

## Faculty of Science

### Master of Computer Science and Applications (MCA)

#### PHYSICS

**Mechanics :** *Concept of inertial and non-inertial frames of reference, fictitious forces, conservative and non-conservative forces. System of particles: Centre of mass for a system of particles, motion of the centre of mass, Expressions for kinetic energy, linear momentum and angular momentum for a system of particles in terms of centre of mass values. Central forces and the law of conservation of angular momentum.*

Rotational Motion: Transformation equations for a frame of reference rotating with respect to an inertial frame of reference, Coriolis force. Rotation of a rigid body: Energy and moment of inertia and moment of inertia as a tensor, principal axes, angular momentum and kinetic energy of rotation with respect to principal axis, moment of inertia for a spherical shell and solid sphere, rolling bodies. Central force, Kepler's laws.

**Special Relativity:** Postulates of special theory of relativity, Lorentz transformations, velocity addition, length contraction and time dilation, variation of mass with velocity, relativistic form of Newton's second law, equivalence of mass and energy, relativistic transformations of momentum and energy.

**Electricity and Magnetism :** Gauss's law, Dielectrics, polarization of dielectrics, Poisson and Laplace's equations in dielectric, polarizability, Clausius-Mossotti relation. Capacitors. Continuity equation, transient currents, growth and decay of d.c. in LCR circuits, Thevenin's theorem, superposition theorem and maximum power transfer theorem. Alternating currents: LCR circuit, series resonance, sharpness of resonance and Q-factor, power in AC circuits.

**Optics:** Fermat's principle and its applications. Chromatic and spherical aberrations, removal. Coma, astigmatism, curvature of the field, distortion. Interference of light waves, coherence. Fresnel's biprism. Newton's rings. Michelson's interferometer. Polarization of light waves. Production of polarized light. Brewster's law, Malus' law. Double refraction. Quarter and half wave plates. Analysis of polarized light. Fraunhofer diffraction: Fraunhofer diffraction at two and N slits, diffraction grating, grating spectrum, Rayleigh criterion of resolution, resolving power of grating.

**Electronics :** BJT Amplifier;  $\alpha$ ,  $\beta$  and their relation, hybrid parameters. Characteristics of their simple circuits, load line, Q-point and its change due to temperature variation. BJT biasing: fixed biasing, self-bias, stability factor. RC coupled amplifier, its frequency response characteristics. Feedback in amplifiers, advantages of negative feedback amplifier. Positive feedback and Barkhausen criterion for oscillations, circuit diagrams and working for RC phase-shift, Wein's bridge oscillators. RC differentiator and integrator.

**Mathematical Method** :Cauchy's integral theorem, Cauchy's integral formula, Taylor and Laurent series, Cauchy's residue theorem, Gradient, divergence and curl. Gauss's theorem, Green's theorem, Stoke's theorem.

Legendre function: The polynomial solution of the Legendre equation, the Legendre function of the second kind, the generating function, upper bound for  $\frac{1}{2}P_n(x)^{1/2}$ , Rodrigues' formula, orthogonality relation. Associated Legendre functions and its orthogonality property. Laguerre functions.

### **Modern Physics :**

Black body radiation experiment and Planck's hypothesis, Photoelectric effect, Compton effect, Wave function and its simple properties.

Alpha-particle scattering experiment, Rutherford's model of atom; Bohr model, energy levels hydrogen spectrum.

Composition and size of nucleus, atomic masses.

Radioactivity – alpha, beta and gamma particles and their properties, Mass-energy relation, mass defect; binding energy per nucleon and its variation with mass number; nuclear fission, nuclear reactor, nuclear fusion.

Basic principle of a LASER, Properties of laser beam.

Crystalline and amorphous structure: Lattice, basis, primitive cell, unit cell, Bravais Lattices, common crystal structures, Bragg's law.

## **MATHEMATICS**

### **Calculus**

Successive differentiation: Derivatives of higher order, nth derivative of well-known functions, Leibnitz's theorem (without proof). Expansion of functions, Maclaurin's theorem and Taylor's theorem (without proof), Indeterminate forms:  $\frac{0}{0}$ ,  $\frac{\infty}{\infty}$ ,  $0 \times \infty$ ,  $\infty - \infty$ , and  $0^0$ ,  $1^\infty$ ,  $\infty^0$ . Asymptotes of the algebraic curves, parallel asymptotes, Asymptotes parallel to x-axis and y-axis.

