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 B.A (Honors), B.Com (Honors) & B.Sc. (Honors)

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory+ Practical</td>
</tr>
<tr>
<td></td>
<td>140</td>
</tr>
</tbody>
</table>

**I. Core Course**

(14 Papers)  
Core Course Practical / Tutorial*  
14X2=56  
14X1=70

**II. Elective Course**

(8 Papers)

A.1. Discipline Specific Elective  
4X4=16  
4X5=20

A.2. Discipline Specific Elective Practical/ Tutorial*  
4 X 2=8  
4X1=4

B.1. Generic Elective/ Interdisciplinary  
4X4=16  
4X5=20

B.2. Generic Elective Practical/ Tutorial*  
4 X 2=8  
4X1=4

(4 Papers)

- Optional Dissertation or project work in place of one Discipline Specific Elective paper (6 credits) in 6th Semester

**III. Ability Enhancement Courses**

1. Ability Enhancement Compulsory

   (2 Papers of 2 credit each)  
   2 X 2=4  
   2 X 2=4

   - Environmental Science  
   - English/MIL Communication

2. Ability Enhancement Elective (Skill Based)

   (Minimum 2)  
   2 X 2=4  
   2 X 2=4

(2 Papers of 2 credit each)

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
## Structure

<table>
<thead>
<tr>
<th>Core Course (14)</th>
<th>Ability Enhancement Compulsory Course (AECC) (2)</th>
<th>Skill Enhancement Course (SEC) (2)</th>
<th>Elective Discipline Specific DSE (4)</th>
<th>Elective: Generic (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>C 1 Calculus (including practicals)</td>
<td></td>
<td></td>
<td>GE-1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(English communication/MIL)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>/Environmental Science</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C 2 Algebra</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>C 3 Real Analysis</td>
<td>(English communication/MIL)</td>
<td></td>
<td>GE-2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>/Environmental Science</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C 4 Differential Equations (including practicals)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>C 5 Theory of Real functions</td>
<td>SEC-1</td>
<td></td>
<td>GE-3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>LaTeX and</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Environment Science</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
<td>Module 1</td>
<td>Module 2</td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td>--------------------------------------------------</td>
<td>-----------------------------------------------</td>
<td>-----------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>C 6</td>
<td>Group Theory-I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C 7</td>
<td>Multivariate Calculus (including practicals)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>C 8 Partial Differential Equations</td>
<td>SEC-2 Computer Algebra Systems and Related Softwares</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(including practicals)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C 9 Riemann Integration &amp; Series of functions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C 10 Ring Theory &amp; Linear Algebra-I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>C 11 Metric Spaces</td>
<td>DSE-1 (including practicals)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(i) Numerical Methods</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>or</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) Mathematical Modeling and Graph Theory</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>or</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iii) C++ Programming</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>DSE-2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(i) Mathematical Finance</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>or</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) Discrete Mathematics</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C 12 Group Theory-II</td>
<td></td>
<td>or</td>
<td></td>
</tr>
<tr>
<td>--------</td>
<td>---------------------</td>
<td>--------</td>
<td>----</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(iii) Cryptography and Network Security</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>C 13 Complex Analysis (including practicals)</th>
<th></th>
<th>DSE-3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>(i) Probability theory &amp; Statistics</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>or</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(ii) Mechanics</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>or</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(iii) Bio-Mathematics</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>DSE-4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(i) Number Theory</td>
</tr>
<tr>
<td></td>
<td>or</td>
</tr>
<tr>
<td></td>
<td>(ii) Linear Programming and Theory of Games</td>
</tr>
<tr>
<td></td>
<td>or</td>
</tr>
<tr>
<td></td>
<td>(iii) Applications of Algebra</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>C 14 Ring Theory and Linear Algebra-II</th>
<th></th>
<th></th>
</tr>
</thead>
</table>
C1- Calculus (including practicals)

Total marks: 150
Theory: 75
Practical: 50
Internal Assessment: 25
5 Lectures, 4 Practicals (each in group of 15-20)

Hyperbolic functions, Higher order derivatives, Applications of Leibnitz rule.
[2]: Chapter 7 (Section 7.8)

The first derivative test, concavity and inflection points, Second derivative test, Curve sketching using first and second derivative test, limits at infinity, graphs with asymptotes. Graphs with asymptotes, L'Hopital's rule, applications in business, economics and life sciences.
[1]: Chapter 4 (Sections 4.3, 4.4, 4.5, 4.7)

Parametric representation of curves and tracing of parametric curves, Polar coordinates and tracing of curves in polar coordinates. Reduction formulae, derivations and illustrations of reduction formulae of the type , , , ,
[1]: Chapter 9 (Section 9.4)
[2]: Chapter 11(Section 11.1), Chapter 8 (Sections 8.2-8.3, pages 532-538 )

Volumes by slicing; disks and washers methods, Volumes by cylindrical shells. Arc length, arc length of parametric curves, Area of surface of revolution
[2]: Chapter 6 (Sections 6.2-6.5)
Techniques of sketching conics, reflection properties of conics, Rotation of axes and second degree equations, classification into conics using the discriminant
[2]: Chapter 11 (Section 11.4, 11.5) ( Statements of Theorems 11.5.1 and 11.5.2)

[1]: Chapter 10 (Sections 10.1-10.4)
[2]: Chapter 13 (Section 13.5)

Practical / Lab work to be performed on a computer:

Modeling of the following problems using Matlab / Mathematica / Maple etc.
1. Plotting of graphs of function of type (greatest integer function), , , (even and odd positive integer), (even and odd positive integer), (a positive integer) , , . Discuss the effect of and on the graph.
2. Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.
3. Sketching parametric curves.
4. Tracing of conics in Cartesian coordinates.
5. Obtaining surface of revolution of curves.
6. Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic paraboloid, hyperbolic paraboloid using Cartesian co-ordinates.
7. To find numbers between two real numbers and plotting of finite and infinite subset of R.
8. Matrix operations (addition, multiplication, inverse, transpose, determinant, rank, eigenvectors, eigenvalues, Characteristic equation and verification of Cayley Hamilton equation, system of linear equations)
9. Graph of Hyperbolic functions.
11. Complex numbers and their representations, operations like addition, multiplication, division, modulus. Graphical representation of polar form.

REFERENCES:
C2- Algebra

Total Marks: 100
Theory: 75
Internal Assessment: 25
5 Lectures, 1 Tutorial (per week per student)

Polar representation of complex numbers, nth roots of unity, De Moivre’s theorem for rational indices and its applications.
[1]: Chapter 2

Equivalence relations, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set, Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm, Congruence relation between integers, Principles of Mathematical Induction, statement of Fundamental Theorem of Arithmetic.
[2]: Chapter 2 (Section 2.4), Chapter 3, Chapter 4 (Sections 4.1 up to 4.1.6, 4.2 up to 4.2.11, 4.4 (till 4.4.8), 4.3.7 to 4.3.9), Chapter 5 (5.1.1, 5.1.4).

Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation $Ax = b$, solution sets of linear systems, applications of linear systems, linear independence. Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Subspaces of $\mathbb{R}^n$, dimension of subspaces of $\mathbb{R}^n$ and rank of a matrix, Eigen values, Eigen Vectors and Characteristic Equation of a matrix.
[3]: Chapter 1 (Sections 1.1-1.9), Chapter 2 (Sections 2.1-2.3, 2.8-2.9), Chapter 5 (Sections 5.1, 5.2).

REFERENCES:
1. Titu Andreescu and Dorin Andrica, Complex Numbers from A to .... Z, Birkhauser, 2006.
C3- Real Analysis

Total marks: 100
Theory: 75
Internal Assessment: 25
5 Lectures, 1 Tutorial (per week per student)

Algebraic and Order Properties of $\mathbb{R}$, d-neighborhood of a point in $\mathbb{R}$, Idea of countable sets, uncountable sets and uncountability of $\mathbb{R}$.

[1]: Chapter 1 (Section 1.3), Chapter 2 (Sections 2.1, 2.2.7, 2.2.8)

Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets, Suprema and Infima, The Completeness Property of $\mathbb{R}$, The Archimedean Property, Density of Rational (and Irrational) numbers in $\mathbb{R}$, Intervals.
[1]: Chapter 2 (Sections 2.3, 2.4, 2.5.)

Limit points of a set, Isolated points, Illustrations of Bolzano-Weierstrass theorem for sets.
[1]: Chapter 4 (Section 4.1)

[1]: Chapter 3 (Section 3.1-3.5)

[2]: Chapter 6 (Section 6.2)

REFERENCES:


**C4- Differential Equations (including practicals)**

Total marks: 150  
Theory: 75  
Practical: 50  
Internal Assessment: 25  
5 Lectures, 4 Practicals (each in group of 15-20)

Differential equations and mathematical models, order and degree of a differential equation, exact differential equations and integrating factors of first order differential equations, reducible second order differential equations, application of first order differential equations to acceleration-velocity model, growth and decay model.

[2]: Chapter 1 (Sections 1.1, 1.4, 1.6), Chapter 2 (Section 2.3)  
[3]: Chapter 2.

