Draft Undergraduate Syllabus
B. A. (non-Honours)
with Mathematics

Under
Dibrugarh University
(To be effective from session 2019-20)

As approved in the BoS meetings held on 30/11/2016, 10/03/2017 and 08/09/2019

Choice Based Credit System in B.A. with Mathematics

Semester	Core Course (12)	Ability Enhancement Compulsory Course (AECC)	Skill Enhancement Course (SEC) (2)	Discipline Specific Elective (DSE) (6)	Generi Electiv (GE)(6
I	**General English 1.1** **DSC-1A Differential Calculus** **DSC-2A**	**Multi-disciplinary Course (4C)**			
II	**Comm. English-1.2** **DSC-1B Differential Equations** **DSC-C2B**	**Environmental Science (2C)**			
III	**Comm. Hindi/ MIL / Alt. Eng. 1.1** **DSC-1C Real Analysis** **DSC-2C**		**SEC-1.1(2C)**		
IV	Comm. Hindi/MIL/ Alt. Eng. 1.2 **DSC-1D Algebra** **DSC-2D**		**SEC-2.1(2C)**		
V			**SEC-1.2(2C)**	**DSE-1A** **DSE-2A**	GE-1
VI			**SEC-2.2**	**DSE-1B** **DSE-2B**	GE-2

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
3. Numerical Techniques using MATLAB/MATHEMATICA

Details of Courses under B.A. with Mathematics

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

• 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)**	3×2 = 6	3×2 =6
(2 Papers of 2 credits each)		
Environmental Science **English /MIL Communication**		
2. **Skill Enhancement Course (SEC)** **(4 Papers of 2 credits each)**	4×2 = 8	4×2 = 8
	Total credit = 122	**Total credit = 122**

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**

DSC-1A: Differential Calculus

Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1=6;
(L=5, P=0, T=1)

Objectives: After going through this course the students should be able to

- differentiate functions
- find tangent, normal, curvature, asymptotes etc., of a given curve.

Unit-1 Marks: 25, Contact hrs: 30

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

Unit-2 Marks: 25, Contact hrs: 30

Tangents and normals, Curvature, Asymptotes, Singular points, Tracing of curves. Parametric representation of curves and tracing of parametric curves, Polar coordinates and tracing of curves in polar coordinates.

Unit-3 Marks: 30, Contact hrs: 30

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(1+x), $(1+x)^m$, Maxima and Minima, Indeterminate forms.

Books Recommended

1. H. Anton, I. Birens and S. Davis, *Calculus*, John Wiley and Sons, Inc., 2002.
2. G.B. Thomas and R.L. Finney, *Calculus*, Pearson Education, 2007.

DSC-1B: Differential Equations

Total Marks: 100, Theory: 80, IA: 20,

Credit: 5+1=6;

(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to use various methods to solve differential equations

Unit-1 Marks: 30, Contact hrs: 30

First order exact differential equations. Integrating factors, rules to find an integrating factor. First order higher degree equations solvable for x, y, p. Methods for solving higher-order differential equations. Basic theory of linear differential equations, Wronskian, and its properties. Solving a differential equation by reducing its order.

Unit-2 Marks: 20, Contact hrs: 25

Linear homogenous equations with constant coefficients, Linear non-homogenous equations, The method of variation of parameters, The Cauchy-Euler equation, Simultaneous differential equations, Total differential equations.

Unit-3 Marks: 20, Contact hrs: 25

Order and degree of partial differential equations, Concept of linear and non-linear partial differential equations, Formation of first order partial differential equations, Linear partial differential equation of first order, Lagrange's method, Charpit's method.

Unit-4 Marks: 10, Contact hrs: 10

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

Books Recommended

1. Shepley L. Ross, *Differential Equations*, 3rd Ed., John Wiley and Sons, 1984.
I. Sneddon, *Elements of Partial Differential Equations*, McGraw-Hill, International Edition, 1967.

DSC-1C: Real Analysis

Total Marks: 100, Theory: 80, IA: 20,

Credit: 5+1=6;

(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- Analyse the properties of the Real line
- Describe various analytical properties of the real number system.

Unit-1 Marks: 20, Contact hrs: 20

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.

Unit-2 Marks: 20, Contact hrs: 20

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).

Unit-3 Marks: 20, Contact hrs: 20

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.

