Choice Based Credit System (CBCS)

UNIVERSITY OF DELHI

DEPARTMENT OF MATHEMATICS

UNDERGRADUATE PROGRAMME
(Courses effective from Academic Year 2015-16)

SYLLABUS OF COURSES TO BE OFFERED
Core Courses, Elective Courses & Ability Enhancement Courses

Disclaimer: The CBCS syllabus is uploaded as given by the Faculty concerned to the Academic Council. The same has been approved as it is by the Academic Council on 13.7.2015 and Executive Council on 14.7.2015. Any query may kindly be addressed to the concerned Faculty.

Undergraduate Programme Secretariat

Preamble

The University Grants Commission (UGC) has initiated several measures to bring equity, efficiency and excellence in the Higher Education System of country. The important measures taken to enhance academic standards and quality in higher education include innovation and improvements in curriculum, teaching-learning process, examination and evaluation systems, besides governance and other matters.

The UGC has formulated various regulations and guidelines from time to time to improve the higher education system and maintain minimum standards and quality across the Higher Educational Institutions (HEIs) in India. The academic reforms recommended by the UGC in the recent past have led to overall improvement in the higher education system. However, due to lot of diversity in the system of higher education, there are multiple approaches followed by universities towards examination, evaluation and grading system. While the HEIs must have the flexibility and freedom in designing the examination and evaluation methods that best fits the curriculum, syllabi and teaching–learning methods, there is a need to devise a sensible system for awarding the grades based on the performance of students. Presently the performance of the students is reported using the conventional system of marks secured in the examinations or grades or both. The conversion from marks to letter grades and the letter grades used vary widely across the HEIs in the country. This creates difficulty for the academia and the employers to understand and infer the performance of the students graduating from different universities and colleges based on grades.

The grading system is considered to be better than the conventional marks system and hence it has been followed in the top institutions in India and abroad. So it is desirable to introduce uniform grading system. This will facilitate student mobility across institutions within and across countries and also enable potential employers to assess the performance of students. To bring in the desired uniformity, in grading system and method for computing the cumulative grade point average (CGPA) based on the performance of students in the examinations, the UGC has formulated these guidelines.

CHOICE BASED CREDIT SYSTEM (CBCS):

The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill based courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Therefore, it is necessary to introduce uniform grading system in the entire higher education in India. This will benefit the students to move across institutions within India to begin with and across countries. The uniform grading system will also enable potential employers in assessing the performance of the candidates. In order to bring uniformity in evaluation system and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations, the UGC has formulated the guidelines to be followed.

Outline of Choice Based Credit System:

1. **Core Course:** A course, which should compulsorily be studied by a candidate as a core requirement is termed as a Core course.
2. **Elective Course:** Generally a course which can be chosen from a pool of courses and which may be very specific or specialized or advanced or supportive to the discipline/ subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill is called an Elective Course.
   - **2.1 Discipline Specific Elective (DSE) Course**: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).
   - **2.2 Dissertation/Project**: An elective course designed to acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member is called dissertation/project.
   - **2.3 Generic Elective (GE) Course**: An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.
     P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/subject and vice versa and such electives may also be referred to as Generic Elective.
3. **Ability Enhancement Courses (AEC)/Competency Improvement Courses/Skill Development Courses/Foundation Course:** The Ability Enhancement (AE) Courses may be of two kinds: AE Compulsory Course (AECC) and AE Elective Course (AEEC). "AECC" courses are the courses based upon the content that leads to Knowledge enhancement. They ((i) Environmental Science, (ii) English/MIL Communication) are mandatory for all disciplines. AEEC courses are value-based and/or skill-based and are aimed at providing hands-on-training, competencies, skills, etc.
   - **3.1** AE Compulsory Course (AECC): Environmental Science, English Communication/MIL Communication.
   - **3.2** AE Elective Course (AEEC): These courses may be chosen from a pool of courses designed to provide value-based and/or skill-based instruction.

