

UNIVERSITY OF LUCKNOW
DEPARTMENT OF MATHEMATICS AND ASTRONOMY
SYLLABUS OF M.A./M.Sc. (MATHEMATICS) TWO YEAR PROGRAMME
(SESSION 2025-26 ONWARDS)

M.A./M.Sc. SEMESTER I

Core Course 1: Topology

Credit: 4

T:04

Course Outcomes:

1. Define and illustrate the concept of topological spaces and continuous functions,
2. Illustrate the concept of limit point, dense sets, interior, exterior, boundary points.
3. Identify and understand bases, sub-bases and different type of spaces like Lindelof, separable, and their properties.
4. Understand the concept of compact spaces, connected spaces, locally compact spaces & locally connected spaces.

Unit I

Countable and uncountable sets, Schroeder-Bernstein theorem, Cantor's Theorem, Cantor's Sets, Cantor's continuum hypothesis, Zorn's Lemma, Well ordering principle.

Unit II

Topological spaces: Definitions and Examples, open base and open subbase for a topology, Lindelof theorem, limit points, closure, interior; Continuous functions, Homeomorphisms; relative topology, Metric Topology, Product Topology, Weak topology, The function algebras $C(X, \mathbb{R})$ and $C(X, \mathbb{C})$.

Unit III

Compact spaces, Heine Borel theorem, product of spaces, Tychonoff theorem, generalized Heine Borel theorem, locally compact spaces, compactness for metric spaces, Ascoli's theorem.

Unit IV

Separation Axioms: T_1 and Hausdorff spaces, completely regular and normal spaces, Urysohn's lemma; Tietze extension theorem, Urysohn's imbedding theorem; Stone Cech compactification.

Unit V

Connected spaces, the components of a space, totally disconnected space, locally connected space.

References

Text Books:

1. G.F. Simmons: Introduction to Topology and Modern Analysis, Mc-Graw Hill Book Company.
2. J.R. Munkres: Topology - A first course, Prentice Hall India Pvt. Ltd.

Suggested Readings:

1. J.L. Kelley: General Topology. Van Nostrand. Reinhold Co, New York 1995

Web References:

Digital platforms web links: NPTEL/SWAYAM/ MOOCS/Openstax.org
<https://openlearninglibrary.mit.edu/courses>
<http://heecontent.upsdc.gov.in/SearchContent.aspx>
<https://www.lkouniv.ac.in/en/article/e-content-faculty-of-science>

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Core Course 2: Module Theory

Credit: 4

T:04

Course Outcomes:

1. Identify cyclic modules, simple modules, finitely generated modules etc.
2. Find a basis of a free module.
3. Use the basis to describe module homomorphisms.
4. Describe the structure of a finitely generated module over a PID.

Unit I

Modules: definition and examples, simple modules, submodules, module homomorphisms, quotient modules, torsion free and torsion modules.

Unit II

Direct sum of modules, exact sequences, short exact sequence, split exact sequences. Five lemma.

Unit III

Free modules, modules over division rings are free modules, invariant rank property.

Unit IV

Free modules over PIDs, invariant factor theorem for submodules, finitely generated modules over PID, chain of invariant ideals, fundamental structure theorem for finitely generated module over a PID.

Unit V

Projective and injective modules, divisible groups.

References:

Text Books:

1. V.Sahai and V. Bist: Algebra, Fourth Edition, Narosa.
2. I.B.S. Passi and I.S. Luther: Algebra, Volume 3 Modules, Narosa

Suggested Readings:

1. S. Lang: Algebra, Addison Wesley.

Web References:

Digital platforms web links: NPTEL/SWAYAM/ MOOCS/Openstax.org
<https://openlearninglibrary.mit.edu/courses>
<http://heecontent.upsdc.gov.in/SearchContent.aspx>
<https://www.lkouniv.ac.in/en/article/e-content-faculty-of-science>

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Core Course 3: Differential Geometry of Manifolds

Credit: 4

T:04

Course Outcomes:

1. Elaborate the concept of differentiable manifolds and their examples.
2. Clarify the concepts of vector fields, tangent vectors & tangent spaces in a manifold.
3. Apply various concepts of differential calculus to the settings of abstract set called manifold.
4. Use Riemannian metric on a given manifold to find the various types of curvatures with emphasis on the surface/ types of manifold.
5. Bring out different connections on Riemannian manifold and its properties.
6. Calculate curvature tensor & tensors of respective connections.