Introduction to compartmental models, lake pollution model (with case study of Lake Burley Griffin), drug assimilation into the blood (case of a single cold pill, case of a course of cold pills, case study of alcohol in the bloodstream), exponential growth of population, limited growth of population, limited growth with harvesting.

[1]: Chapter 2 (Sections 2.1, 2.5-2.8), Chapter 3 (Sections 3.1-3.3)

General solution of homogeneous equation of second order, principle of superposition for a homogeneous equation, Wronskian, its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler’s equation, method of undetermined coefficients, method of variation of parameters, applications of second order differential equations to mechanical vibrations.

[2]: Chapter 3 (Sections 3.1-3.5).
Equilibrium points, interpretation of the phase plane, predator-prey model and its analysis, competing species and its analysis, epidemic model of influenza and its analysis, battle model and its analysis.

[1]: Chapter 5 (Sections 5.1, 5.3-5.4, 5.6-5.7), Chapter 6.

**Practical / Lab work to be performed on a computer:**
Modeling of the following problems using Matlab / Mathematica / Maple etc.

1. Plotting of second order solution family of differential equation.
2. Plotting of third order solution family of differential equation.
3. Growth model (exponential case only).
4. Decay model (exponential case only).
5. (a) Lake pollution model (with constant/seasonal flow and pollution concentration).
   (b) Case of single cold pill and a course of cold pills.
   (c) Limited growth of population (with and without harvesting).
6. (a) Predatory-prey model (basic volterra model, with density dependence, effect of DDT, two prey one predator).
   (b) Epidemic model of influenza (basic epidemic model, contagious for life, disease with carriers).
   (c) Battle model (basic battle model, jungle warfare, long range weapons).
7. Plotting of recursive sequences.
8. Find a value of that will make the following inequality holds for all :
   (i) , (ii) ,
   (ii) , (iv) etc.
9. Study the convergence of sequences through plotting.
10. Verify Bolzano Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot.
11. Study the convergence/divergence of infinite series by plotting their sequences of partial sum.
12. Cauchy’s root test by plotting nth roots.

13. Ratio test by plotting the ratio of nth and n+1th term.

14. For the following sequences < >, given Find such that

(a) 

(b) 

(c) 

(d) 

(e) 

15. For the following series , calculate , and identify the convergent series (a)

(b) (c) (d) (e) (f)

(g) (h) 

(j) (k) (l)

REFERENCES:


C5 Theory of Real Functions

Total marks: 100
Theory: 75
Internal Assessment: 25
5 Lectures, 1 Tutorial (per week per student)

Limits of functions (epsilon-delta approach), sequential criterion for limits, divergence criteria. Limit theorems, one sided limits. Infinite limits & limits at infinity.
[1] Chapter 4, Section 4.1, Section 4.2, Section 4.3 (4.3.1 - 4.3.16)

Continuous functions, sequential criterion for continuity & discontinuity. Algebra of continuous functions.
[1] Chapter 5, Section 5.1, 5.2

Continuous functions on an interval, intermediate value theorem, location of roots theorem, preservation of intervals theorem.

Uniform continuity, non-uniform continuity criteria, uniform continuity theorem.
[1]Chapter 5, Section 5.4 (5.4.1 to 5.4.3)

Differentiability of a function at a point & in an interval, Carathéodory’s theorem, algebra of differentiable functions.
[1]Chapter 6, Section 6.1 (6.1.1 to 6.1.7)

Relative extrema, interior extremum theorem. Rolle’s theorem, Mean value theorem, intermediate value property of derivatives - Darboux’s theorem. Applications of mean value theorem to inequalities & approximation of polynomials Taylor’s theorem to inequalities.
[1] Chapter 6, Section 6.2 (6.2.1 to 6.2.7, 6.2.11, 6.2.12)

Cauchy’s mean value theorem. Taylor’s theorem with Lagrange’s form of remainder, Taylor’s theorem with Cauchy’s form of remainder, application of Taylor’s theorem to convex functions, relative extrema. Taylor’s series & Maclaurin’s series expansions of exponential & trigonometric functions.
[1] Chapter 6, Section 6.3 (6.3.2) Section 6.4 (6.4.1 to 6.4.6)
REFERENCES:

Suggestive Readings
C6 Group Theory –I

Total Marks: 100
Theory: 75
Internal Assessment: 25
5 Lectures, 1 Tutorial (per week per student)

Symmetries of a square, Dihedral groups, definition and examples of groups including permutation groups and quaternion groups (illustration through matrices), elementary properties of groups. Subgroups and examples of subgroups, centralizer, normalizer, center of a group, product of two subgroups. Properties of cyclic groups, classification of subgroups of cyclic groups.
[1]: Chapters 1, Chapter 2, Chapter 3 (including Exercise 20 on page 66 and Exercise 2 on page 86), Chapter 4.

Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group, properties of cosets, Lagrange’s theorem and consequences including Fermat’s Little theorem. External direct product of a finite number of groups, normal subgroups, factor groups, Cauchy’s theorem for finite abelian groups.
[1]: Chapter 5 (till end of Theorem 5.7), Chapter 7 (till end of Theorem 7.2, including Exercises 6 and 7 on page 168), Chapter 8 (till the end of Example 2), Chapter 9 (till end of Example 10, Theorem 9.3 and 9.5).

Group homomorphisms, properties of homomorphisms, Cayley’s theorem, properties of isomorphisms, First, Second and Third isomorphism theorems.
[1]: Chapter 6 (till end of Theorem 6.2), Chapter 10.

REFERENCES:

SUGGESTED READING:
C7 Multivariate Calculus (including practicals)

Total marks: 150
Theory: 75
Practical: 50
Internal Assessment: 25
5 Lectures, 4 Practicals (each in group of 15-20)

Functions of several variables, limit and continuity of functions of two variables. Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters, directional derivatives, the gradient, maximal and normal property of the gradient, tangent planes

[1]: Chapter 11 (Sections 11.1(Pages 541-543), 11.2-11.6)

Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems, Definition of vector field, divergence and curl

[1]: Chapter 11(Sections 11.7 (Pages 598-605), 11.8(Pages 610-614))
Chapter 13 (Pages 684-689)


[1]: Chapter 12 (Sections 12.1, 12.2, 12.3, 12.4 (Pages 652-660), 12.5, 12.6)


[1]: Chapter 13 (Section 13.2, 13.3, 13.4(Page 712–716), 13.5(Page 723–726, 729-730), 13.6 (Page 733–737), 13.7 (Page 742–745))

REFERENCES:
SUGGESTED READING:


Practical / Lab work to be performed on a computer:

Modeling of the following problems using *Matlab / Mathematica / Maple* etc.

1. Draw the following surfaces and find level curves at the given heights:

   (i) ,

   (ii) , (iii) ,

   (iv)

   (v)

   (vi) .

2. Draw the following surfaces and discuss whether limit exits or not as approaches to the given points. Find the limit, if it exists:

   (i) ,

   (ii)

   (iii) ,

   (iv) ,

   (v) ,
3. Draw the tangent plane to the following surfaces at the given point:

(i) , (ii) ,
(iii) ,
(iv) ,
(v) .

4. Use an incremental approximation to estimate the following functions at the given point and compare it with calculated value:

(i) , (ii) ,
(iii) ,
(iv) .

5. Find critical points and identify relative maxima, relative minima or saddle points to the following surfaces, if it exist:

(i) , (ii) , (iii) , (iv) .

6. Draw the following regions $D$ and check whether these regions are of **Type I** or **Type II**:
7. Illustrations of the following:
1. Let be any function and be any number. For given and , find a such that for all satisfying , the inequality holds. For examples:
   (i)
   (ii)
   (iii)
   (iv)

8. Discuss the limit of the following functions when tends to 0:

9. Discuss the limit of the following functions when tends to infinity:

10. Discuss the continuity of the functions at in practical 2.

11. Illustrate the geometric meaning of Rolle’s theorem of the following functions on the given interval:

12. Illustrate the geometric meaning of Lagrange’s mean value theorem of the following functions on the given interval:
13. For the following functions and given , if exists, find such that and discuss uniform continuity of the functions:

(i) 

(ii) 

(iii) 

(iv) 

(v) 

(vi) 

(vii) 

14. Verification of Maximum –Minimum theorem, boundedness theorem & intermediate value theorem for various functions and the failure of the conclusion in case of any of the hypothesis is weakened.

15. Locating points of relative & absolute extremum for different functions

16. Relation of monotonicity & derivatives along with verification of first derivative test.

17. Taylor’s series - visualization by creating graphs:
   a. Verification of simple inequalities
   b. Taylor’s Polynomials – approximated up to certain degrees
   c. Convergence of Taylor’s series
   d. Non-existence of Taylor series for certain functions
   e. Convexity of the curves
C8 Partial Differential Equations (including practicals)

Total marks: 150
Theory: 75
Practical: 50
Internal Assessment: 25
5 Lectures, 4 Practicals (each in group of 15-20)

Introduction, classification, construction and geometrical interpretation of first order partial differential equations (PDE), method of characteristic and general solution of first order PDE, canonical form of first order PDE, method of separation of variables for first order PDE.
[1]: Chapter 2.