Project work/Dissertation is considered as a special course involving application of knowledge in solving / analyzing /exploring a real life situation / difficult problem. A Project/Dissertation work would be of 6 credits. A Project/Dissertation work may be given in lieu of a discipline specific elective paper.

Details of Courses Under Undergraduate Programme (B.A./ B.Com.)

Course	***Credits**	
	Paper+ Practical	Paper + Tutorial
I. Core Course	12X4= 48	12X5=60
(12 Papers)		
Two papers – English		
Two papers – MIL		
Four papers – Discipline 1.		
Four papers – Discipline 2.		
Core Course Practical / Tutorial*	12X2=24	12X1=12
(12 Practicals)		
II. Elective Course	6x4=24	6X5=30
(6 Papers)		
Two papers- Discipline 1 specific		
Two papers- Discipline 2 specific		
Two papers- Inter disciplinary		
Two papers from each discipline of choice and two papers of interdisciplinary nature.		
Elective Course Practical / Tutorials*	6 X 2=12	6X1=6
(6 Practical/ Tutorials*)		
Two papers- Discipline 1 specific		
Two papers- Discipline 2 specific		
Two papers- Generic (Inter disciplinary)		
Two papers from each discipline of choice including papers of interdisciplinary nature.		
III. Ability Enhancement Courses		
1**. Ability Enhancement Compulsory**	2 X 2=4	2 X 2=4
(2 Papers of 2 credits each)		
Environmental Science		
English Communication/MIL		
2**. Ability Enhancement Elective**	4 X 2=8	4 X 2=8
(Skill Based)		
(4 Papers of 2 credits each)		
	Total credit= 120	**Total = 120**

- **Optional Dissertation or project work in place of one elective paper (6 credits) in 6th Semester**

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

***wherever there is a practical there will be no tutorial and vice-versa.**

Sl. No.	CORE COURSE (12)	Ability Enhancement Compulsory Course	Skill Enhancement Course (SEC) (2)	Discipline Specific Elective DSE (6)
I	Calculus			
II	Algebra			
III	Analytic Geometry and Applied Algebra		SEC-1 LaTeX and HTML	
IV	Analysis		SEC-2 Computer Algebra Systems and Related Softwares	
V			SEC-3 Operating System: Linux	DSE-1 (I) Differential Equations or (ii) Discrete Mathematics
VI			SEC-4 Transportation and Game Theory	DSE-2 (I) Numerical Analysis or (ii) Statistics

Semester-I

Paper I Calculus
Five Lectures per week + Tutorial as per University rules
Max. Marks 100 (including internal assessment)
Examination 3 hrs.

SECTION – I
Limit and.Continuity, Types of discontinuities. Differentiability of functions. Successive differentiation, Leibnitz.s theorem, Partial differentiation, Euler's theorem on homogeneous functions.

SECTION - II
Tangents and normals, Curvature, Asymptotes, Singular points, Tracing of curves.

SECTION – III

Rolle.s theorem, Mean Value Theorems, Taylor's Theorem with Lagrange's *&* Cauchy's forms of remainder. Taylor's series, Maclaurin's series of sin x, cos x, e^x, log(l+x), $(l+x)^m$, Applications of Mean Value theorems to Monotonic functions and inequalities. Maxima & Minima. Indeterminate forms.

Books Recommended:

1. George B. Thomas, Jr., Ross L. Finney : *Calculus and Analytic Geometry*, Pearson Education (Singapore); 2001.
2. H. Anton, I. Bivens and S. Davis : Calculus, John Wiley and Sons (Asia) Pte. Ltd. 2002.
3. R.G. Bartle and D.R. Sherbert : Introduction to Real Analysis, John Wiley and Sons (Asia) Pte. Ltd. 1982

Semester-II

Paper II **Algebra**
Five Lectures per week + Tutorial as per University rules
Max. Marks 100 (including internal assessment)
Examination 3 hrs.

SECTION - I
Definition and examples of a vector space, Subspace and its properties, Linear independence and dependence of vectors, basis and dimension of a vector space. 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. Cayley-Hamilton theorem, Characteristic roots and vectors.

