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
(For B.Sc. (Prog.) Physical Sciences /Applied Physical Sciences)

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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.Sc.)

Course	***Credits**	
	Theory+ Practical	Theory+Tutorials
I. Core Course	12X4= 48	12X5=60
(12 Papers)		
04 Courses from each of the		
03 disciplines of choice		
Core Course Practical / Tutorial*	12X2=24	12X1=12
(12 Practical/ Tutorials*)		
04 Courses from each of the		
03 Disciplines of choice		
II. Elective Course	6x4=24	6X5=30
(6 Papers)		
Two papers from each discipline of choice		
including paper of interdisciplinary nature.		
Elective Course Practical / Tutorials*	6 X 2=12	6X1=6
(6 Practical / Tutorials*)		
Two Papers from each discipline of choice		
including paper of interdisciplinary nature		
III. Ability Enhancement Courses		
1**. Ability Enhancement Compulsory**	2 X 2=4	2X2=4
(2 Papers of 2 credits each)		
Environmental Science		
English/MIL Communication		
2**. Ability Enhancement Elective**	4 X 2=8	4 X 2=8
(Skill Based)		
(4 Papers of 2 credits each)		
	Total credit= 120	**Total credit= 120**

- **Optional Dissertation or project work in place of one Discipline 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 practical there will be no tutorials and vice -versa**

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

MATHEMATICS Papers for

B.Sc.(Prog.) Physical 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, R^2, R^3 as vector spaces over R . Standard basis for each of them. Concept of Linear Independence and examples of different bases. Subspaces of R^2, R^3. 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 $(-1)^n/n$, I/n^2, $(1+1/n)^n$, sin n/n, x^n 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 e^x, 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 Algerbra and its consequences, De Moivre's theorem for rational indices and its simple applications.

Recommended Books

1. George B. Thomas, Jr., Ross L. Finney : *Calculus and Analytic Geometry*, Pearson Education (Singapore); 2001.
2. T.M. Apostal : *Calculus, vol. 1,* John Wiley and Sons (Asia) : 2002.
3. A.I. Kostrikin: *Introduction to Algebra*, Springer Verlag, 1984.

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

Limit and continuity of a function: (ε-δ and sequential approach). Properties of continuous functions including intermediate value theorem, Differentiability, Rolle's theorem, Lagrange's mean value theorem, Cauchy mean value theorem with geometrical interpretations. Uniform continuity. Definitions and techniques for finding asymptotes singular points, Tracing of standard curves. Integration of irrational functions. Reduction formulae. Rectification. Quadrature. Volumes.

Unit II: Geometry and Vector Calculus

Techniques for sketching parabola, ellipse and hyperbola. Reflection properties of parabola, ellipse and hyperbola . Classification of quadratic equations representing lines, parabola, ellipse and hyperbola. Differentiation of vector valued functions, gradient, divergence, curl and their geometrical interpretation. Spheres, Cylindrical surfaces. Illustrations of graphing standard quadric surfaces like cone, ellipsoid.

Recommended Books

1. H. Anton, I. Bivens and S. Davis: *Calculus*, John Wiley and Sons (Asia) Pte. Ltd. 2002.
2. R.G. Bartle and D.R. Sherbert : *Introduction to Real Analysis* , John Wiley and Sons (Asia) Pte, Ltd; 1982

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 Zn 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,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, 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: Z_p, Q, R, and 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

1. Joseph A Gallian: *Contemporary Abstract Algebra*, fourth edition, Narosa, 1999.
2. George E Andrews: *Number Theory*, Hindustan Publishing Corporation. 1984
3. . C.W. Curtis, *Linear Algebra, an introductory approach*, Springer-Verlag, 1991.
4. . David M. Blotin, *Linear algebra and Geometry*, Cambridge Press, 1979.

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 R, Archimedean property of 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
1. T. M. Apostol, Calculus, Voulme-1, *John Wiley and Sons* (Asia) Pte Ltd., 2002.
2. R.G. Bartle and D. R Sherbert: *Introduction to real analysis,* John Wiley and Sons (Asia) Pte. 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.

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

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

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 equation 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. Shepley L. Ross: *Differential equations*, Third edition, John Wiley and Sons, 1984
2. I. Sneddon: *Elements of partial differential equations*, McGraw-Hill, International Edition, 1967.

or

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) suficient condition for Hamiltonian cycles, finding Euler cycles and Hamiltonian cycles in a given graph.

Recommended Books

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.
3. K.H. Rosen, *Discrete mathematis and its applications*, McGraw-Hill International Editions, 1999.
4.. C.F. Gerald and P.O. Wheatley, *Applied Numerical Analysis,* Pearson Education Ind. 2004.

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

Floating point representation and computer arithmetic, Significant digits, Errors: Roundoff error, Local truncation error, Global truncation error, Order of a method, Convergence and terminal conditions, Efficient computations Bisection method, Secant method, Regula□Falsi method, Newton–Raphson method, Newton's method for solving nonlinear systems

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

Piecewise polynomial interpolation: Linear interpolation, Cubic spline interpolation (only method), Numerical differentiation: First derivatives and second order derivatives, Richardson extrapolation 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 **Probability and Statistics**
Five Lectures per week + Tutorial as per University rules
Max. Marks 100 (including internal assessment)
Examination 3 hrs

Unit-I

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, Geometric, Negative Binomial distributions. Continuous distributions: Uniform, Normal, Exponential, Gamma distributions

Unit-II

Joint cumulative distribution Function and its properties, Joint probability density functions – marginal and conditional distributions. Expectation of a function of two random variables, Conditional expectations, Independent random variables, Covariance and correlation coefficient.

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:

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.