Unit-4 Marks: 20, Contact hrs: 30

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

1. T. M. Apostol, *Calculus* (Vol. I), John Wiley and Sons (Asia) P. Ltd., 2002.
2. R.G. Bartle and D. R Sherbert, *Introduction to Real Analysis,* John Wiley and Sons (Asia) P.Ltd., 2000.
3. E. Fischer, *Intermediate Real Analysis*, Springer Verlag, 1983.
4. K.A. Ross, *Elementary Analysis- The Theory of Calculus Series*- Undergraduate Texts in Mathematics, Springer Verlag, 2003.

DSC-1D: Algebra

Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1=6;
(L=5, P=0, T=1)

Objectives:: After going through this course the students will be able to

- Describe various algebraic structures on sets;
- Identify the algebraic structures present in different branches of Sciences.

Unit-1 Marks: 20, Contact hrs: 30

Definition and examples of groups, examples of abelian and non-abelian groups, the group 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 GL_n (n,R), groups of symmetries of (i) an isosceles triangle, (ii) an equilateral triangle,
(iii) a rectangle, and (iv) a square, the permutation group symmetric groups, Group of quaternions.

Unit-2 Marks: 30, Contact hrs: 30

Subgroups, cyclic subgroups, the concept of a subgroup generated by a subset and the commutator subgroup of 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.

Unit-3 Marks: 30, Contact hrs: 30

Definition and examples of rings, examples of commutative and non-commutative rings: rings from number systems, 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

1. John B. Fraleigh, *A First Course in Abstract Algebra*, 7th Ed., Pearson, 2002**.**
2. M. Artin, *Abstract Algebra*, 2nd Ed., Pearson, 2011.
3. Joseph A Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa, 1999.
4. George E Andrews, *Number Theory*, Hindustan Publishing Corporation, 1984.

DSE-1A.1: Matrices

Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1=6;
(L=5, P=0, T=1)

Objectives:: After going through this course the students will be able to

- Discuss vector spaces, bases, rank of matrix
- Find solution of linear equations using matrices.

Unit-1 Marks: 10, Contact hrs: 30

$\mathbb{R}, \mathbb{R}^2, \mathbb{R}^3$ as vector spaces over $\mathbb{R}$. Standard basis for each of them. Concept of Linear Independence and examples of different bases. Subspaces of $\mathbb{R}^2, \mathbb{R}^3$.

Unit-2 Marks: 20, Contact hrs: 20

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.

Unit-3 Marks: 20, Contact hrs: 20

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.

Unit-4 Marks: 30, Contact hrs: 20

Matrices in diagonal form. Reduction to diagonal form upto matrices of order 3. Computation of matrix inverses using elementary row operations. Rank of matrix. Solutions of a system of linear equations using matrices. Illustrative examples of above concepts from Geometry, Physics, Chemistry, Combinatorics and Statistics.

Books Recommended

1. A.I. Kostrikin, *Introduction to Algebra*, Springer Verlag, 1984.
2. S. H. Friedberg, A. L. Insel and L. E. Spence, *Linear Algebra*, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
3. Richard Bronson, Theory and Problems of Matrix Operations, Tata McGraw Hill, 1989.

DSE-1A.2: Mechanics

Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1=6;
(L=5, P=0, T=1)

Objectives : After going through this course the students will be able to

- Describe the moment of a force and couple, general equation of equilibrium
- Solve problems of centre of gravity, simple harmonic motion.

Unit-1 Marks: 16, Contact hrs: 20

Conditions of equilibrium of a particle and of coplanar forces acting on a rigid Body,

Unit-2 Marks: 16, Contact hrs: 20

Laws of friction, Problems of equilibrium under forces including friction,

Unit-3 Marks: 16, Contact hrs: 20

Centre of gravity, Work and potential energy.

Unit-4 Marks: 16, Contact hrs: 15

Velocity and acceleration of a particle along a curve: radial and transverse components (plane curve), tangential and normal components (space curve),

Unit-5 Marks: 16, Contact hrs: 15

Newton's Laws of motion, Simple harmonic motion, Simple Pendulum, Projectile Motion.

Books Recommended

1. A.S. Ramsay, *Statics*, CBS Publishers and Distributors (Indian Reprint), 1998.
2. A.P. Roberts, *Statics and Dynamics with Background in Mathematics*, Cambridge University Press, 2003.

DSE 1A.3: Linear Algebra

Total Marks: 100, Theory: 80, IA: 20,

Credit: 5+1=6;

(L=5, P=0, T=1)

Objectives:: After going through this course the students will be able to

- Discuss vector space, subspace;
- Define Basis and explain their properties.

Unit-1 Marks: 20, Contact hrs: 20

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

Unit-2 Marks: 20, Contact hrs: 30

Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations.

Unit-3 Marks: 20, Contact hrs: 20

Dual Space, Dual Basis, Double Dual, Eigen values and Eigen vectors, Characteristic Polynomial.

Unit-4 Marks: 20, Contact hrs: 20

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

Books Recommended

1. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra,* 4th Ed., Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.
2. David C. Lay, *Linear Algebra and its Applications,* 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
3. S. Lang, *Introduction to Linear Algebra,* 2nd Ed., Springer, 2005.
4. Gilbert Strang, *Linear Algebra and its Applications*, Thomson, 2007.

DSE 1B.1: Numerical Methods

Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1=6;
(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- Apply the numerical methods and interpolation formulae in solving algebraic equations;
- Solve differential equation using Numerical techniques.

Unit-1 Marks: 40, Contact hrs:45

Algorithms, Convergence, Bisection method, False position method, Fixed point iteration method, Newton's method, Secant method,
LU decomposition, Gauss-Jacobi, Gauss-Siedel and SOR iterative methods.

Unit-1 Marks: 40, Contact hrs:45

linear and higher order Lagrange and Newton interpolation:, finite difference operators.
Numerical differentiation: forward difference, backward difference and central Difference.

Integration: trapezoidal rule, Simpson's rule, Euler's method.

Books Recommended

1. B. Bradie, *A Friendly Introduction to Numerical Analysis*, Pearson Education, India, 2007.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, *Numerical Methods for Scientific and Engineering Computation*, 5th Ed., New age International Publisher, India, 2007.

DSE 1B.2: Complex Analysis

Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1=6;
(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- Define analytic function
- Describe complex number system, its differentiation and integration.

Unit-1 Marks: 25, Contact hrs: 30

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.

Unit-2 Marks: 30, Contact hrs: 20

Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function, derivatives of functions, definite integrals of functions. Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. Cauchy- Goursat theorem, Cauchy integral formula.

Unit-3 Marks: 15, Contact hrs: 20

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

Unit-4 Marks: 10, Contact hrs: 20

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

Books Recommended

1. James Ward Brown and Ruel V. Churchill, *Complex Variables and Applications,* 8th Ed., McGraw – Hill International Edition, 2009.
2. Joseph Bak and Donald J. Newman, *Complex analysis,* 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., New York, 1997.

DSE 1B.3: Linear Programming

Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1=6;
(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- describe various optimization techniques pertaining to linear programming
- apply linear programming to problems arising out of real life problems.

Unit-1 Marks: 20, Contact hrs: 20

Linear Programming Problems, Graphical Approach for Solving some Linear Programs. Convex Sets, Supporting and Separating Hyperplanes.

Unit-2 Marks: 20, Contact hrs: 30

Theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables,

Unit-3 Marks: 20, Contact hrs: 20

Two-phase method, Big-M method and their comparison.

Unit-4 Marks: 20, Contact hrs: 20

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

Books Recommended

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, *Linear programming and Network Flows,* 2nd Ed., John Wiley and Sons, India, 2004.
2. F.S. Hillier and G.J. Lieberman, *Introduction to Operations Research,* 8th Ed., Tata McGraw Hill, Singapore, 2004.
3. Hamdy A. Taha, *Operations Research, An Introduction,* 8th Ed., Prentice-Hall India, 2006.

SEC 1.1: Logic and Sets

Total Marks: 50, Theory: 40, IA: 10,

Credit: 2;

(L=2, P=0, T=0)

Objectives: After going through this course the students will be able to

- list the truth and falsity of a logical statement
- Differentiate between a logical statement and an ordinary statement
- Define and describe various properties of sets.

Unit-1 Marks: 20, Contact hrs:10

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

Unit-2 Marks: 10, Contact hrs: 10

Sets, subsets, Set operations, the laws of set theory and Venn diagrams. Examples of finite and infinite sets. Finite sets and counting principle. Empty set, properties of empty set. Standard set operations. Classes of sets. Power set of a set.