SECTION - II
De Moivre.s theorem (both integral and rational index). Solutions of equations using trigonometry, Expansion for Cos nx. Sin nx in terms of powers of Sin x, Cosx, and $Cos^n x$, $Sin^n x$ in terms of Cosine and Sine of multiples of x, Summation of series, Relation between roots and coefficients of n^{th} degree equation. Solutions of cubic and biquadratic equations, when some conditions on roots of the equation are given, Symmetric functions of the roots for cubic and biquadratic equations.

SECTION - III
Integers modulo n, Permutations, Groups, subgroups, Lagrange's Theorem, Euler's Theorem, Symmetry Groups of a segment of a line, and regular n-gons for n=3, 4, 5 and 6. Rings and subrings in the context of C[0,1] and Z_n.

Recommended Books:
1. Abstract Algebra with a Concrete Introduction, John A. Beachy and William D. Blair, Prentice Hall, 1990.
2. Modern Abstract Algebra with Applications, W.J. Gilbert, John Wiley & Sons 1976.

Semester-III

Paper III : **Analytic Geometry and Applied Algebra**
Five Lectures per week + Tutorial as per University rules
Max. Marks 100 (including internal assessment)
Examination 3 hrs.

SECTION-I : Geometry
Techniques for sketching parabola, ellipse and hyperbola. Reflection properties of parabola, ellipse and hyperbola and their applications to signals, classification of quadratic equation representing lines, parabola, ellipse and hyperbola.

SECTION-II : 3-Dimensional Geometry and Vectors
Rectangular coordinates in 3-space; spheres, cylindrical surfaces cones. Vectors viewed geometrically, vectors in coordinate system, vectors determine by length and angle, dot product, cross product and their geometrical properties. Parametric equations of lines in plane, planes in 3-space.

SECTION - III : Applied Algebra
Latin Squares, Table for a finite group as a Latin Square, Latin squares as in Design of experiments, Mathematical models for Matching jobs, Spelling Checker, Network Reliability, Street surveillance, Scheduling Meetings, Interval Graph Modelling and Influence Model, Picher Pouring Puzzle,.

Recommended Books:
1. Calculus, H. Anton, 1. Birens and S.Davis, John Wiley and Sons, Inc. 2002.
2. Applied Combinatorics, A Tucker, John Waley & Sons, 2003.

Semester-IV

Paper IV : **Analysis**
Five Lectures per week + Tutorial as per University rules
Max. Marks 100 (including internal assessment)
Examination 3 hrs.

SECTION-I
Order completeness of Real numbers, open and closed sets, limit point of sets, Bolzano Weierstrass Theorem, properties of continuous functions, Uniform continuity.

SECTION-II
Sequences, convergent and Cauchy sequences, sub-sequences, limit superior and limit inferior of a sequence, monotonically increasing and decreasing sequences, infinite series and their convergences, positive term series, comparison tests, Cauchy's nth root test, D. Alembert's ratio test, Raabe's test, alternating series, Leibnitz's test, absolute and conditional convergence.

SECTION-III
Riemann integral, integrability of continuous and monotonic functions

Books Recommended:
1. R.G. Bartle and D.R.Sherbert, Introduction to Real Analysis, John Wiley and Sons (Asia) Pvt. Ltd., 2000.
2. Richard Courant & Fritz John, Introduction to Calculus and Analysis I, Springer-Verlag, 1999.
3. S. K. Berbarian, Real Analysis, Springer - Verlag, 2000.

Semester-V

DSE-1

(I) Differential Equations

or

(ii) Discrete Mathematics

Paper V **Differential Equations**
Five Lectures per week + Tutorial as per University rules
Max. Marks 100 (including internal assessment)
Examination 3 hrs.

Ordinary differential equations
First order exact differential equations including rules for finding integrating factors, first order higher degree equations solvable for x, y, p, Wronskian and its properties, Linear homogeneous equations with constant coefficients, Linear non-homogeneous equations. The method of variation of parameters. Euler's equations. Simultaneous differential equations. Total differential equations.

Partial differential equations
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 equations of first order, Lagrange.s method, Charpit.s method, classification of second order partial differential equations into elliptic, parabolic and hyperbolic through illustrations only.