Mathematical modeling of vibrating string, vibrating membrane, conduction of heat in solids, gravitational potential, conservation laws and Burger’s equations, classification of second order PDE, reduction to canonical forms, equations with constant coefficients, general solution.
[1]: Chapter 3 (Sections 3.1-3.3, 3.5-3.7), Chapter 4.

Cauchy problem for second order PDE, homogeneous wave equation, initial boundary value problems, non-homogeneous boundary conditions, finite strings with fixed ends, non-homogeneous wave equation, Riemann problem, Goursat problem, spherical and cylindrical wave equation.
[1]: Chapter 5.

Method of separation of variables for second order PDE, vibrating string problem, existence and uniqueness of solution of vibrating string problem, heat conduction
problem, existence and uniqueness of solution of heat conduction problem, Laplace and beam equation, non-homogeneous problem.

[1]: Chapter 7.
Practical / Lab work to be performed on a computer:
Modeling of the following problems using Matlab / Mathematica / Maple etc.

1. Solution of Cauchy problem for first order PDE.
2. Plotting the characteristics for the first order PDE.
3. Plot the integral surfaces of a given first order PDE with initial data.

4. Solution of wave equation for any 2 of the following associated conditions:
   (a) 
   (b) 
   (c) 
   (d) 

5. Solution of one-Dimensional heat equation, for a homogeneous rod of length l.
   That is - solve the IBVP:

7. Approximating solution to Initial Value Problems using any of the following approximate methods:

(a) The Euler Method

(b) The Modified Euler Method.

(c) The Runge-Kutta Method.

Comparison between exact and approximate results for any representative differential equation.

8. Draw the following sequence of functions on given the interval and discuss the pointwise convergence:

(i) , (ii)

(iii) , (iv)

(v) , (vi)

(Vii)

(viii)

9. Discuss the uniform convergence of sequence of functions above.

REFERENCE:

SUGGESTED READING:
C9 Riemann Integration & Series of Functions

Total marks: 100
Theory: 75
Internal Assessment: 25
5 Lectures, 1 Tutorial (per week per student)

Riemann integration; inequalities of upper and lower sums; Riemann conditions of integrability. Riemann sum and definition of Riemann integral through Riemann sums; equivalence of two definitions; Riemann integrability of monotone and continuous functions, Properties of the Riemann integral; definition and integrability of piecewise continuous and monotone functions. Intermediate Value theorem for Integrals; Fundamental theorems of Calculus.
[1] Chapter 6 (Art. 32.1 to 32.9, 33.1, 33.2, 33.3, 33.4 to 33.8, 33.9, 34.1, 34.3)

Improper integrals; Convergence of Beta and Gamma functions.
[3] Chapter 7 (Art. 7.8)

Pointwise and uniform convergence of sequence of functions. Theorems on continuity, derivability and integrability of the limit function of a sequence of functions.
[2] Chapter 8, Section 8.1, Section 8.2 (8.2.1 – 8.2.2), Theorem 8.2.3, Theorem 8.2.4 and Theorem 8.2.5

Series of functions; Theorems on the continuity and derivability of the sum function of a series of functions; Cauchy criterion for uniform convergence and Weierstrass M-Test
[2] Chapter 9, Section 9.4 (9.4.1 to 9.4.6)

Limit superior and Limit inferior. Power series, radius of convergence, Cauchy Hadamard Theorem, Differentiation and integration of power series; Abel's Theorem; Weierstrass Approximation Theorem.
[1] Chapter 4, Art. 26 (26.1 to 26.6), Theorem 27.5

REFERENCES:
3. Charles G. Denlinger, Elements of Real Analysis, Jones and Bartlett (Student Edition), 2011.
C 10 Ring Theory & Linear Algebra-I

Total Marks: 100
Theory: 75
Internal Assessment: 25
5 Lecture, 1 Tutorial (per week per student)

Definition and examples of rings, properties of rings, subrings, integral domains and fields, characteristic of a ring. Ideals, ideal generated by a subset of a ring, factor rings, operations on ideals, prime and maximal ideals. Ring homomorphisms, properties of ring homomorphisms, Isomorphism theorems I, II and III, field of quotients.
[2]: Chapter 12, Chapter 13, Chapter 14, Chapter 15.

Vector spaces, subspaces, algebra of subspaces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces. Linear transformations, null space, range, rank and nullity of a linear transformation, matrix representation of a linear transformation, algebra of linear transformations, Isomorphisms, Isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix.
[1]: Chapter 1 (Sections 1.2-1.6, Exercise 29, 33, 34, 35), Chapter 2 (Sections 2.1-2.5).

