Mathematics Syllabus for BS / BSC / Masters / MPhil

Instructions:

The objective of "Champion of Subject" is to test the conceptual abilities of the students and candidates regarding the subject.

- This is the comprehensive syllabus for the "Champion of Subject".
- Candidates are advised to thoroughly go through and study the syllabus
- The test will comprise of 120 MCQs.
- The time allowed for the test will be 120 min.
- MCQs will cover part or all the syllabus mentioned below.
- Munzill reserved the right to conduct an online or physical test.

Preliminaries:

- Real numbers and the real line
- Functions and their graphs
- Shifting and scaling graphs
- The solution of equations involving absolute values
- Inequalities

Limit and Continuity:

- Limit of a function
- left hand and right-hand limits.
- Theorems of limits
- Continuity & Continuous functions

Derivatives and its Applications:

- Differentiable functions
- Differentiation of polynomial, rational and transcendental functions
- Mean value theorems and applications
- Higher derivatives, Leibniz's theorem
- L'Hospitals Rule
- Intermediate value theorem, Rolle's theorem
- Taylor's and Maclaurin's theorem with their remainders

Integration and Definite Integrals:

- Techniques of evaluating indefinite integrals
- Integration by substitutions, Integration by parts. Integration by partial fractions

- Change of variable in indefinite integrals
- Definite integrals, Fundamental theorem of calculus
- Reduction formulas for algebraic and trigonometric integrands
- Improper integrals, Gamma functions
- Numerical integration

Plane Analytic Geometry:

- Conic section and quadratic equations
- Classifying conic section by eccentricity
- Translation and rotation of the axis
- Properties of circle, parabola, ellipse, hyperbola
- Polar coordinates, conic sections inpolar coordinates
- Graphing in polar coordinates
- Tangents and normal, pedal equations, parametric representations of curves

Applications of Integration:

- Asymptotes.
- Relative extrema, points of inflection and concavity
- Singular, points, tangents at the origin Graphing of Cartesian and polar curves
- Area under the curve, area between two curves
- Arc length and intrinsic equations
- Curvature, radius and centre of curvature
- Involute and evolute, envelope

Analytic Geometry of Three Dimensions:

- Rectangular coordinates system in a space
- Cylindrical and spherical coordinate system
- Direction ratios and direction cosines of a line
- Equation of straight lines and planes in three dimensions
- The shortest distance between skew lines
- Equation of sphere, cylinder, cone, ellipsoids, paraboloids, hyperboloids
- Quadric and ruled surfaces
- Spherical trigonometry, Direction of Qibla

Matrices, Determinants and System of Linear Equations

- Definition of the matrix, various types of matrices
- Algebra of matrices
- The determinant of square matrix, cofactors and minors

- Laplace expansion of determinants
- Elementary matrices, Adjoint and inverses of matrices
- Rank of a matrix
- Introduction to systems of linear equations
- Cramer's rule, Gaussian elimination and Gauss Jordan method
- Solution of homogenous and non-homogenous linear equations
- Net workflow problems

Vector Spaces
- Real vector spaces, subspaces
- Linear combination and spanning set.
- Linear independence and linear dependence, basis and dimension, row space, Column space and Null space

Linear Transformations
- Introduction to linear transformation
- Matrices of linear transformations
- Rank and nullity

Inner Product Spaces
- Inner product and norm
- Cauchy Schwarz inequality
- Norm of a vector, triangle inequality
- Parallelogram identity
- Orthonormal sets and basis 189
- The Gram-Schmidt process
- Eigen values and Eigen vectors
- Diagonalization, Orthogonal diagonalization
- Orthogonal matrices, similar matrices

Introduction to Differential Equations
- Historical background and motivation
- Basic mathematical models: Directional fields
- Classification of differential equations
- Formation of differential equation

First Order Differential Equations
- Modeling with first order differential equations

- Applications of first order ODEs in problems of decay and growth, population dynamics, logistic equation
- Separable equations
- Homogeneous and non-homogeneous equations
- Linear and nonlinear equations
- Exact and non-exact equations and integrating factors
- Orthogonal trajectory, Bernoulli, Ricatti, Clairaut's equations

Second-Order Differential Equations
- Homogenous equations
- Homogenous equations with constant coefficients
- Fundamental solutions of linear homogenous equations
- Operator method, Method of undetermined coefficients
- Cauchy Euler's equation
- Linear independence and the Wronski
- Variation of parameters, reduction of order
- Applications to mechanical and electrical systems

Higher-Order Linear Differential Equations
- General theory of nth order linear differential equations
- Homogenous equations with constant coefficients
- The methods of undermined coefficients
- The method of variation of parameters

Power Series Solution of Second Order Linear Differential Equations and Laplace Transforms
- Power Series solution near an ordinary point, Legendr's equation
- Regular singular points, Series solution near a regular singular point 190
- Laplace transform, inverse Laplace transform
- Applications of Laplace transforms to solve ODEs

Vectors:
- Introduction to vector algebra
- Scalar and vector product
- Scalar triple product and vector triple product
- Applications to geometry
- Vector equation of a line and plane
- Limit, continuity and differentiability of vector point functions

- Partial derivatives of vector point functions
- Scalar and vector fields
- The gradient, divergence and curl Expansion formulas.