Recommended Books:
1. Calculus, H. Anton, 1. Birens and S.Davis, John Wiley and Sons, Inc. 2002.
2. Differential Equations, S.L.Ross, John Wiley and Sons, Third Edition, 1984.
3. Elements of Partial Differential Equations, I.Sneddon, McGraw-Hill International Editions, 1967.

or

Paper V **Discrete Mathematics**

Five Lectures per week + Tutorial as per University rules
Max. Marks 100 (including internal assessment)
Examination 3 hrs.

SECTION-I

Definition, examples and properties of posets, maps between posets, Algebraic lattice, lattice as a poset, duality principal, sublattice ,Hasse diagram. Products and homomorphisms of lattices, Distributive lattice, complemented lattice.
Boolean Algebra, Boolean polynomial, CN form, DN form.

SECTION-II

Simplification of Boolean polynomials, Karnaugh diagram. Switching Circuits and its applications. Finding CN form and DN form, Graphs, subgraph, complete graph, bipartite graph, degree sequence, Euler's theorem for sum of degrees of all vertices.

SECTION-III

Eulerian circuit, Seven bridge problem, Hamiltonian cycle, Adjacency matrix.
Dijkstra's shortest path algorithm (improved version). Chinese postman problem, Digraphs. Definitions and examples of tree and spanning tree , Kruskal's algorithm to find the minimum spanning tree. Planar graphs, coloring of a graph and chromatic number.

References:

[1] Applied Abstract Algebra (2nd Edition) Rudolf Lidl, Gunter Pilz, Springer, 1997.
[2] Discrete Mathematics with Graph Theory (3rd Edition) Edgar G. Goodaire, Michael M. Parmenter, Pearson, 2005.
[3] Discrete Mathematics and its applications with combinatorics and graph theory by Kenneth H Rosen (7th Edition), Tata McGrawHill Education private Limited, 2011.

Semester-VI

DSE-2

(I) Numerical Analysis

or

(ii) Statistics

Paper VI **Numerical Analysis**
Five Lectures per week + Tutorial as per University rules
Max. Marks 100 (including internal assessment)
Examination 3 hrs.

Section-I

Significant digits, Error, Order of a method, Convergence and terminal conditions, Efficient computations Bisection method, Secant method, RegulaFalsi method, Newton Raphson method, Newton's method for solving nonlinear systems

Section-II

Gauss elimination method (with row pivoting) and Gauss□Jordan method, Gauss Thomas method for tridiagonal systems Iterative methods: Jacobi and Gauss-Seidel iterative methods Interpolation: Lagrange's form and Newton's form Finite difference operators, Gregory Newton forward and backward differences Interpolation

Section-III

Numerical differentiation: First derivatives and second order derivatives, Numerical integration: Trapezoid rule, Simpson's rule (only method), Newton□Cotes open formulas, Extrapolation methods: Romberg integration, Gaussian quadrature, Ordinary differential equation: Euler's method Modified Euler's methods: Heun method and Mid-point method, Runge-Kutta second methods: Heun method without iteration, Mid-point method and Ralston's method Classical 4^{th} order Runge-Kutta method, Finite difference method for linear ODE

REFERNCES:

[1] Laurence V. Fausett, Applied Numerical Analysis, Using MATLAB, Pearson, 2/e (2012)
[2] M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age International Publisher, 6/e (2012)
[3] Steven C Chapra, Applied Numerical Methods with MATLAB for Engineers and Scientists, Tata McGraw Hill, 2/e (2010)

Or

Paper VI **Statistics**
Five Lectures per week + Tutorial as per University rules
Max. Marks 100 (including internal assessment)
Examination 3 hrs.

Section-I

Probability Classical, relative frequency and axiomatic approaches to probability. Theorems of total and compound probability. Conditional probability, independent events, Bayes Theorem. Random Variables. Discrete and continuous random variables, Distribution function, Expectation of a random variable, Moments, moment generating functions.

