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 (CBS):
The CBS 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.Sc.)

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
<th>Theory+ Practical</th>
<th>Theory+ Tutorials</th>
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</thead>
<tbody>
<tr>
<td><strong>I. Core Course</strong></td>
<td>(12 Papers)</td>
<td>12X4=48</td>
<td>12X5=60</td>
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<tr>
<td>(12 Papers)</td>
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<tr>
<td>04 Courses from each of the</td>
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<tr>
<td>03 disciplines of choice</td>
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<tr>
<td>Core Course Practical / Tutorial*</td>
<td>12X2=24</td>
<td>12X1=12</td>
<td></td>
</tr>
<tr>
<td>(12 Practical/ Tutorials*)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>04 Courses from each of the</td>
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<tr>
<td>03 Disciplines of choice</td>
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<tr>
<td><strong>II. Elective Course</strong></td>
<td>(6 Papers)</td>
<td>6x4=24</td>
<td>6X5=30</td>
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<tr>
<td>(6 Papers)</td>
<td></td>
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<tr>
<td>Two papers from each discipline of choice</td>
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<tr>
<td>including paper of interdisciplinary nature.</td>
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<td></td>
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</tr>
<tr>
<td>Elective Course Practical / Tutorials*</td>
<td>6 X 2=12</td>
<td>6X1=6</td>
<td></td>
</tr>
<tr>
<td>(6 Practical / Tutorials*)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two Papers from each discipline of choice</td>
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<td></td>
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<tr>
<td>including paper of interdisciplinary nature.</td>
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<tr>
<td>- Optional Dissertation or project work in place of one Discipline elective paper (6 credits) in 6th Semester</td>
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<tr>
<td><strong>III. Ability Enhancement Courses</strong></td>
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<td></td>
</tr>
<tr>
<td>1. Ability Enhancement Compulsory</td>
<td>2 X 2=4</td>
<td>2X2=4</td>
<td></td>
</tr>
<tr>
<td>(2 Papers of 2 credits each)</td>
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<td></td>
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<tr>
<td>Environmental Science</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>English/MIL Communication</td>
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<tr>
<td>2. Ability Enhancement Elective</td>
<td>4 X 2=8</td>
<td>4 X 2=8</td>
<td></td>
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<tr>
<td>(Skill Based)</td>
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<tr>
<td>(4 Papers of 2 credits each)</td>
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<tr>
<td>Total credit= 120</td>
<td>Total credit= 120</td>
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</table>

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*
**Structure of B.Sc. Mathematical Sciences**

**Choice Based Credit System (CBCS)**

(a) Six papers of Mathematics are compulsory, one in each semester. There are four core courses and two disciplines elective for each discipline.

(b) Six papers each from two of the following three disciplines: Statistics, Operational Research, and Computer Science.

(c) Two skill based papers to be chosen from any of the four disciplines.

### SEMESTER – I

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>Maths –I</td>
</tr>
<tr>
<td>OR-I, CS-I</td>
</tr>
<tr>
<td>or</td>
</tr>
<tr>
<td>CS-I, Stats-I</td>
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<tr>
<td>or</td>
</tr>
<tr>
<td>Stats-I, OR-I</td>
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</table>

**Ability Enhancement Course**

### SEMESTER – II

<table>
<thead>
<tr>
<th>Course</th>
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</thead>
<tbody>
<tr>
<td>Maths –II</td>
</tr>
<tr>
<td>OR-II, CS-II</td>
</tr>
<tr>
<td>or</td>
</tr>
<tr>
<td>CS-II, Stats-II</td>
</tr>
<tr>
<td>or</td>
</tr>
<tr>
<td>Stats-II, OR-II</td>
</tr>
</tbody>
</table>

**Ability Enhancement Course**

### SEMESTER – III

<table>
<thead>
<tr>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maths –III</td>
</tr>
<tr>
<td>OR-III, CS-III</td>
</tr>
<tr>
<td>or</td>
</tr>
<tr>
<td>CS-III, Stats-III</td>
</tr>
<tr>
<td>or</td>
</tr>
<tr>
<td>Stats-III, OR-III</td>
</tr>
</tbody>
</table>

**Skill Enhancement Course**

SEC MT-1/SEC OR-1/ SEC CS-1/ SEC ST-1
### SEMESTER – IV

<table>
<thead>
<tr>
<th>Skill Enhancement Course-2</th>
<th>Maths –IV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR-IV, CS-IV</td>
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<tr>
<td></td>
<td>or CS-IV, Stats-IV</td>
</tr>
<tr>
<td></td>
<td>or Stats-IV, OR-IV</td>
</tr>
</tbody>
</table>

### SEMESTER – V

<table>
<thead>
<tr>
<th>Skill Enhancement Course-3</th>
<th>Maths DSE-1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR, CS, DSE 1</td>
</tr>
<tr>
<td></td>
<td>or CS, Stats, DSE 1</td>
</tr>
<tr>
<td></td>
<td>or Stats, OR, DSE 1</td>
</tr>
</tbody>
</table>

### SEMESTER – VI

<table>
<thead>
<tr>
<th>Skill Enhancement Course-4</th>
<th>Maths DSE-2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR, CS, DSE 2</td>
</tr>
<tr>
<td></td>
<td>or CS, Stats, DSE 2</td>
</tr>
<tr>
<td></td>
<td>or Stats, OR, DSE 2</td>
</tr>
</tbody>
</table>
MATHEMATICS Papers for

B.Sc. Mathematical Sciences

Semester-I

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

Unit I. 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 eigenvalues and eigenvectors
for such transformations and eigenspaces as invariant subspaces. 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.