Curvature: Angle between radius vector and tangent, derivative of arc length in cartesian, parametric and polar form, Calculation of curvature in cartesian, parametric and polar form. Radius of curvature in the three forms, Multiple points, convexity and concavity of a curve, points of inflexion, Tracing of cartesian curves, Idea of some well known polar curves, Functions of two or more variables, partial differential coefficients, Homogeneous functions, Euler's theorem on homogeneous functions.

Gamma functions, Integration of the type  $\int_0^{\frac{\pi}{2}} \sin^m x \cos^n x \, dx$ , Length of curves for cartesian, parametric and polar equations, Intrinsic equation from cartesian, parametric and polar equations, Volume and Surfaces of solids of revolution of cartesian, parametric and polar curves.

## Geometry

General Equations, pair of straight line through origin, lines joining the origin to the intersection of a curve and a line. The conic section, Equation to a conic section. Intersection of a straight line and a conic. Equation of a tangent to a conic, Condition of tangency. Pair of tangents from a point.

Chord of contact of a pair of tangents to a conic. Pole and polar, Conjugate points. Conjugate lines. The condition of conjugacy. Chord with a given middle point. Centre of a conic and diameter. Equation of the conic when the origin is transferred to the centre. Conjugate diameters.

Change of rectangular axes without change of origin. Removal of  $xy$ -term. Invariants. Nature of conic, Summary. Tracing of Parabola, The asymptotes of hyperbola. Conjugate hyperbola. Asymptotes. The length and position of axes. Coordinate of foci.

Polar equation of a conic when focus is at the pole. Directrices, Tracing of the conic  $\frac{l}{r} = 1 + e \cos \theta$ . Equation of the Chord when the vectorial angles of the extremities are given. Equation of the tangent at the point whose vectorial angle is  $\alpha$ . Normal, Polar. Direction cosines of a line. Projection of a segment. Angles between two lines. Distance of a point from a line. Equation of a plane. Length of perpendicular from a point to a plane. Cylinder and its Equation. Right circular cylinder. Equation of a right circular cylinder.

Equation of a cone. Equation of a cone when the vertex is at the origin. Condition for general equation of second degree to represent a cone. Tangent plane to a cone, A property of the tangent plane to a cone. Condition of tangency. Reciprocal cone. Cone with three mutually perpendicular generators, Number of mutually perpendicular generators.

The standard equation of central conicoids. The tangent plane. Condition of tangency of a plane. Section with a given centre. Locus of the mid-points of a system of parallel chords. The Polar plane, Polar lines. Enveloping cone.

Classification of central conicoids. The Normal. Normals from given point. Conjugate diametral plane and diameters of Ellipsoid. Paraboloid (elliptic and hyperbolic). Tangent plane to a paraboloid.

## Numerical Analysis

Absolute, relative and percentage errors, General error formula, Error in series approximation, Solution of algebraic and transcendental equations, The bisection and Regula-falsi method, Iteration methods namely, Newton-Raphson method, Generalized Newton's method, Solution of system of linear equations using direct methods such as matrix inversion, Gauss elimination and LU decomposition including some iteration methods namely, Jacobi and Gauss-Siedel methods, The algebraic eigen value problems using iterative and Householder methods.

Symbols of  $\Delta$ ,  $\tilde{N}$ ,  $E$ ,  $E^{-1}$ ,  $D$ ,  $m$  and  $d$  and their relations, Newton-Gregory Forward and Backward difference formulae, Gauss's, Stirling's and Bessel's formulae, Lagrange's

formula, Divided Differences and their properties, Newton's general interpolation formula, Inverse interpolation formula and Interpolation with cubic splines.

Numerical Differentiation and Integration, Numerical differentiation of tabular and non-tabular functions including error estimations, Numerical integration using Gauss quadrature formulae, Trapezoidal, Simpson's 1/3- and 3/8-Rule, Weddle's Rule and Newton-Cotes Formula including error estimation, Curve fitting and approximations, Least squares curve fitting procedures, Different types of approximations, Least squares polynomial approximation, Chebyshev polynomials and its application in various approximations.

