and Lebesgue Integrals.

**Unit-II** 10 hours

Riesz Representation theorem, some Integral Inequality.

**Unit-III** 10 hours

Transition Measures and Fubinis theorem, convolution of probability measure on $R^n$ Lebesgue measure on $R^n$

**Unit-IV** 10 hours

Convolution Algebra $L1(R^n)$ approximation on Lp spaces with respect to Lebesgue Measure on $R^x$ , Elementary properties of Banach spaces, projections in Hilbert space, orthogonal squences.

**Text Book:**

K. R. Parthsarathy: Introduction to probability and measure, MacMillan Company. Chapters: 4 (except 4.30, 4.31), 5, 6 (6.40 to 6. 42).

| **Sub. Code: MATH AC409** | **Cultural Heritage of South Odisha** | |
|---|---|---|
| **Semester: IV** | **Credit: Nil** | **Non-Credits Course** |
| **Pre-requisites: Know about Kabi Samrat Upendra Bhanja along with the Arts, Culture and Folk Tradition of Ganjam.** | | |
| **Course Outcome:**<br>- To acquire a valuable understanding of the literary and cultural heritage of South Odisha.<br>- To promote the literature and culture of Odisha on a global scale. | | |

**Unit-I** 10 hours

Literary works of Kabi Samrat Upendra Bhanja

**Unit-II** 10 hours

Other Litterateurs of South Odisha.

**Unit-III** 10 hours

Cultural Heritage of South Odisha.

**Unit-IV** 10 hours

Folk and Tribal Traditions of South Odisha.

**Text Book:**

**Assessment and Expectations from Class:** Mentor-Mentees class, attendance, discipline, punctuality, doubt clearing class.

# Model Questions Paper:

**MA/M.Sc.-Math-**

**YEAR**

Time : 3 hours Full Marks: 70
Answer from both the Sections as per direction.
The figures in the right-hand margin indicate marks
(Paper: )

**SECTION –A**

1. Answer **all** questions from the following : 1×10
   (a)
   (b)
   (c)
   (d)
   (e)
   (f)
   (g)
   (h)
   (i)
   (j)

**SECTION -B**

Answer **all** questions : 15×4

2.
   (a)

   OR

   (b)
3.
   (a)

   OR

   (b)

4.

(a)

OR

(b)

5.

(a)

OR

(b)