REFERENCES:

SUGGESTED READING:
C 11 Metric Spaces

Total marks: 100
Theory: 75
Internal Assessment: 25
5 Lectures, 1 Tutorial (per week per student)

[1] Chapter1, Section 1.2 (1.2.1 to 1.2.6 ). Section 1.3, Section 1.4 (1.4.1 to 1.4.4), Section 1.4 (1.4.5 to 1.4.14 (ii)).

Open and closed balls, neighbourhood, open set, interior of a set, Limit point of a set, closed set, diameter of a set, Cantor’s Theorem, Subspaces, dense sets, separable spaces.
[1] Chapter2, Section 2.1 (2.1.1 to 2.1.16), Section 2.1 (2.1.17 to 2.1.44), Section 2.2, Section 2.3 (2.3.12 to 2.3.16)

Continuous mappings, sequential criterion and other characterizations of continuity, Uniform continuity, Homeomorphism, Contraction mappings, Banach Fixed point Theorem.
[1] Chapter3, Section 3.1, Section3.4 (3.4.1 to 3.4.8), Section 3.5 (3.5.1 to 3.5.7(iv ) ), Section 3.7 ( 3.7.1 to 3.7.5)

Connectedness, connected subsets of $\mathbb{R}$, connectedness and continuous mappings.
[1] Chapter4, Section 4.1 (4.1.1 to 4.1.12)

Compactness, compactness and boundedness, continuous functions on compact spaces.
[1] Chapter5, Section 5.1 (5.1.1 to 5.1.6), Section 5.3 (5.3.1 to 5.3.11)

REFERENCES:

SUGGESTED READINGS:
C 12 Group Theory-II

Total Marks: 100
Theory: 75
Internal Assessment: 25
5 Lectures, 1 Tutorial (per week per student)

Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups, Characteristic subgroups, Commutator subgroup and its properties.
[1]: Chapter 6, Chapter 9 (Theorem 9.4), Exercises 1-4 on page 168, Exercises 52, 58 on page Pg 188.

Properties of external direct products, the group of units modulo n as an external direct product, internal direct products, Fundamental Theorem of finite abelian groups.
[1]: Chapter 8, Chapter 9 (Section on internal direct products), Chapter 11.
Group actions, stabilizers and kernels, permutation representation associated with a given group action, Applications of group actions: Generalized Cayley’s theorem, Index theorem. Groups acting on themselves by conjugation, class equation and consequences, conjugacy in $S_n$, $p$-groups, Sylow’s theorems and consequences, Cauchy’s theorem, Simplicity of $A_n$ for $n \geq 5$, non-simplicity tests.
[2]: Chapter 1 (Section 1.7), Chapter 2 (Section 2.2), Chapter 4 (Section 4.1-4.3, 4.5-4.6).
[1]: Chapter 25.

REFERENCES:
C13 Complex Analysis (including practicals)

Total marks: 150
Theory: 75
Internal Assessment: 25
Practical: 50
5 Lectures, Practical 4 (in group of 15-20)

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.
[1]: Chapter 1 (Section 11), Chapter 2 (Section 12, 13) Chapter 2 (Sections 15, 16, 17, 18, 19, 20, 21, 22)

Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function, derivatives of functions, definite integrals of functions.
[1]: Chapter 2 (Sections 24, 25), Chapter 3 (Sections 29, 30, 34), Chapter 4 (Section 37, 38)

Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals.
[1]: Chapter 4 (Section 39, 40, 41, 43)

[1]: Chapter 4 (Sections 44, 45, 46, 50), Chapter 4 (Sections 51, 52, 53)

Convergence of sequences and series, Taylor series and its examples. Laurent series and its examples, absolute and uniform convergence of power series, uniqueness of series representations of power series.
[1]: Chapter 5 (Sections 55, 56, 57, 58, 59, 60, 62, 63, 66)

Isolated singular points, residues, Cauchy’s residue theorem, residue at infinity. Types of isolated singular points, residues at poles and its examples, definite integrals involving sines and cosines.
[1]: Chapter 6 (Sections 68, 69, 70, 71, 72, 73, 74), Chapter 7 (Section 85).
REFERENCES:

SUGGESTED READING:

LAB WORK TO BE PERFORMED ON A COMPUTER
(MODELING OF THE FOLLOWING PROBLEMS USING MATLAB/ MATHEMATICA/ MAPLE ETC.)
1. Declaring a complex number and graphical representation.
   e.g. \( Z_1 = 3 + 4i, Z_2 = 4 – 7i \)

2. Program to discuss the algebra of complex numbers.
   e.g., if \( Z_1 = 3 + 4i, Z_2 = 4 – 7i \), then find \( Z_1 + Z_2, Z_1 - Z_2, Z_1 \ast Z_2, \) and \( Z_1 / Z_2 \)

3. To find conjugate, modulus and phase angle of an array of complex numbers.
   e.g., \( Z = \begin{bmatrix} 2+ 3i & 4-2i & 6+11i & 2-5i \end{bmatrix} \)

4. To compute the integral over a straight line path between the two specified end points.
   e.g., \( \int_C \), where \( C \) is the straight line path from -1+ i to 2 - i.