Ordinary differential equations, Euler's and modified Euler's methods, Picard's method, Taylor series method, Runge-Kutta methods of 2<sup>nd</sup> and 4<sup>th</sup> order, Multi-step methods, Milne-Simpson method, Adam Bashforth-Moulton method, Boundary value problems using Finite Difference method.

## **Differential Equations**

Exact differential equations. Integrating factors. Total differential equations. Differential equations of first order but not of first degree. Equations solvable for  $p$ ,  $y$  and  $x$ . Clairaut's equations. Linear differential equations of order  $n$ . Homogeneous and non-homogeneous differential equations of order  $n$  with constant coefficients. Complementary functions. Different forms of particular integrals. Linear differential equations with non-constant coefficients. Reduction of order method.

The Cauchy-Euler's equation of order  $n$ . The Legendre's linear equation. Methods of undetermined coefficients and variation of parameters. Series solution of differential equations. Frobenius method. Different cases.

Bessel, Legendre and hypergeometric differential equations and their solutions. Simultaneous total differential equations. Equations of the form  $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$ . Methods of grouping and multipliers. Solution of a system of linear differential equation with constant coefficients. An equivalent triangular system. Degenerate case.

Laplace transforms. Linearity of Laplace transforms. First shifting property. Table of Laplace transforms. Inverse Laplace transforms. Laplace transform of derivative and integrals. Unit step function and its Laplace transform. Second shifting property. Unit impulsive function and its Laplace transform. Convolution and periodic function theorems. Solution of linear differential equations with constant coefficients using Laplace transform methods.

Formation and solution of a partial differential equations. Equations easily integrable. Linear partial differential equations of first order. Non-linear partial differential equation of first order and their different forms. Charpit's method.

Homogeneous linear partial differential equations with constant coefficients. Different cases for complimentary functions and particular integrals. Non-homogeneous partial differential equations with constant coefficients. Classification of second order linear partial differential equations.

Method of separation of variables. Fourier series. Even and odd functions and their Fourier series. Change of interval. Vibration of stretched string. One and two dimensional heat flow. Solution of Laplace equation in Cartesian and polar co-ordinates.

Variation of a functional. Variational problems. Euler's equations and its various cases. External. Functional depending on  $n$  unknown functions, Functionals depending on higher derivatives. Variational problems in parametric form. Isoperimetric problem. Canonical form of Euler's equation. Functionals depending on functions of several independent variables. Ostrogradsky's equation.

### **Advanced Calculus**

Functions of several variables, Contour lines, Level curves and level surfaces, Limits and continuity for functions of two and more variables, Partial derivatives, Partial derivatives and continuity, Differentiability, The chain rule for functions of two and three variables.

Directional derivatives, Gradient vectors, Tangent planes, Linearization and differentials, Extreme values and saddle points, Local and absolute maxima / minima, The method of Lagrange multipliers (with one constraint only), Taylor's series for function of two variables, Partial derivatives with constrained variables.

Double integral over a rectangle region, Double integral as volume, Double integral over non rectangular regions, Fubini's Theorem, Area of a region in a plane, Transformation of double integral from Cartesian to polar co-ordinates and vice-versa, Spherical and cylindrical co-ordinates, Triple integral in Cartesian, Cylindrical and spherical co-ordinates.

Line integral, Gradient field, Green's Theorem in a plane, Evaluation of line integral using Green's Theorem, Surface Area, Surface integral, Stokes Theorem.

### **Algebra**

Binary operations, definitions of Group, Ring and Field with examples, vector spaces, subspaces, span of a set, sum of subspaces, linear dependence and independence, dimension and basis, coordinates of a vector relative to the ordered basis, dimension theorem.

Linear transformation and its properties, range and kernel of a linear transformation, rank and nullity of linear transformation, rank-nullity theorem, inverse of linear transformation.

The vector space  $L(U,V)$  and its dimension, composition of linear transformations, matrix associated with a linear transformation, linear transformation associated with a matrix, matrix as a linear transformation and its rank and nullity.

Elementary row operations and row- reduced echelon form, inverse of a matrix through elementary row operation, solution of a system of linear equations, eigen-values, eigen-vectors.