Unit II. Calculus
Sequences to be introduced through the examples arising in Science beginning
with finite sequences, followed by concepts of recursion and difference
equations. For instance, the sequence arising from Tower of Hanoi game, the
Fibonacci sequence arising from branching habit of trees and breeding habit of
rabbits. Convergence of a sequence and algebra of convergent sequences.
Illustration of proof of convergence of some simple sequences such as (–1)n/n,
ln², (1+1/n)n, sin n/n, xⁿ with 0 < x < 1. Graphs of simple concrete functions such
as polynomial, trigonometric, inverse trigonometric, exponential, logarithmic and
hyperbolic functions arising in problems or chemical reaction, simple pendulum,
radioactive decay, temperature cooling/heating problem and biological
rhythms. Successive differentiation. Leibnitz theorem. Recursion formulae for
higher derivative. Functions of two variables. Graphs and Level Curves of
functions of two variables. Partial differentiation upto second order.
Computation of Taylor’s Maclaurin’s series of functions such as eˣ,
log(1 + x), sin (2x), cos x. Their use in polynomial approximation and error
estimation.Formation and solution of Differential equations arising in population
growth, radioactive decay, administration of medicine and cell division.
Unit III.

Geometrical representation of addition, subtraction, multiplication and division of complex numbers. Lines half planes, circles, discs in terms of complex variables. Statement of the Fundamental Theorem of Algebra and its consequences, De Moivre’s theorem for rational indices and its simple applications.

Recommended Books
Semester-II

Paper II  Calculus and Geometry

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

Unit I: Calculus

Unit II: Geometry and Vector Calculus

Recommended Books
Semester-III

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

**Groups:** Definition and examples of groups, examples of abelian and nonabelian 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 $GL(n,\mathbb{R})$, groups of symmetries of (i) an isosceles triangle, (ii) an equilateral triangle, (iii) a rectangle, and (iv) a square, the permutation group $Sym(n)$, Group of quaternions, 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.

**Rings:** Definition an examples of rings, examples of commutative and noncommutative 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.

**Vector spaces:** Definition and examples of vector spaces. Subspaces and its properties Linear independence, basis, invariance of basis size, dimension of a vector space. Linear Transformations on real and complex vector spaces: definition, examples, kernel, range, rank, nullity, isomorphism theorems.

**Recommended Books**

Semester-IV

Paper IV  Real Analysis

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

Unit I: Real Sequences
Finite and infinite sets, examples of countable and uncountable sets. Real line, bounded sets, suprema and infima, statement of order completeness property of \( \mathbb{R} \), Archimedean property of \( \mathbb{R} \), intervals. Concept of cluster points and statement of Bolzano Weierstrass’ theorem. Cauchy convergence criterion for sequences. Cauchy’s theorem on limits, order preservation and squeeze theorem, monotone sequences and their convergence.

Unit II: Infinite Series
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. Definition and examples of absolute and conditional convergence. Sequences and series of functions, Pointwise and uniform convergence. M-test, change or order of limits. Power Series: radius of convergence, . Definition in terms of Power series and their properties of \( \exp(x) \), \( \sin(x) \), \( \cos(x) \).

Unit III: Riemann Integration
Riemann integral, integrability of continuous and monotonic functions

Recommended Books
Semester-V

DSE-1

(I) Differential Equations

Or

(ii) Mechanics and 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

Partial Differential Equations

Recommended Books

Paper V **Mechanics and Discrete Mathematics**

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

**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.

**Graph Theory**

Types of graphs: Simple graph, Directed graph, Multi graph, and Pseudo graph.  
Graph modeling, terminology and basics. Special Graphs: Complete Graph, Cycles, n-dimensional cubes, Bipartite Graph, Complete Bipartite Graph.

Subgraph and basic algebraic operations on graphs, connectivity, path, cycles, tree to be introduced as a connected graph with no cycles, introduction to shortest path (least number of edges) problem, solution of shortest path problem for simple graphs using complete enumeration. Euler and Hamiltonian graphs (for undirected graphs only): Koenigsburg Bridge Problem, statements and interpretations of (i) necessary and sufficient conditions for Euler cycles and paths (ii) sufficient condition for Hamiltonian cycles, finding Euler cycles and Hamiltonian cycles in a given graph.

**Recommended Books**

Semester-VI

DSE-2

(I) Numerical Methods

or

(ii) Probability and Statistics

Paper VI Numerical Methods

Five Lectures per week + Tutorial as per University rules

Max. Marks 100 (including internal assessment)

Examination 3 hrs

Unit-I


Unit-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

Unit-III


REFERENCES:


Or

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

Unit-I

Unit-II

Unit-III
Linear regression for two variables, The rank correlation coefficient. Chebyshev’s inequality, statement and interpretation of (weak) law of large numbers and strong law of large numbers. Central Limit Theorem for independent and identically distributed random variables with finite variance.

REFERENCES:

* Probability and Statistics will be offered to only those students who have not opted Statistics as a discipline
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:

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


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


References: