Proposed Syllabus and Scheme of Examination

for

B.A. with Mathematics

submitted to

University Grants Commission
New Delhi

under the

Choice Based Credit System

May 2015
## Proposed Scheme for Choice Based Credit System in B.A. with Mathematics

<table>
<thead>
<tr>
<th>Semester</th>
<th>Core Course (12)</th>
<th>Ability Enhancement Compulsory Course (AECC) (2)</th>
<th>Skill Enhancement Course (SEC) (2)</th>
<th>Discipline Specific Elective (DSE) (4)</th>
<th>Generic Elective (GE) (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Differential Calculus C2A (English/MIL Communication) / Environmental Science</td>
<td></td>
<td></td>
<td>DSE1A GE 1 DSE2A</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Differential Equations C2B MIL/English - 1</td>
<td>Environmental Science / (English /MIL Communication)</td>
<td></td>
<td>DSE1B GE 2 DSE2B</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Real Analysis C2C English/MIL - 2</td>
<td></td>
<td>SEC1</td>
<td></td>
<td></td>
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<tr>
<td>4</td>
<td>Algebra C3D MIL/English - 2</td>
<td></td>
<td>SEC2</td>
<td></td>
<td></td>
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<tr>
<td>5</td>
<td></td>
<td></td>
<td>SEC3 DSE1A DSE2A</td>
<td>GE 1</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
<td>SEC4 DSE1B DSE2B</td>
<td>GE 2</td>
<td></td>
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</tbody>
</table>

### Discipline Specific Electives (DSE)

#### DSE 1A (choose one)

1. Matrices
2. Mechanics
3. Linear Algebra

#### DSE 1B (choose one)

1. Numerical Methods
2. Complex Analysis
3. Linear Programming
Skill Enhancement Course (SEC)

SEC 1 (choose one)

1. Logic and Sets
2. Analytical Geometry
3. Integral Calculus

SEC 2 (choose one)

1. Vector Calculus
2. Theory of Equations
3. Number Theory

SEC 3 (choose one)

1. Probability and Statistics
2. Portfolio Optimization
3. Mathematical Modeling

SEC 4 (choose one)

1. Boolean Algebra
2. Transportation and Game Theory
3. Graph Theory

Generic Elective (GE)

GE 1 (choose one)

1. Mathematical Finance
2. Queuing and Reliability Theory

GE 2 (choose one)

1. Descriptive Statistics and Probability Theory
2. Sample Surveys and Design of Experiments
Details of Courses under B.A. with Mathematics

<table>
<thead>
<tr>
<th>Course</th>
<th>Theory + Practical</th>
<th>Theory + Tutorials</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I. Core Course</strong></td>
<td>12×4 = 48</td>
<td>12×5 = 60</td>
</tr>
<tr>
<td>(12 Papers)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two papers – English</td>
<td></td>
<td></td>
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<tr>
<td>Two papers – MIL</td>
<td></td>
<td></td>
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<tr>
<td>Four papers – Discipline 1</td>
<td></td>
<td></td>
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<tr>
<td>Four papers – Discipline 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Core Course Practical / Tutorial</strong>*</td>
<td>12×2 = 24</td>
<td>12×1 = 12</td>
</tr>
<tr>
<td>(12 Practical/ Tutorials*** )</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>II. Elective Course</strong></td>
<td>6×4 = 24</td>
<td>6×5 = 30</td>
</tr>
<tr>
<td>(6 Papers)</td>
<td></td>
<td></td>
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<tr>
<td>Two papers – Discipline 1 specific</td>
<td></td>
<td></td>
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<tr>
<td>Two papers – Discipline 2 specific</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two papers – Generic (Interdisciplinary)</td>
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<td></td>
</tr>
<tr>
<td>Two papers from each discipline of choice and two papers of interdisciplinary nature.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Elective Course Practical / Tutorials</strong>*</td>
<td>6×2 = 12</td>
<td>6×1 = 6</td>
</tr>
<tr>
<td>(6 Practical / Tutorials*** )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two papers – Discipline 1 specific</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two papers – Discipline 2 specific</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two papers – Generic (Interdisciplinary)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two Papers from each discipline of choice including paper of interdisciplinary nature</td>
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<td></td>
</tr>
</tbody>
</table>