## **Statistics**

**Descriptive Statistics** : Measures of central tendency, Dispersion, Skewness and Kurtosis, Scatter diagram, Correlation coefficient, Rank correlation, Spearman's and Kendall's measures, Multiple correlations in three variables, Partial correlation in three variables, Regression lines, Regression coefficient and Principle of least squares and curve fitting.

**Probability Theory** : Definition of probability, Discrete and Continuous sample space, Events, Independent and Mutually Exclusive Events, Random Experiment, Conditional Probability, Baye's theorem and its application, Random Variables, mathematical expectation, Chebyshev's inequality.

**Probability Distributions** : Uniform, Binomial, Poisson, Geometric, Hypergeometric, Normal Exponential Gamma and Beta Distribution, their means, variances and other properties

**Sampling Theory** : Concept of population and sampling, Census and sample survey, random sample, sample size, Non-sampling errors, Concept of bias and standard error of an estimate, sampling distributions, Tests of significance based on t, chi-square and F tests.

**Statistical Inference** : Requirements of a good estimator, Methods of estimation (MLE and method of moments), Interval Estimation. Testing of hypothesis, simple and composite hypothesis, Errors of first and second type and critical region.

**Design of Experiments and LPP** : ANOVA for one way and two way classifications, Principles of Design of Experiments, CRD, RBD and LSD, General LPP, Graphical and Simplex Method of Solving LPP.

## **Computer Science**

**FUNDAMENTALS & Information Technology and Information Systems :** Recent IT tools and technologies, SDLC, ERD and System Design Principles.

**COMPUTER ARCHITECTURE :** Number System, Integer and Floating Point representations, Addition and subtraction of signed and unsigned numbers, Multiplication and division of signed and unsigned numbers, CISC and RISC characteristics, Cache memory – Organization and Structure, Cache mapping algorithms, Cache replacement policies, Input / Output techniques.

**PROGRAMMING CONCEPT :** C, C++, Java, arithmetic, logical bitwise and conditional operators, Data, Expressions, Statements, Control Flow, iteration, Functions, Lists, Tuples, Dictionaries, Files, Modules, Packages, Object oriented programming concepts.

**DATA STRUCTURES AND ALGORITHMS :** Arrays, stacks, queues, linked lists, trees, binary search trees, binary heaps, graphs, searching, sorting, time and space complexity, algorithm design techniques: greedy, dynamic programming and divide-and-conquer, linear search, binary search.

**OPERATING SYSTEM :** Operating System and its function, Instruction Execution, Interrupts, Memory Management, Scheduling, etc. Case study of Linux / Unix OS.

**DATABASE MANAGEMENT SYSTEM :** Database Systems Concepts & Architecture, Data Models, Schemas & Instances, DBMS Architecture & Data Independence, Database Languages & Interfaces, Data modeling using the Entity-Relationship Approach, Relational Database Design: Functional Dependencies & Normalization for Relational Databases, Functional Dependencies, Normal forms based on primary keys (1NF, 2NF, 3NF & BCNF), Loss less join & Dependency preserving decomposition, SQL, PL-SQL, Database Security.

**DATA COMMUNICATION AND COMPUTER NETWORKS :** Fundamentals of Data Communication and Networks; Network models : OSI Model, Peer-to-peer processes, Interfaces, Layers in OSI model, TCP / IP model-Architecture, Layers in TCP / IP model, Similarities; Addressing: Physical, logical and port addressing. Signals: Analog and digital signals : Digital-to-Digital conversion: Line coding schemes; Analog-to-Digital conversion: Modulation and demodulation; Multiplexing; Wired Media : Magnetic media, Twisted wire-pair, Co-axial Cable, Fiber optics; Wireless media: Infrared, Radio and Microwave Transmission; Satellite Communication: Orbits, Footprints, GEO, MEO and LEO; Error detection and correction; LAN technologies; Network Security, Information Security and Web Security.

**TEST PAPER DETAILS :** There shall be one objective type of paper of 100 marks comprising 100 Questions with the following breakup:

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|-----------------------------|---|-------------|
| a) Mathematics & Statistics | : | 30 Question |
| b) Physics                  | : | 20 Question |
| c) Computer Science         | : | 50 Question |