Unit I

Definition and examples of differentiable manifolds, tangent vectors, tangent spaces, vector fields and their examples, Jacobian map.

Unit II

Immersion and submersions, diffeomorphism and their examples, curve in a manifold, integral curves and their examples, distributions, hypersurface of \mathbb{R}^n , submanifolds.

Unit III

Standard connection on \mathbb{R}^n , covariant derivative, sphere map, Weingarten map, Gauss equation, Gauss curvature equation and Codazzi-Mainardi equations.

Unit IV

Invariant viewpoint, Cartan view point, coordinate view point, difference tensor of two connections, torsion and curvature tensors.

Unit V

Riemannian manifolds, length and distance in Riemannian manifolds, Riemannian connection and curvature, curves in Riemannian manifolds, submanifolds of Riemannian manifolds.

References:

Text Books:

1. N.J. Hicks: Notes on Differential Geometry, D. Van Nostrand, 1965.
2. U. C. De, A. A. Shaikh: Differential Geometry of Manifolds, Narosa Publishing House.

Suggested Readings:

1. Y. Matsushima: Differentiable Manifolds, Marcel Dekker, Inc. New York, 1972.

Web References:

Digital platforms web links: NPTEL/SWAYAM/ MOOCS/Openstax.org
<https://openlearninglibrary.mit.edu/courses>
<http://heecontent.upsdc.gov.in/SearchContent.aspx>
<https://www.lkouniv.ac.in/en/article/e-content-faculty-of-science>

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Core Course 4: Fluid Mechanics

Credit: 4

T:04

Course Outcomes:

1. Understand the concept of fluid and their classification, models and approaches to study the fluid flow.
2. Formulate mass and momentum conservation principle and obtain solution for non viscous flow.
3. Know potential theorems, minimum energy theorem and circulation theorem.
4. Understand two dimensional motion, circle theorem and Blasius theorem.

Unit I

Types of fluids, Continuum hypothesis, Lagrangian and Eulerian method of describing fluid motion, Motion of Fluid element: Translation, Rotation and Deformation. Stream lines, Path lines and streak lines. Material derivative. Acceleration of a fluid particle in Cartesian, Cylindrical Polar and Spherical Polar Coordinates. Vorticity Vector, Vortex Lines, Rotational and Irrotational motion of fluid, Rotational velocity, Velocity Potential, Boundary surface, Boundary condition.

Unit II

Reynold transport theorem. Principle of conservation of Mass-Equation of continuity (By Lagrangian and Eulerian method). Equation of Continuity in different coordinate systems. Body force and Surface force. Euler's equation of motion-conservation of momentum, Bernoulli's Equation, Energy Equation, Impulsive effects.

Unit III

Irrotational motion in two dimensions: Stream function, Physical significance of stream function, source, sink, Doublet and vortex, their images in two dimension. Complex Velocity Potential. Milne-Thompson circle theorem .

Unit IV

Vortex, Vortex motion, Image of Vortex, Kelvin Circulation Theorem, Complex potential due to row of Vortex, Kirchhoff vortex Theorem, Blasius Theorem and Kutta-Joukowski Theorem.

Unit V

Irrotational motion produced by motion of circular cylinders in an infinite mass of liquid, Liquid Streaming past circular cylinder, Kinetic energy of liquid, Motion of sphere through a liquid at rest at infinity. Liquid streaming past a fixed sphere, Axis-Symmetric flow, Stoke's function.

References:

Text Books:

1. F. Chorlton: Text Book of Fluid Dynamics, C.B.S. Publishers, Delhi.
2. Z.U.A. Warsi: Fluid Dynamics, Theoretical and Computational Approaches, CRC Press.
3. S.W. Yuan: Foundation of Fluid Mechanics, Prentice Hall of India Pvt. Ltd. New Delhi.
4. N. Curle and H.J. Davies: Modern fluid dynamics, Van Nostrand.

Suggested Readings:

1. G. K. Bachelor: An Introduction to Fluid Dynamics. Cambridge University Press. London.
2. R.W. Fox, P.J. Pritchard and A.T. McDonald: Introduction to Fluid Mechanics, Seventh Edition, John Wiley & Sons, 2009.