Unit-3 Marks: 10, Contact hrs: 10

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

1. R.P. Grimaldi, *Discrete Mathematics and Combinatorial Mathematics*, Pearson Education, 1998.
2. P.R. Halmos, *Naive Set Theory*, Springer, 1974.
3. E. Kamke, *Theory of Sets*, Dover Publishers, 1950.

SEC 1.2: Analytical Geometry

Total Marks: 50, Theory: 40, IA: 10,
Credit: 2;
(L=2, P=0, T=0)

Objectives: After going through this course the students will be able to

- Sketch parabola, ellipse and hyperbola
- Solve various geometrical problems analytically.

Unit-1 Marks: 20, Contact hrs:15

Techniques for sketching parabola, ellipse and hyperbola. Reflection properties of parabola, ellipse and hyperbola.

Unit-2 Marks: 20, Contact hrs:15

Classification of quadratic equations representing lines, parabola, ellipse and hyperbola. Spheres, Cylindrical surfaces. Illustrations of graphing standard quadric surfaces like cone, ellipsoid.

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. H. Anton, I. Bivens and S. Davis, *Calculus*, John Wiley and Sons (Asia) Pvt. Ltd., 2002.
3. S.L. Loney, *The Elements of Coordinate Geometry*, McMillan and Company, London.
4. R.J.T. Bill, *Elementary Treatise on Coordinate Geometry of Three Dimensions*, McMillan India Ltd., 1994.

SEC 1.3: Integral Calculus

Total Marks: 50, Theory: 40, IA: 10,
Credit: 2;
(L=2, P=0, T=0)

Objectives: After going through this course the students will be able to

- Learn properties of definite integral, reduction formulae
- Find areas, lengths, volume etc by using integration.

Unit-1 Marks: 20, Contact hrs:15

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.

Unit-2 Marks: 20, Contact hrs:15

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

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. H. Anton, I. Bivens and S. Davis, *Calculus*, John Wiley and Sons (Asia) P. Ltd., 2002.

SEC 2.1: Vector Calculus

Total Marks: 50, Theory: 40, IA: 10,
Credit: 2;
(L=2, P=0, T=0)

Objectives: After going through this course the students will be able to

- Evaluate differentiation of vector functions
- Determine gradient, divergence and curl of differentiable functions.

Unit-1 Marks: 20, Contact hrs:15

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

Unit-2 Marks: 20, Contact hrs:15

Gradient, divergence and curl.

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. H. Anton, I. Bivens and S. Davis, *Calculus*, John Wiley and Sons (Asia) P. Ltd. 2002.
3. P.C. Matthew's, *Vector Calculus*, Springer Verlag London Limited, 1998.

SEC 2.2: Theory of Equations

Total Marks: 50, Theory: 40, IA: 10,
Credit: 2;
(L=2, P=0, T=0)

Objectives: After going through this course the students will be able to discuss various properties of algebraic equations, symmetric properties of roots and determination of roots.

Unit-1 Marks: 20, Contact hrs:15

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.

Unit-2 Marks: 20, Contact hrs:15

Symmetric functions, Applications symmetric function of the roots, Transformation of equations. Solutions of reciprocal and binomial equations. Algebraic solutions of the cubic and biquadratic. Properties of the derived functions.

Books Recommended

1. W.S. Burnside and A.W. Panton, *The Theory of Equations*, Dublin University Press, 1954.
2. C. C. MacDuffee, *Theory of Equations*, John Wiley & Sons Inc., 1954.

SEC 2.3: Number Theory

Total Marks: 50, Theory: 40, IA: 10,

Credit: 2;

(L=2, P=0, T=0)

Objectives: After going through this course the students will be able to

- obtain solutions of Diophantine equations
- define number theoretic functions

Unit-1 Marks: 20, Contact hrs:15

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.

Unit-2 Marks: 20, Contact hrs:15

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

1. David M. Burton, *Elementary Number Theory* 6th Ed., Tata McGraw-Hill Edition, Indian reprint, 2007.
2. Richard E. Klima, Neil Sigmon, Ernest Stitzinger, *Applications of Abstract Algebra with Maple*, CRC Press, Boca Raton, 2000.
3. Neville Robinns, *Beginning Number Theory,* 2nd Ed., Narosa Publishing House Pvt. Limited, Delhi, 2007.