Section-II

Discrete and continuous distribution, Bionomial, Poisson, geometric. Normal and exponential distributions, bivariate distribution, conditional distribution and marginal distribution, Correlation and regression for two variables, weak law of large numbers, central limit theorem for independent and identically distributed random variables.

Section-III

Statistical inference, definition of random sample, parameter and statistic concept of sampling distribution standard error, sampling distribution of mean variance of random sample from a normal population, Test of significance based on F and chi-square distribution t and F.

REFERENCES:

1. Robert V. Hogg, Joseph W. Mc Kean and Allen T. Craig. Introduction of Mathematical Statistics, Pearson Education, Asia, 2007
2. Irvin Miller and Marylees Miller, John E. Freund's Mathematical Statistics with Applications (7_{th}Ed$_n$), Pearson Education, Asia, 2006.
3. Sheldon Ross, Introduction to Probability Models (9_{th} Edition), Academic Press, Indian Reprint, 2007

Skill Enhancement Course Papers

SEC-1 LaTeX and HTML
2L+ 2Practical per week

Elements of LaTeX; Hands-on-training of LaTex; graphics in LaTeX; PSTricks; Beamer presentation; HTML, creating simple web pages, images and links, design of web pages.

[1] Chapter 9-11, 15

Practical

Six practical should be done by each student. The teacher can assign practical from the exercises from [1].

References:

[1] Martin J. Erickson and Donald Bindner, A Student's Guide to the Study, Practice, and Tools of Modern Mathematics, CRC Press, Boca Raton, FL, 2011.
[2] L. Lamport. LATEX: A Document Preparation System, User's Guide and ReferenceManual. Addison-Wesley, New York, second edition, 1994.

SEC-2 Computer Algebra Systems and Related Softwares
2L+ 2Practical per week

Use of Mathematica, Maple, and Maxima as calculator, in computing functions, in making graphs; MATLAB/Octave for exploring linear algebra and to plot curve and surfaces; the statistical software R: R as a calculator, explore data and relations, testing hypotheses, generate table values and simulate data, plotting.

[1] Chapter 12-14

Practical

Six practical should be done by each student. The teacher can assign practical from the exercises from [1].

References:

[1] Martin J. Erickson and Donald Bindner, A Student's Guide to the Study, Practice, and Tools of Modern Mathematics, CRC Press, Boca Raton, FL, 2011.
[2] L. Lamport. LATEX: A Document Preparation System, User's Guide and ReferenceManual. Addison-Wesley, New York, second edition, 1994.

SEC-3 Operating System: Linux
2L+ 2Practical per week

The Operating System: Linux history, Linux features, Linux distributions, Linux's relationship to Unix, Overview of Linux architecture, Installation, Start up scripts, system processes (an overview), Linux Security, The Ext2 and Ext3 File systems: General Characteristics of, The Ext3 File system, file permissions. User Management: Types of users, the powers of Root, managing users (adding and deleting): using the command line and GUI tools. Resource Management in Linux: file and directory management, system calls for files Process Management, Signals, IPC: Pipes, FIFOs, System V IPC, Message Queues, system calls for processes, Memory Management, library and system calls for memory.

References:

[1] Arnold Robbins, Linux Programming by Examples The Fundamentals, 2nd Ed., Pearson Education, 2008.
[2] Cox K, Red Hat Linux Administrator's Guide, PHI, 2009.
[3] R. Stevens, UNIX Network Programming, 3rd Ed., PHI, 2008.
[4] Sumitabha Das, Unix Concepts and Applications, 4th Ed., TMH, 2009.
[5] Ellen Siever, Stephen Figgins, Robert Love, Arnold Robbins, Linux in a Nutshell, 6th Ed., O'Reilly Media, 2009.
[6] Neil Matthew, Richard Stones, Alan Cox, Beginning Linux Programming, 3rd Ed., 2004.

SEC-4 Transportation and Game Theory
2L+ 1 Tutorial per week

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

References:

[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.