Web References:

Digital platforms web links: NPTEL/SWAYAM/ MOOCS/Openstax.org
<https://openlearninglibrary.mit.edu/courses>
<http://heecontent.upsdc.gov.in/SearchContent.aspx>
<https://www.lkouniv.ac.in/en/article/e-content-faculty-of-science>

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Core Course 5: Cryptography I

Credit: 2

T:02

Course Outcomes:

After the completion of the course, students are expected to have the ability of:

1. A broad theoretical background in cryptography.
2. Understanding of traditional ciphers and their cryptanalysis.
3. Understanding of working of modern stream and Block cipher.
4. Understanding of construction of finite fields.
5. Understanding of symmetric key cryptography.

Unit I

Definition of Cryptosystem, Symmetric cipher model, Mono and Poly alphabetic traditional Substitution ciphers e.g. Additive cipher, Caesar cipher, Playfair cipher, Hill cipher, one time pad, Vigenere cipher.

Unit II

Transposition ciphers, cryptanalysis of these traditional ciphers, Stream and block cipher definition, linear feedback shift register (LFSR).

Unit III

Modern stream cipher based on LFSR, RC-4 stream cipher and A5/1 stream cipher.

Unit IV

Modern Block cipher, Feistel cipher, Data encryption standard (DES) block cipher, S-box design of DES.

Unit V

Construction of finite fields, modular polynomial arithmetic, advance encryption standard (AES), block cipher, S-box design of AES, cryptographic properties of Boolean functions, vectorial Boolean functions.

Books Recommended:

1. Behrouz A. Forouzan: Cryptography and network security, Tata McGraw-Hill.
2. William Stallings: Cryptography and network security Principles and practices, Pearson Education.

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Value Added Credited Course (Intradepartmental): Mathematical Biology

Credit: 2

T:02

Course Outcomes:

After the completion of the course, students are expected to have the ability to:

1. Identify and explain the role of mathematics in the process of modelling in the field of natural and social sciences.
2. Apply the various growth models of population
3. Explain and apply the models of harvesting and mutualism

Unit I

Continuous population model for single species, exponential population growth model, continuous population growth model: Malthus model for population growth, general population growth model.

Unit II

Qualitative analysis: equilibrium points, stability analysis, logistic population growth model and their qualitative analysis, logistic growth model for non isolated population.

Unit III

Harvesting a single natural population, constant effort harvesting, constant yield harvesting.

Unit IV

Continuous models for interacting population: Interaction between species, two species models, definition of stability, community matrix approach, Competition: Lotka-Volterra models, competition in field experiments, competition for space.

Unit V

Predator-Prey interaction, Lotka-Volterra models, dynamics of simple Lotka-Volterra models.

Books Recommended:

1. J.D.Murray: Mathematical Biology, Springer-Verlag, Berlin.
2. A. Hasting: Population Biology Concepts and Models, Springer.
3. J. Mazumdar: An introduction to Mathematical Physiology and Biology, Cambridge University Press.
4. F. Brauer, C. Castillo-Chavez: Mathematical Models in Population Biology and Epidemiology, Springer, New York.

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M.A./M.Sc. SEMESTER II

Core Course 6: Functional Analysis

Credit: 4

T:04

Course Outcomes:

After the completion of the course, students are expected to have the ability to :

1. Apply Holder's and Minkowski's inequalities.
2. Construct conjugate of a linear operator.
3. Basic understanding of orthogonal and orthonormal sets.
4. Construct complete orthonormal basis from a given linearly independent set.
5. Describe the spectral theorem.

Unit I

Banach Spaces: the definition and some examples, continuous linear transformations, the Hahn Banach theorem.

Unit II

The natural imbedding of N in N^{**} , the open mapping theorem, the closed graph theorem, uniform boundedness theorem, the conjugate of an operator.

Unit III

Hilbert spaces: the definition and some simple properties, orthogonal complements, orthogonal sets, the conjugate space H^* .

Unit IV

The adjoint of an operator, self adjoint operators, normal and unitary operators, projections.

Unit V

Finite dimensional spectral theory: spectrum of an operator, the spectral theorem, uniqueness of spectral decomposition.

Books Recommended :

1. G. F. Simmons: Introduction to Topology & Modern Analysis, McGraw Hill.
2. V.B. Limaye: Functional Analysis, Wiley Eastern Ltd.