SEC 3.1: Probability and Statistics

Total Marks: 50, Theory: 40, IA: 10,

Credit: 2;

(L=2, P=0, T=0)

Objectives: After going through this course the students will be able to

- Characterize the statistical techniques.
- Describe the mathematical theory of probability

Unit-1 Marks: 20, Contact hrs:15

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.

Unit-2 Marks: 20, Contact hrs:15

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

1. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, *Introduction to Mathematical Statistics*, Pearson Education, Asia, 2007.
2. Irwin Miller and Marylees Miller, John E. Freund, *Mathematical Statistics with Application,* 7th Ed., Pearson Education, Asia, 2006.
3. Sheldon Ross, *Introduction to Probability Model,* 9th Ed., Academic Press, Indian Reprint, 2007.

SEC 3.2: Portfolio Optimization

Total Marks: 50, Theory: 40, IA: 10,
Credit: 2;
(L=2, P=0, T=0)

Objectives: After going through this course the students will be able to define portfolio optimization and apply them to real world problems

Unit-1 Marks: 10, Contact hrs: 10

Financial markets. Investment objectives. Measures of return and risk. Types of risks.

Unit-2 Marks: 20, Contact hrs:10

Portfolio of assets. Expected risk and return of portfolio. Diversification. Mean-variance portfolio optimization- the Markowitz model and the two-fund theorem, risk-free assets and one fund theorem, efficient frontier.

Unit-3 Marks: 10, Contact hrs:10

Portfolio performance evaluation measures.

Books Recommended

1. F.K. Reilly, Keith C. Brown, *Investment Analysis and Portfolio Management*, 10th Ed., South-Western Publishers, 2011.
2. H.M. Markowitz, *Mean-Variance Analysis in Portfolio Choice and Capital Markets*, Blackwell, New York, 1987.
3. D.G. Luenberger, *Investment Science*, 2nd Ed., Oxford University Press, 2013.

SEC 3.3: Mathematical Modeling

Total Marks: 50, Theory:40, IA: 10,

Credit: 2;

(L=2, P=0, T=0)

Objectives:: After going through this course the students will be able to solve differential equations and linear programming problems used in mathematical modelling

Unit-1 Marks: 20, Contact hrs:15

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.

Unit-2 Marks: 20, Contact hrs:15

Applications to Traffic Flow. Vibrating string, vibrating membrane, conduction of heat in solids, gravitational potential, conservation laws.

Books Recommended

1. Shepley L. Ross, *Differential Equations*, 3rd Ed., John Wiley and Sons, 1984.
2. I. Sneddon, *Elements of Partial Differential Equations*, McGraw-Hill, International Edition, 1967.

SEC 4.1: Boolean Algebra

Total Marks: 50, Theory: 40, IA: 10,
Credit: 2;
(L=2, P=0, T=0)

Objectives: After going through this course the students will be able to

- define lattice
- identify various lattice properties and apply them to describe switching circuits.

Unit-1 Marks: 20, Contact hrs:15

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.

Unit-2 Marks: 20, Contact hrs:15

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

1. B A. Davey and H. A. Priestley, *Introduction to Lattices and Order,* Cambridge University Press, Cambridge, 1990.
2. Rudolf Lidl and Günter Pilz, *Applied Abstract Algebra,* 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.

SEC 4.2: Transportation and Game Theory

Total Marks: 50, Theory: 40, IA: 10,

Credit: 2;

(L=2, P=0, T=0)

Objectives: After going through this course the students will be able to

- model the transportation problem mathematically
- describe the conflicts among rational agents using game theory.

Unit-1 Marks: 20, Contact hrs:15

Transportation problem and its mathematical formulation, northwest-corner method, least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem, assignment problem and its mathematical formulation, Hungarian method for solving assignment problem.

Unit-2 Marks: 20, Contact hrs:15

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

Books Recommended

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, *Linear Programming and Network Flows,* 2nd Ed., John Wiley and Sons, India, 2004.
2. F. S. Hillier and G. J. Lieberman, *Introduction to Operations Research,* 9th Ed., Tata McGraw Hill, Singapore, 2009.
3. Hamdy A. Taha, *Operations Research, An Introduction,* 8th Ed., Prentice-Hall India, 2006.