5. To perform contour integration.
   e.g., (i) \( \), where \( C \) is the Contour given by \( x = y^2 +1 \); .
     (ii) , where \( C \) is the contour given by , which can be parameterized by \( x = \cos (t), y = \sin (t) \) for .

6. To plot the complex functions and analyze the graph.
e.g., (i) \( f(z) = Z \)

(ii) \( f(z) = Z^3 \)

4. \( f(z) = (Z^4 - 1)^{1/4} \)

5. etc.

7. To perform the Taylor series expansion of a given function \( f(z) \) around a given point \( z \).

The number of terms that should be used in the Taylor series expansion is given for each function. Hence plot the magnitude of the function and magnitude of its Taylor series expansion.

\[
\text{e.g., } (i) \ f(z) = \exp(z) \text{ around } z = 0, \ n = 40.
\]

\[
(ii) \ f(z) = \exp(z^2) \text{ around } z = 0, \ n = 160.
\]

8. To determine how many terms should be used in the Taylor series expansion of a given function \( f(z) \) around \( z = 0 \) for a specific value of \( z \) to get a percentage error of less than 5%.

\[
\text{e.g., For } f(z) = \exp(z) \text{ around } z = 0, \text{ execute and determine the number of necessary terms to get a percentage error of less than 5% for the following values of } z:
\]

(i) \( z = 30 + 30i \)

(ii)

9. To perform Laurents series expansion of a given function \( f(z) \) around a given point \( z \).

\[
\text{e.g., } (i) \ f(z) = (\sin z - 1)/z^4 \text{ around } z = 0
\]

\[
(ii) \ f(z) = \cot (z)/z^4 \text{ around } z = 0.
\]

10. To compute the poles and corresponding residues of complex functions.

\[
\text{e.g.,}
\]

11. To perform Conformal Mapping and Bilinear Transformations.
C 14 Ring Theory and Linear Algebra – II

Total Marks : 100
Theory: 75
Internal Assessment: 25
5 Lectures, 1 Tutorial (per week per student)

Polynomial rings over commutative rings, division algorithm and consequences, principal ideal domains, factorization of polynomials, reducibility tests, irreducibility tests, Eisenstein criterion, unique factorization in \( \mathbb{Z}[x] \).
Divisibility in integral domains, irreducibles, primes, unique factorization domains, Euclidean domains.
[1]: Chapter 16, Chapter 17, Chapter 18.

Dual spaces, dual basis, double dual, transpose of a linear transformation and its matrix in the dual basis, annihilators, Eigenspaces of a linear operator, diagonalizability, invariant subspaces and Cayley-Hamilton theorem, the minimal polynomial for a linear operator.
[2]: Chapter 2 (Section 2.6), Chapter 5 (Sections 5.1-5.2, 5.4), Chapter 7(Section 7.3).

Inner product spaces and norms, Gram-Schmidt orthogonalization process, orthogonal complements, Bessel’s inequality, the adjoint of a linear operator, Least Squares Approximation, minimal solutions to systems of linear equations, Normal and self-adjoint operators, Orthogonal projections and Spectral theorem.
[2]: Chapter 6 (Sections 6.1-6.4, 6.6).

REFERENCES:

SUGGESTED READING:
(Linear Algebra)
1. S Lang, Introduction to Linear Algebra (2nd edition), Springer, 2005
(Ring theory and group theory)
DSE-1 (including practicals): Any one of the following (at least two shall be offered by the college):

**DSE-1(i) Numerical Methods**

Total marks: 150  
Theory: 75  
Practical: 50  
Internal Assessment: 25  
5 Lectures, 4 Practicals (each in group of 15-20)

[1]: Chapter 1 (Sections 1.1-1.2), Chapter 2 (Sections 2.1-2.5), Chapter 3 (Section 3.5, 3.8).

Lagrange and Newton interpolation: linear and higher order, finite difference operators.  
[1]: Chapter 5 (Sections 5.1, 5.3)  
[2]: Chapter 4 (Section 4.3).