S. No.	Existing	Proposed
1	Skill Enhancement Courses (SEC) offered to B.Sc. (H) Mathematics (in 3rd and 4th Semester) are of 3 Credits	Since these courses should of 4 Credits according to UGC Guidelines, amendments have been made in the existing Courses to make them of 4 Credits
2	Skill Enhancement Courses (SEC) offered to B.A./ B.Sc. Programme (in 3rd, 4th, 5th and 6th Semesters) are of 3 Credits	Since these courses should of 4 Credits according to UGC Guidelines, amendments have been made in the existing Courses to make them of 4 Credits
3	Only One Generic Elective Paper is offered (in 1st, 2nd and 3rd Semester) to students of B.Sc. (H), B.A. (H) & B.Com (H) other than B.Sc. (H) Mathematics.	Two Generic Elective Papers are now offered each semester to students of B.Sc. (H), B.A. (H) & B.Com (H) other than B.Sc. (H) Mathematics.
4	No Generic Elective papers were being offered to students of B.A, B.Sc. & B.Com Programme in the 5th and 6th Semester	Generic Elective papers are now offered to students of B.A, B.Sc. & B.Com Programme in the 5th and 6th Semester

15/6/16

Annexure - I

SKILL ENHANCEMENT COURSES (SEC)
IN
B.A/ B.Sc. PROGRAMME

Semester	Core Course (12)	Ability Enhancement Compulsory Course (AECC) (2)	Skill Enhancement Course (SEC) (4)	Discipline Specific Elective (DSE) (4)	Generic Elective (GE) (2)
I					
II					
III			SEC-1 **(Mathematical Typesetting System: LaTeX)**		
IV			SEC-2 **(Computer Algebra Systems)**		
V			SEC-3 **(Statistical Software: R)**		
VI			SEC-4 **(Transportation and Network Flow Problems)**		

17/7/16

SEC-1: Mathematical Typesetting System: LaTeX

4 Credits (2 Lectures + 4 Practical per week)
Theory: 50 marks (including internal assessment)
Practical: 50 marks

Introduction to TeX and LaTeX, typesetting a simple document, adding basic information to documents, environments, footnotes, sectioning and displayed material

Assents and symbols, Mathematical Typesetting (Elementary and Advanced): subscript/ superscript, fractions, roots, ellipsis, mathematical symbols, arrays, delimiters, multiline formulas, spacing and changing style in math mode

Graphics in LaTeX, simple pictures using PS Tricks, Plotting of functions

Beamer Presentation

[1] Chapter 9 (9.1-9.8), Chapter 10 (10.1-10.3), Chapter 11 (11.1-11.4)
[2] Chapter 2 (2.1-2.5), Chapter 3 (3.1-3.3), Chapter 7 (7.1-7.2)

Practical
(Ideal Lab Practical Batch Size: 15-20 Students)
[1] Chapter 9 (Exercises 4-10), Chapter 10 (Exercises 1, 3, 4, 6-9), Chapter 11 (1, 3, 4, 5).

References:
[1] Martin J. Erickson and Donald Bindner, *A Student's Guide to the Study, Practice, and Tools of Modern Mathematics*, CRC Press, Boca Raton, FL, 2011.
[2] L. Lamport, *LATEX: A Document Preparation System, User's Guide and Reference Manual*. Addison-Wesley, New York, 2nd edition, 1994.

SEC-2: Computer Algebra Systems

4 Credits (2 **Lectures + 4 Practical per week)**
Theory: 50 marks (including internal assessment)
Practical: 50 marks

Computer Algebra Systems (CAS), use of a CAS as a calculator

Computing and plotting functions in 2D, Customizing Plots, Animating plots, producing table of values, working with piecewise defined functions, combining graphics

Simple Programming in a CAS

Applications in Algebra: Factoring, expanding and finding roots of polynomials, working with rational and trigonometric functions, solving general equations

Applications in Calculus: Computing limits, first and higher order derivatives, maxima and minima, integration, computing definite and indefinite integrals

Working with matrices, performing gauss elimination, operations (transpose, determinant, inverse), minors and cofactors, solving system of linear equations, rank and nullity of a matrix, eigenvalue, eigenvector and diagonalization

[1] Chapter 12 (12.1-12.5)
[2] Chapter 1, Chapter 3 (3.1-3.6, 3.8), Chapter 4 (4.1-4.3, 4.5-4.7, 4.9), Chapter 5 (5.1, 5.3, 5.5, 5.6, 5.10, 5.11), Chapter 7 (7.1-7.4, 7.6-7.8)
Note: Theoretical and Practical demonstration should be carried out only in one of the CAS: Maxima/ Mathematica/ Maple or any other.