- Optional Dissertation or project work in place of one elective paper (6 credits) in 6th Semester
III. Ability Enhancement Courses

1. Ability Enhancement Compulsory Courses (AECC) 2×2 = 4
(2 Papers of 2 credits each)
   Environmental Science
   English /MIL Communication

2. Skill Enhancement Course (SEC) 4×2 = 8
(4 Papers of 2 credits each)

Total credit = 120

Institute should evolve a system/policy about ECA/ General Interest/ Hobby/ Sports/ NCC/ NSS/ related courses on its own.

*wherever there is practical there will be no tutorials and vice-versa
Core 1.1: Differential Calculus

Limit and Continuity (ε and δ definition), Types of discontinuities, Differentiability of functions, Successive differentiation, Leibnitz’s theorem, Partial differentiation, Euler’s theorem on homogeneous functions.


Rolle’s theorem, Mean Value theorems, Taylor’s theorem with Lagrange’s and Cauchy’s forms of remainder, Taylor’s series, Maclaurin’s series of sin x, cos x, e^x, log(l+x), (l+x)^m, Maxima and Minima, Indeterminate forms.

Books Recommended

Core 2.1: Differential Equations


Classification of second order partial differential equations into elliptic, parabolic and hyperbolic through illustrations only.

Books Recommended


Core 3.1: Real Analysis

Finite and infinite sets, examples of countable and uncountable sets. Real line, bounded sets, suprema and infima, completeness property of R, Archimedean property of R, intervals. Concept of cluster points and statement of Bolzano-Weierstrass theorem.

Real Sequence, Bounded sequence, Cauchy convergence criterion for sequences. Cauchy’s theorem on limits, order preservation and squeeze theorem, monotone sequences and their convergence (monotone convergence theorem without proof).

Infinite series. Cauchy convergence criterion for series, positive term series, geometric series, comparison test, convergence of p-series, Root test, Ratio test, alternating series, Leibnitz’s test (Tests of Convergence without proof). Definition and examples of absolute and conditional convergence.

Sequences and series of functions, Pointwise and uniform convergence. M_n-test, M-test, Statements of the results about uniform convergence and integrability and differentiability of functions, Power series and radius of convergence.

Books Recommended


Core 4.1: Algebra

Definition and examples of groups, examples of abelian and non-abelian groups, the group $\mathbb{Z}_n$ of integers under addition modulo $n$ and the group $U(n)$ of units under multiplication modulo $n$. Cyclic groups from number systems, complex roots of unity, circle group, the general linear group $\text{GL}_n(n, \mathbb{R})$, groups of symmetries of (i) an isosceles triangle, (ii) an equilateral triangle, (iii) a rectangle, and (iv) a square, the permutation group $\text{Sym}(n)$, Group of quaternions.

Subgroups, cyclic subgroups, the concept of a subgroup generated by a subset and the commutator subgroup of a group, examples of subgroups including the center of a group. Cosets, Index of subgroup, Lagrange’s theorem, order of an element, Normal subgroups: their definition, examples, and characterizations, Quotient groups.

Definition and examples of rings, examples of commutative and non-commutative rings: rings from number systems, $\mathbb{Z}_n$ the ring of integers modulo $n$, ring of real quaternions, rings of matrices, polynomial rings, and rings of continuous functions. Subrings and ideals, Integral domains and fields, examples of fields: $\mathbb{Z}_p$, $\mathbb{Q}$, $\mathbb{R}$, and $\mathbb{C}$. Field of rational functions.

Books Recommended

DSE 1A.1: Matrices

R, R², R³ as vector spaces over R. Standard basis for each of them. Concept of Linear Independence and examples of different bases. Subspaces of R², R³.

Translation, Dilation, Rotation, Reflection in a point, line and plane. Matrix form of basic geometric transformations. Interpretation of eigen values and eigen vectors for such transformations and eigen spaces as invariant subspaces.