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Core Course 7: Riemannian Manifolds and Bundle Theory

Credit: 4

T:04

Course Outcomes:

1. Use Riemannian metric for studying various types of curvatures in a manifold and to calculate Ricci tensor & Ricci curvature.
2. Recognize whether a given manifold is Einstein or not.
3. Explain Levi-Civita connection, Koszul connection and other important connections which are used in manifolds.
4. Understand the concepts of tensors and forms.
5. Understand covariant derivative and contraction in manifolds.
6. Understand Lie groups and Lie algebras with examples.
7. Explain the idea of principal fibre bundle, linear fibre bundle and the relation between them.

Unit I

Sectional curvature, Schur's theorem, Riemannian manifold, geodesic in a Riemannian manifold, projective curvature tensor, concircular curvature tensor, conformal curvature tensor, conharmonic curvature tensor, Einstein manifolds.

Unit II

Levi-Civita connection, linear connection, semi-symmetric connection, quarter symmetric connection, Koszul formula, Ricci identity.

Unit III

Tensors and forms, exterior derivative, contraction, Lie derivative, general covariant derivative.

Unit IV

Lie groups and Lie algebras with examples, homomorphism, isomorphism, one parameter subgroups and exponential map, Lie transformation group.

Unit V

Principal fibre bundle, linear frame bundle, associated bundles, tangent bundle.

Books Recommended:

1. N.J. Hicks: Notes on Differential Geometry, D. Van Nostrand, 1965.
2. B.B. Sinha: An introduction to Modern Differential Geometry, Kalyani Publishers
3. U. C. De, A. A. Shaikh: Differential Geometry of Manifolds, Narosa Publishing House.

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Core Course 8: Advanced Fluid Mechanics

Credit: 4

T:04

Course Outcomes:

1. Understand the concept of fluid and their classification, models and approaches to study the fluid flow.
2. Formulate mass and momentum conservation principle and obtain solution for non- viscous flow.
3. Understand two dimensional motion, circle theorem and Blasius theorem.
4. Understand the concept of stress and strain in viscous flow and to derive Navier-Stokes equations of motion and solve some exactly solvable problems.

Unit I

Newton's law of viscosity, nature of stress, stress components in real fluid, symmetry of stress tensor. Transformation of stress components. Stress invariants, Principal Stresses, Nature of Strain, Rates of strain components, transformation of rate of strain components, Rate of Strain Quadric, Relation between Stress and rate of Strain, Boundary conditions for viscous fluid.

Unit II

Navier-Stokes equation of motion-Conservation of momentum, Navier-Stokes equations in orthogonal coordinate systems (particularly in Cartesian, cylindrical and spherical coordinate systems), Energy Equation- Conservation of Energy, Energy dissipation function, Energy dissipation due to viscosity, Diffusion of vorticity.

Unit III

Plane Poiseuille and Couette flows between two parallel plates, Steady viscous flow through tubes of uniform cross-section in form of circle, ellipse and equilateral triangle under constant pressure gradient. Flow between two co-axial cylinders and concentric spheres, unsteady viscous flow over a flat plate.

Unit IV

Dynamical similarity, Reynolds number, slow viscous flow, Stoke's flow. Solution of Stokes equations, uniform flow past a sphere at low Reynolds number, torque and drag on a sphere due to a uniform flow. Flow past a circular cylinder, Stokes paradox.

Unit V:

Prandtl's boundary layer concept, boundary layer thickness- displacement, momentum of energy. momentum and energy integrals, condition for separation, boundary layer flow along a semi-infinite plate in a uniform stream, Blasius solution. Integral Theorem.

Books Recommended:

1. G. K. Batchelor: An Introduction to Fluid Dynamics, Cambridge University Press
2. F. Chorlton: Text Book of Fluid Dynamics, C.B.S. Publishers, New Delhi.
3. Z.U.A. Warsi: Fluid Dynamics, Theoretical and Computational approaches, C.R.C. Press
4. S.W. Yuan: Foundation of Fluid Mechanics, Prentice Hall of India Pvt. Ltd., New Delhi
5. L. Rosenhead: Laminar Boundary layer, Oxford Press
6. R.W. Fox, P.J. Pritchard and A.T. McDonald: Introduction to Fluid Mechanics, Seventh Edition, John Wiley & Sons, 2009
7. J. Happel and H. Brenner: Low Reynolds Number Hydrodynamics with Special Applications to Particulate Media, Prentice-Hall, Inc. 1965

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Core Course 9: Approximation Theory

Credit: 4

T:04

Course Outcomes:

After the completion of the course, students are expected to have the ability to:

1. Understand the concepts of interpolation processes, finite element methods etc.
2. Apply the knowledge of the theory, in research on this area.
3. Use the Weierstrass Approximation theorem, first lacunary interpolation i.e., (0, 2) interpolation and spline interpolation.