Practical
(Ideal Lab Practical Batch Size: 15-20 Students)
[1] Chapter 12 (Exercises 1-4, 8-12)
[2] Chapter 3 [Exercises 3.2 (1), 3.3 (1, 2, 4), 3.4 (1, 2), 3.5 (1-4), 3.6 (2, 3)], Chapter 4 [Exercises 4.1, 4.2, 4.5, 4.7, 4.9], Chapter 5 [Exercises 5.1 (1), 5.3, 5.5, 5.6 (1, 2, 4), 5.10 (1, 3), 5.11 (1, 2)], Chapter 7 [Exercises 7.1 (1), 7.2, 7.3 (2), 7.4 (1), 7.6]

References:
[1] Martin J. Erickson and Donald Bindner, *A Student's Guide to the Study, Practice, and Tools of Modern Mathematics*, CRC Press, Boca Raton, FL, 2011.
[2] Bruce F. Torrence and Eve A. Torrence, *The Student's Introduction to MATHEMATICA: A Handbook for Precalculus, Calculus, and Linear Algebra*, Cambridge University Press, 2009.

SEC-3: Statistical Software: R

4 Credits (2 **Lectures + 4 Practical per week)**
Theory: 50 marks (including internal assessment)
Practical: 50 marks

Introducing R, Using R as a calculator, Reading and getting data into R: combine and scan commands, viewing named objects and removing objects from R, types and structure of data items with their properties, working with history commands, saving work in R

Manipulating vectors, data frames, matrices and lists, viewing objects within objects, constructing data objects and their conversions

Summary commands, Summary statistics for vectors, data frames, matrices and lists, summary tables

Stem and leaf Plot, Histogram, density function and its plotting

Plotting in R, Box-whisker Plots, Scatter Plot, Pairs Plot, line charts, Pie Chart, Cleveland Dot Charts, Bar Charts, saving graphs

[1] Chapter 14 (14.1-14.4, 14.7)
[2] Chapters 2-5, 7

Practical
(Ideal Lab Practical Batch Size: 15-20 Students)

[1] Chapter 14 (Exercises 1-3)
[2] Relevant exercises of Chapters 2-5, 7
The practical may be done on the database to be downloaded from https://data.gov.in/

References:

[1] Martin J. Erickson and Donald Bindner, *A Student's Guide to the Study, Practice, and Tools of Modern Mathematics*, CRC Press, Boca Raton, FL, 2011.
[2] M. Gardener, *Beginning R: The Statistical Programming Language*, Wiley Publications, 2012.

SEC-4: Transportation and Network Flow Problems

4 Credits (3 **Lectures + 2 Practical per week)**
Theory: 75 marks (including internal assessment)
Practical: 25 marks

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, transshipment problem

Network models, shortest-path problem, minimum spanning tree problem, maximum flow problem, minimum cost flow problem, project network, CPM and PERT

Practical
(Ideal Lab Practical Batch Size: 15-20 Students)

Use TORA/ Excel spreadsheet to solve transportation problem, assignment problem, shortest-path problem, minimum spanning tree problem, maximum flow problem, CPM and PERT calculations of exercises from [1].
Case 8.1: Shipping Wood to Market, and Case 8.3: Project Pickings from [2].

References:

[1] Hamdy A. Taha, Operations Research, An Introduction, Prentice-Hall, 9th Ed., 2010.
[2] F. S. Hillier and G. J. Lieberman, Introduction to Operations Research-concepts and cases 9th Ed., Tata McGraw Hill, 2010
[3] Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and Network Flows, 4th Ed., John Wiley and Sons, India, 2010