Types of matrices. Rank of a matrix. Invariance of rank under elementary transformations. Reduction to normal form, Solutions of linear homogeneous and non-homogeneous equations with number of equations and unknowns upto four.


Books Recommended


DSE 1A.2: Mechanics

Conditions of equilibrium of a particle and of coplanar forces acting on a rigid Body, Laws of friction, Problems of equilibrium under forces including friction, Centre of gravity, Work and potential energy. Velocity and acceleration of a particle along a curve: radial and transverse components (plane curve), tangential and normal components (space curve), Newton’s Laws of motion, Simple harmonic motion, Simple Pendulum, Projectile Motion.

Books Recommended


**DSE 1A.3: Linear Algebra**

Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces.

Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations. Dual Space, Dual Basis, Double Dual, Eigen values and Eigen vectors, Characteristic Polynomial.

Isomorphisms, Isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix.

**Books Recommended**


**DSE 1B.1: Numerical Methods**


Lagrange and Newton interpolation: linear and higher order, finite difference operators. Numerical differentiation: forward difference, backward difference and central Difference. Integration: trapezoidal rule, Simpson’s rule, Euler’s method.

**Books Recommended**


**DSE 1B.2: Complex Analysis**

Limits, Limits involving the point at infinity, continuity. Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings. Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability.


Liouville’s theorem and the fundamental theorem of algebra. Convergence of sequences and series, Taylor series and its examples.

Laurent series and its examples, absolute and uniform convergence of power series.

**Books Recommended**


**DSE 1B.3: Linear Programming**

Linear Programming Problems, Graphical Approach for Solving some Linear Programs. Convex Sets, Supporting and Separating Hyperplanes. Theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method, Big-M method and their comparison.

Duality, formulation of the dual problem, primal- dual relationships, economic interpretation of the dual, sensitivity analysis.

**Books Recommended**


SEC 1.1: Logic and Sets

Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contrapositive and inverse propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.


Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections. Relation: Product set, Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation.

Books Recommended


SEC 1.2: Analytical Geometry


Books Recommended


SEC 1.3: Integral Calculus

Integration by Partial fractions, integration of rational and irrational functions. Properties of definite integrals. Reduction formulae for integrals of rational, trigonometric, exponential and logarithmic functions and of their combinations.

Areas and lengths of curves in the plane, volumes and surfaces of solids of revolution. Double and Triple integrals.

Books Recommended


SEC 2.1: Vector Calculus

Differentiation and partial differentiation of a vector function. Derivative of sum, dot product and cross product of two vectors.

Gradient, divergence and curl.

Books Recommended

SEC 2.2: Theory of Equations

General properties of polynomials, Graphical representation of a polynomials, maximum and minimum values of a polynomials, General properties of equations, Descarte’s rule of signs positive and negative rule, Relation between the roots and the coefficients of equations.


Books Recommended

**SEC 2.3: Number Theory**

Division algorithm, Lame’s theorem, linear Diophantine equation, fundamental theorem of arithmetic, prime counting function, statement of prime number theorem, Goldbach conjecture, binary and decimal representation of integers, linear congruences, complete set of residues.

Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Möbius inversion formula, the greatest integer function, Euler’s phi-function.

**Books Recommended**


SEC 3.1: Probability and Statistics

Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function, discrete distributions: uniform, binomial, Poisson, continuous distributions: uniform, normal, exponential.

Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions, expectation of function of two random variables, conditional expectations, independent random variables.

Books Recommended


SEC 3.2: Portfolio Optimization


Books Recommended

SEC 3.3: Mathematical Modeling

Applications of differential equations: the vibrations of a mass on a spring, mixture problem, free damped motion, forced motion, resonance phenomena, electric circuit problem, mechanics of simultaneous differential equations.


Books Recommended


SEC 4.1: Boolean Algebra

Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, maximal and minimal elements, lattices as ordered sets, complete lattices, lattices as algebraic structures, sublattices, products and homomorphisms.