SEC 4.3: Graph Theory

Total Marks: 50, Theory: 40, IA: 10,
Credit: 2;
(L=2, P=0, T=0)

Objectives: Students will be introduced to the fundamentals of Graph Theory and different representations of a Graph for practical applications.

Unit-1 Marks: 20, Contact hrs:15

Definition, examples and basic properties of graphs, pseudographs, complete graphs, bi-partite graphs, isomorphism of graphs, paths and circuits, Eulerian circuits, Hamiltonian cycles,

Unit-2 Marks: 20, Contact hrs:15

The adjacency matrix, weighted graph, travelling salesman's problem, shortest path, Dijkstra's algorithm, Floyd-Warshall algorithm.

Books Recommended

1. Edgar G. Goodaire and Michael M. Parmenter, *Discrete Mathematics with Graph Theory* 2nd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2003.
2. Rudolf Lidl and Günter Pilz, *Applied Abstract Algebra*, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.

GE 1.1: Mathematical Finance

Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1 = 6;
(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- Build quantitative models of financial mathematics/industries
- Apply models to obtain information of practical value in the financial mathematics

Unit-1 Marks: 20, Contact hrs:30

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).

Unit-2 Marks: 20, Contact hrs: 20

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.

Unit-3 Marks: 20, Contact hrs: 20

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).

Unit-4 Marks: 20, Contact hrs: 20

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

1. David G. Luenberger, *Investment Science,* Oxford University Press, Delhi, 1998.
2. John C. Hull, *Options, Futures and Other Derivatives*, 6th Ed., Prentice-Hall India, Indian reprint, 2006.
3. Sheldon Ross, *An Elementary Introduction to Mathematical Finance*, 2nd Ed., Cambridge University Press, USA, 2003.

GE 1.2: Queueing and Reliability Theory

Total Marks: 100, Theory: 80, IA: 20,
Credit: 6(5+1);
(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- Design and control model.
- Fit mathematical model to real data.

Unit-1 Marks: 40, Contact hrs: 45

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.

Unit-2 Marks: 40, Contact hrs: 45

Basics of reliability. Classes of life distributions. Series, parallel, configurations. Reliability models, Reliability, Mean Time before failure and Hazard rate of Exponential and Weibull distributions. Concepts and definitions of preventive maintenance, corrective maintenance and age replacement.

Books Recommended

1. R.B. Cooper, *Introduction to Queueing Theory*, 2nd Ed., North Holland, 1981.
2. D. Gross, C. M. Harris, *Fundamentals of Queueing Theory*, 3rd Ed., John Wiley and Sons Inc. P. Ltd., 2002.
3. U.N. Bhat, *An Introduction to Queueing Theory: Modelling and Analysis in Applications* (*Statistics for Industry and Technology*), Birkhauser Boston, 2008.
4. U.N. Prabhu, *Foundations of Queueing Theory*, International Series in Operations Research & Management Science, Kluwer Academic Publishers, 2nd Ed., 2002.
5. John G. Rau, *Optimization and Probability in Systems Engineering*, V.N. Reinhold Co., 1970.
6. Riccardo Manzini, Alberto Regattieri, Hoang Pham, Emilio Ferrai, *Maintenance for Industrial Systems*, Springer-Verlag, London Limited, 2010.
7. P.K. Kapur, R.B. Garg, S. Kumar, *Contributions to Hardware and Software Reliability*, World Scientific, Singapore, 1999.

GE 2.1: Descriptive Statistics and Probability Theory

Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1 = 6;
(L=5, P=0, T=1)

Objectives: After going through this course you will be able to

- Explain the idea of probability
- Give statistical predictions.

Unit-1 Marks: 30, Contact hrs:30

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).

Unit-2 Marks: 30, Contact hrs:30

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).

Unit-3 Marks: 20, Contact hrs: 30

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

1. J.E. Freund, *Mathematical Statistics with Applications*, 7th Ed., Pearson Education, 2009.
2. A.M. Goon, M.K. Gupta and B. Dasgupta, *Fundamentals of Statistics*, Vol. I, 8th Ed., World Press, Kolkatta, 2005.
3. S.C. Gupta and V.K. Kapoor, *Fundamentals of Mathematical Statistics*, 11th Ed., Sultan Chand and Sons, 2007.
4. R.V. Hogg, A.T. Craig and J.W. Mckean, *Introduction to Mathematical Statistics*, 6th Ed., Pearson Education, 2005.
5. A.M. Mood, F.A. Graybill and D.C. Boes, *Introduction to the Theory of Statistics*, 3rd Ed., Tata McGraw Hill Publication, 2007.