Unit I

Different types of approximations, Weierstrass approximation theorem, monotone operators, Markoff inequality, Bernstein inequality.

Unit II

Hermite and HF interpolation, Fejérs theorem for HF interpolation, Lobatto and Radau quadrature formulas, (0, 2)-interpolation on the nodes of $\pi_n(x)$, existence, uniqueness.

Unit III

Explicit representation of (0,2) interpolation, existence, uniqueness and explicit representation of Pál type (0;1) interpolation on the zeroes of $\pi_n(x)$.

Unit IV

Erdős-Túran Theorem, Jackson's theorems (I to V), Dini-Lipschitz theorem, converse of Jackson's theorem, Bernstein theorems (I, II, III), Zygmund theorem.

Unit V

Spline interpolation, existence, uniqueness, explicit representation of cubic splines, certain extremal properties and uniform approximation.

Books Recommended:

1. T.J. Rivlin: An Introduction to the Approximation of Functions, Dover Publications, NY.
2. E. W. Cheney: Introduction to Approximation Theory, McGraw-Hill Book Company.
3. A. Ralston: A First Course in Numerical Analysis, McGraw-Hill Book Company.

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Core Course 10: Cryptography II

Credit: 2

T:02

Course Outcomes:

After the completion of the course, students are expected to have the ability of:

1. A broad theoretical background in cryptography.
2. Understanding of Public key cryptography (PKC).
3. Understanding of some methods PKC.
4. Understanding of digital signature.
5. Understanding of Elliptic curves and Elliptic curve cryptography.
6. Understanding of some modern factorization methods and discrete log finding methods.

Unit I

Public key cryptosystem (PKC) or asymmetric cryptography, design of PKC e.g one way function and trapdoor function.

Unit II

Discrete logarithm, discrete log problem (DLP), Diffie Hellman key exchange, RSA cryptosystem, Rabin cryptosystem, ElGamal encryption.

Unit III

Message integrity, Hash function, cryptographic hash function, Hash function based on block ciphers

Unit IV

Message authentication, Message authentication codes (MAC), digital signature, RSA digital signature scheme, ElGamal digital signature scheme.

Unit V

Elliptic curves, Elliptic curve arithmetic, Elliptic curve cryptography, some modern factorization techniques e.g. $p-1$ method, quadratic sieve, number field sieve, some techniques of finding discrete logarithm: Shanks Baby step Giant step algorithm, Pollard rho algorithm, Pohlig-Hellman algorithm.

Books Recommended:

1. Behrouz A. Forouzan: Cryptography and network security, Tata McGraw-Hill.
2. W. Stallings: Cryptography and network security Principles and practices, Pearson Education.

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Interdepartmental Course A: Astronomy & Astrophysics

Credit: 2

T:02

Course Outcomes:

After the completion of the course, students are expected to have the ability to:

1. Use Celestial Coordinates system to specify the positions of stars, planets, satellites, galaxies and other celestial objects in three dimensional space
2. Explore the parent star Sun and its importance for sustaining life on the earth
3. Show familiarity with techniques to explore the solar surface temperature
4. Understand the solar atmosphere and its effect on the Earth and other planets
5. Understand the origin of the solar system
6. Explore the Terrestrial, Jovian & Dwarf planets, Comets and Meteoroids.
7. Describe the formation and evolution of stars which is a key research field for all major questions in astrophysics and cosmology
8. Illustrate Hertzsprung-Russell Diagram which is a graphical tool that astronomers use to classify stars according to their luminosity, spectral type, color, temperature and evolutionary stage
9. Plot the stars on the H-R diagram according to their temperatures, spectral classes, and luminosity by which astronomers can classify stars into their different types
10. Show understanding about the Binary star systems which are very important in astrophysics because calculations of their orbits allow the masses of their component stars to be directly determined, that in turn allows other stellar parameters, such as radius and density, to be indirectly estimated
11. Describe that the Galaxies are organized clusters of billions of stars, gas, dust, and matter in all other forms, all bound by the force of gravity
12. Provide details about their Milky Way, the galaxy containing our universe

Unit I: Celestial sphere

Constellations and nomenclatures of stars, The cardinal points and circles on the celestial sphere, Coordinate system, Equatorial, Ecliptic system, Hour angle, Twilight, Spherical triangle, Polar triangle and related problems.