Forces:
- Fundamental concepts and principles
- Inertial-non-inertial frames, Newton's laws
- Resultant of several concurrent forces
- The parallelogram law of forces
- Resolution of a forces, triangle of forces
- Lamy's theorem, polygon of forces
- Conditions of equilibrium for a particle
- External and internal forces, principle of transmissibility
- Resultant of like and unlike parallel forces
- Moment of forces about a point, Varigon's theorem
- Moment of a couple, equivalent couples, the composition of couples
- Reduction of coplanar forces to a force or a couple

Friction:
- Dry friction and fluid friction
- Laws of dry friction, coefficients of friction, angle of friction
- Equilibrium of a particle on a rough inclined plane
- Particle on a rough inclined plane acted on by an external force
- Conditions for sliding or titling

Virtual Work:
- Principle of virtual work
- Problems involving tensions and thrust

Centre of Mass and Gravity:
- Discrete and continuous systems, density of rigid and elastic bodies
- Centroid: Discrete and continuous systems, solid region, region bounded by planes
- Semi circular regions, sphere, hemisphere, cylinder and cone

Kinematics:
- Rectilinear motion of particles
- Uniform rectilinear motion, uniformly accelerated rectilinear motion

- The curvilinear motion of the particle, rectangular components of velocity and acceleration
- Tangential and normal components
- Radial and transverse components

Projectile motion:
- Motion of a Projectile, Trajectory
- Range of projectile, Time of flight, height of projectile
- Vertical motion and motion on inclined plane

Kinetics:
- Work, power, kinetic energy, conservative force fields
- Conservation of energy, impulse, torque
- Conservation of linear ad angular momentum
- Non-conservative forces

Simple Harmonic Motion
- The simple harmonic oscillator, amplitude, period, frequency,
- Resonance and energy
- The damped harmonic oscillator, overdamped, critically damped and underdamped
- Motion, forces vibrations

Central Forces and Planetary Motion
- Central force fields, equations of motion, potential energy, orbits
- Kepler's laws of planetary motion
- Apsidal distance and apsidal angles for nearly circular orbits
- Motion in an inverse square field

Collisions of particles:
- Laboratory and centre of mass frames of reference
- Elastic and inelastic collisions
- impulse and momentum Motion in a circle and on other curves

Complex Numbers
- Complex Numbers and their properties
- Polar form, argand diagram, separating into real and imaginary parts
- De Moivre's theorem and its applications
- Elementary functions: circular, logarithmic, hyperbolic, exponential functions

- Series solution by using complex numbers

Functions of Several Variables Functions of two variables, Graphs of functions of two variables
- Limit and continuity of a function of two variables
- The partial derivative, Computing partial derivatives algebraically
- The second-order partial derivative, Local linearity and the differential
- Tangent planes and normal lines
- Optimization, Maxima and minima of a function of two variables
- Lagrange multipliers

Multiple Integrals
- Double integral in rectangular and polar form
- Triple integral in rectangular, Cylindrical and spherical coordinates
- Substitutions in multiple integrals
- Moments and centre of mass

Sequence and Series
- Sequences, Infinite series, Convergence of sequence and series
- The integral test, Comparison tests, Ratio test, Root test
- Alternative series, Absolute and conditional convergence
- Power series, Interval and radius of convergence

Elementary Number Theory
- Prime Numbers
- Theorems related to prime numbers
- Divisibility of primes, The Euclidean algorithm, The equation $ax + by = c$
- Congruences, Linear congruences, Techniques for solving $ax = b(mod m)$

Group Theory
- Binary operations
- Definition, Examples and formation of groups
- Subgroups
- Order of group, Order of an element
- Abelian groups
- Cyclic groups, Cosets, Lagrange's theorem
- Permutation, Even and odd permutations
- Symmetric groups

- Introduction to rings and fields

Metric Spaces
- Definition and various examples of metric spaces
- Holder's inequality, Cauchy-Schwarz and Minkowski's inequality
- Open ball (or open sphere) and closed balls
- The diameter of a set
- Distance between two sets
- Neighbourhoods
- Open and closed sets
- Interior, Exterior and boundary points
- Limit points, Closure of a set