GE 2.2: Sample Surveys and Design of Experiments

Total Marks: 100, Theory: 80, IA: 20,
Credit: 5+1 = 6;
(L=5, P=0, T=1)

Objectives: After going through this course the students will be able to

- Explain various issues related to sampling.
- Design effective questionnaire.
- Design experiment and do regression analysis.

Unit-1 Marks: 16, Contact hrs: 30 Sample Surveys: Concepts of population and sample. Complete enumeration vs. sampling. Need for sampling. Principal and organizational aspects in the conduct of a sample survey. Properties of a good estimator, Sampling and non-sampling errors.

Unit-2 Marks: 16, Contact hrs: 15 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.

Unit-3 Marks: 16, Contact hrs: 15 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.

Unit-4 Marks: 16, Contact hrs:15 Design of experiments: Principles of experimentation, uniformity trails, completely randomized, Randomized block and Latin square designs. Missing plot technique, 2^2 and 2^3 Factorial experiments: construction and analysis.

Unit-5 Marks: 16, Contact hrs:15 Regression Analysis: Two variable linear model – estimation, testing and problems of predication. Predication of the estimated regression equation, interval estimation, variance estimation.

Books Recommended

1. W.G. Cochran*, Sampling Techniques,* John Wiley and Sons, New York, 1997.
2. A.M. Goon, M.K. Gupta, and B. Dasgupta, *Fundamentals of Statistics* (Vol. II), 8th Ed.,

World Press, Kolkata, 2005.
3. A.M. Goon, M.K. Gupta and B. Dasgupta, *An Outline of Statistical Theory* (Vol. II), 3rd Ed., World Press, Kolkata, 2005.
4. S.C. Gupta and V.K. Kapoor, *Fundamentals of Applied Statistics*, 4th Ed., Sultan Chand and Sons, 2008.
5. A.M. Kshirsagar, *A Course in Linear Models*, Marcel Dekker, Inc., N.Y., 1983.
6. D.C. Montgomery, *Designs and Analysis of Experiments*, John Wiley and Sons, New York, 2001.
7. D.C. Montgomery, E.A. Peak and G.G. Vinning, *Introduction to Linear Regression Analysis*, 3rd Ed., John Wiley and Sons, 2006.
8. P. Mukhopadhyay, *Theory and Methods of Surveys Sampling*, Prentice Hall of India, 1998.
9. D. Singh and F.S. Chaudhary, *Theory and Analysis of Sample Survey Designs*, New Age International (P) Ltd., 1995.
10. P.V. Sukhatme, B.V. Sukhatme, S. Sukhatme and C. Ashok, *Sampling Theory of Surveys with Applications*, Lowa State University Press, Lowa, USA, 1984.

GE 2.3: Numerical Techniques using MATLAB/ MATHEMATICA

Total Marks: 100, Theory: 80, IA: 20,

Credit: 6;

(L=2, P=8, T=0)

Objectives: After going through this course the students will be able to

- Use Mathematica/Matlab to solve numerical problems.
- Design algorithms for numerical evaluations of Mathematical problems.

Practical / Laboratory work to be performed on computer based on numerical methods by using Matlab/Mathematica

Impart basics of the software (Matlab/Mathematica) as a prerequisite for the course (4 weeks lectures).

Suggestive List of project work:

1. Evaluation of arithmetic expression, exponential, logarithmic and trigonometric functions.
2. Operations in matrices (addition, multiplication, inverse, transpose, determinant, rank, diagonal, upper –lower triangular matrix).
3. Solutions of algebraic and simultaneous equations.
4. Plotting of graphs (algebraic functions of various degrees, trigonometric, exponential, hyperbolic function).
5. Computation of limit, differentiation, integration and solution of ordinary differential equations.
6. Operations in complex numbers.
7. Solutions of equation by bisection method and Newton-Raphson method.
8. Evaluation of integrals by using Simpson's quadrature formulae.