Unit II: The Sun and Planets

Sun: Interior structure of the Sun, atmosphere, solar activity, sunspots and magnetic field, solar wind.

Planets: Study of Terrestrial planets, Jovian planets- their surface features & atmospheres. Tidal forces, Roche limit.

Dwarf planets: Definitions and locations.

Debris of the Solar system: Comets, Asteroids, Meteoroids.

Unit III: Stellar Structure and Evolution

Stars: Magnitude scales, Colour index, Basic of star formation and evolution. Hertzsprung-Russell (HR) diagram, Spectral classification, Energy generation of stars.

Basics of degenerate remnants of stars: White dwarfs, Neutron stars, Pulsars, Black Holes, Chandrasekhar limit.

Unit IV: High Energy Astrophysics

Observational tools: Blackbody radiation, Specific intensity and flux density, Stellar parallax.

Formation & Structure of spectral lines, Radiative transfer.

Radiative processes in Astrophysics: Synchrotron emission, Energy loss and electron spectrum, Compton scattering, Bremsstrahlung, Thermal bremsstrahlung.

Binary stars: Classification, Accretion disks in binaries, Hulse-Taylor binary pulsar.

Unit V: The Milky way galaxy and Galaxies beyond

What are Galaxies & its types, The Milky Way Galaxy: Structure, Mass, Size. Hubble's Classification, Formation of galaxies.

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Books recommended:

1. W. M. Smart, Textbook on Spherical Astronomy, Cambridge University Press.
2. I. Todhunter, Spherical trigonometry, The Macmillan company, London.
3. B. W. Carroll and D. A. Ostlie, Modern Astrophysics, Addison-Wesley Publishing Co.
4. Eric Chaisson & Steve Macmillan, Astronomy Today, Prentice Hall, New Jersey.
5. John D Fix, Astronomy-Journey to the Cosmic Frontier, Mosby, New York.
6. B. Basu, T. Chattopadhyay & S.N. Biswas, AN Introduction to Astrophysics.
7. M. Zeilik and S. A. Gregory Introductory Astronomy & Astrophysics, 4th Edition, Saunders College Publishing.
8. T. Padmanabhan, Theoretical Astrophysics, Vol. I: Astrophysical Processes, Cambridge University Press
9. T. Padmanabhan, Theoretical Astrophysics, Vol. II: Stars and Stellar Systems, Cambridge University Press.
10. F. Shu, Mill Valley, The Physical Universe: An Introduction to Astronomy, University Science Books.
11. V. B. Bhatia, Textbook of Astronomy and Astrophysics with Elements of Cosmology, Pub-New Delhi, Narosa Publishing House.

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Interdepartmental Course B: Mathematics in Computer Design

Credit: 2

T:02

Course Outcomes:

After the completion of the course, students are expected to have the ability to :

1. Show familiarity with the awareness and understanding of day-to-day applications of mathematics specially in computer sciences
2. Possess insights related to computer's hardware and software design

Unit I

Preliminary concepts of mathematical functions and relations.

Unit II

Number theory and study of residues, different types of number systems: binary, octal and hexa number systems, conversions from one number system to another.

Unit III

Matrices: Solution of system of simultaneous linear equations, Eigen values and Eigen vectors.

Unit IV

Applications in computer hardware design, circuit design using universal gates.

Unit V

Elementary applications in software design, software design tools, syntax analyzers, processing of natural languages.

Books Recommended:

1. G.E. Andrews, Number Theory, Hindustan Publ. Corp., Delhi
2. M Morris Mano, Digital logic and Computer Design, Pearson.
3. F. Ayres, Matrices, Schaum Outline Series, Mc Graw Hill Book Co.
4. Introduction of Theory of Computation, Sipser, Michael, PWS Publishing
5. D. E. Knuth: The Art of Computer Programming, Addison Wesley.
6. R. P. Gabriel: Patterns of Software, Oxford University Press.