Definition, examples and properties of modular and distributive lattices, Boolean algebras, Boolean polynomials, minimal forms of Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, switching circuits and applications of switching circuits.

Books Recommended


SEC 4.2: Transportation and Game Theory


Game theory: formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure.

Books Recommended


SEC 4.3: Graph Theory

Definition, examples and basic properties of graphs, pseudographs, complete graphs, bi-partite graphs, isomorphism of graphs, paths and circuits, Eulerian circuits, Hamiltonian cycles, the adjacency matrix, weighted graph, travelling salesman’s problem, shortest path, Dijkstra’s algorithm, Floyd-Warshall algorithm.

Books Recommended


GE 1.1: Mathematical Finance

Basic principles: Comparison, arbitrage and risk aversion, Interest (simple and compound, discrete and continuous), time value of money, inflation, net present value, internal rate of return (calculation by bisection and Newton-Raphson methods), comparison of NPV and IRR. Bonds, bond prices and yields, Macaulay and modified duration, term structure of interest rates: spot and forward rates, explanations of term structure, running present value, floating-rate bonds, immunization, convexity, putable and callable bonds.

Asset return, short selling, portfolio return, (brief introduction to expectation, variance, covariance and correlation), random returns, portfolio mean return and variance, diversification, portfolio diagram, feasible set, Markowitz model (review of Lagrange multipliers for 1 and 2 constraints), Two fund theorem, risk free assets, One fund theorem, capital market line, Sharpe index. Capital Asset Pricing Model (CAPM), betas of stocks and portfolios, security market line, use of CAPM in investment analysis and as a pricing formula, Jensen’s index.

Books Recommended

GE 1.2: Queueing and Reliability Theory

General concepts of queueing system, Measures of performance, Arrival and Service Processes, Single server and multi server models, channels in parallel with limited and unlimited queues-M/M/1/K, M/M/C. Queues with unlimited service. Finite source queues. Application of simple queueing decision model’s, Design and control models.


Books Recommended


GE 2.1: Descriptive Statistics and Probability Theory

Concepts of a statistical population and sample from a population, quantitative and qualitative data, nominal, ordinal and time-series data, discrete and continuous data. Presentation of data by tables and by diagrams, frequency distributions for discrete and continuous data, graphical representation of a frequency distribution by histogram and frequency polygon, cumulative frequency distributions (inclusive and exclusive methods).

Measures of location (or central tendency) and dispersion, moments, measures of skewness and kurtosis, cumulants. Bivariate data: Scatter diagram, principle of least-square and fitting of polynomials and exponential curves. Correlation and regression. Karl Pearson coefficient of correlation, Lines of regression, Spearman's rank correlation coefficient, multiple and partial correlations (for 3 variates only).

Random experiment, sample point and sample space, event, algebra of events, Definition of Probability - classical, relative frequency and axiomatic approaches to probability, merits and demerits of these approaches (only general ideas to be given). Theorem on probability, conditional probability, independent events. Baye’s theorem and its applications.

Books Recommended


GE 2.2: Sample Surveys and Design of Experiments


SRSWR & SRSWOR, determination of sample size. Stratified random sampling and different allocations. Systematic sampling, comparison of known sampling strategies under linear trend. Ratio and Regression estimators and their comparison with SRSWOR estimator.

Indian Official Statistics: Present Official Statistical System in India relating to census of population, agriculture, industrial production, and prices; methods of collection of official statistics, their reliability and limitation and the principal publications containing such statistics. Also the various agencies responsible for the data collection- C.S.O., N.S.S.O., Office of Registrar General, their historical development, main functions and important publications.

Analysis of variance and covariance: Analysis of variance and covariance (with one concomitant variable) in one-way and two-way classified data with equal number of observations per cell.

Design of experiments: Principles of experimentation, uniformity trials, completely randomized, Randomized block and Latin square designs. Missing plot technique, $2^2$ and $2^3$ Factorial experiments: construction and analysis.

Regression Analysis: Two variable linear model – estimation, testing and problems of predication. Predication of the estimated regression equation, interval estimation, variance estimation.

Books Recommended