Numerical differentiation: forward difference, backward difference and central difference. Integration: trapezoidal rule, Simpson’s rule, Euler’s method.  
[1]: Chapter 6 (Sections 6.2, 6.4), Chapter 7 (Section 7.2)

**Note:** Emphasis is to be laid on the algorithms of the above numerical methods.

**Practical / Lab work to be performed on a computer:**  
Use of computer aided software (CAS), for example Matlab / Mathematica / Maple / Maxima etc., for developing the following Numerical programs:

(i) Calculate the sum $\frac{1}{1} + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \cdots + \frac{1}{N}$.

(ii) To find the absolute value of an integer.
(iii) Enter 100 integers into an array and sort them in an ascending order.

(iv) Any two of the following
   (a) Bisection Method
   (b) Newton Raphson Method
   (c) Secant Method
   (d) Regular Falsi Method

(v) LU decomposition Method

(vi) Gauss-Jacobi Method

(vii) SOR Method or Gauss-Siedel Method

(viii) Lagrange Interpolation or Newton Interpolation

(ix) Simpson’s rule.

Note: For any of the CAS Matlab / Mathematica / Maple / Maxima etc., Data types-simple data types, floating data types, character data types, arithmetic operators and operator precedence, variables and constant declarations, expressions, input/output, relational operators, logical operators and logical expressions, control statements and loop statements, Arrays should be introduced to the students.

REFERENCES:


SUGGESTED READING:

DSE-1(ii) Mathematical Modeling & Graph Theory

Total marks: 150
Theory: 75
Practical: 50
Internal Assessment: 25
5 Lectures, 4 Practicals (each in group of 15-20)

Power series solution of a differential equation about an ordinary point, solution about a regular singular point, Bessel’s equation and Legendre’s equation, Laplace transform and inverse transform, application to initial value problem up to second order.

[2]: Chapter 7 (Sections 7.1-7.3), Chapter 8 (Sections 8.2-8.3).

Monte Carlo Simulation Modeling: simulating deterministic behavior (area under a curve, volume under a surface), Generating Random Numbers: middle square method, linear congruence, Queuing Models: harbor system, morning rush hour, Overview of optimization modeling, Linear Programming Model: geometric solution algebraic solution, simplex method, sensitivity analysis

[3]: Chapter 5 (Sections 5.1-5.2, 5.5), Chapter 7.

Graphs, digraphs, networks and subgraphs, vertex degree, paths and cycles, regular and bipartite graphs, four cube problem, social networks, exploring and traveling, Eulerian and Hamiltonian graphs, applications to dominoes, diagram tracing puzzles, Knight’s tour problem, gray codes.

[1]: Chapter 1 (Section 1.1), Chapter 2, Chapter 3.

Note: Chapter 1 (Section 1.1), Chapter 2 (Sections 2.1-2.4), Chapter 3 (Sections 3.1-3.3) are to be reviewed only. This is in order to understand the models on Graph Theory.

Practical / Lab work to be performed on a computer:
Modeling of the following problems using Matlab / Mathematica / Maple etc.

(i) Plotting of Legendre polynomial for $n = 1$ to 5 in the interval $[0,1]$. Verifying graphically that all the roots of $P_n(x)$ lie in the interval $[0,1]$. 


(ii) Automatic computation of coefficients in the series solution near ordinary points
(iii) Plotting of the Bessel’s function of first kind of order 0 to 3.
(iv) Automating the Frobenius Series Method
(v) Random number generation and then use it for one of the following
   (a) Simulate area under a curve
   (b) Simulate volume under a surface
(vi) Programming of either one of the queuing model
   (a) Single server queue (e.g. Harbor system)
   (b) Multiple server queue (e.g. Rush hour)
(vii) Programming of the Simplex method for 2/3 variables

REFERENCES:

DSE-1(iii) C++ PROGRAMMING

Total marks: 150
Theory: 75
Practical: 50
Internal Assessment: 25
5 Lectures, 4 Practicals (each in group of 15-20)

Introduction to structured programming: data types- simple data types, floating data types, character data types, string data types, arithmetic operators and operators precedence, variables and constant declarations, expressions, input using the extraction operator >> and cin, output using the insertion operator << and cout, preprocessor directives, increment(++) and decrement(--), operations, creating a C++ program, input/ output, relational operators, logical operators and logical expressions, if and if-else statement, switch and break statements.

[1] Chapter 2 (pages 37-95), Chapter 3 (pages 96 -129), Chapter 4 (pages 134-178)

“for”, “while” and “do-while” loops and continue statement, nested control statement, value returning functions, value versus reference parameters, local and global variables, one dimensional array, two dimensional array, pointer data and pointer variables,


Reference:

Suggested Readings:

Note: Practical programs of the following (and similar) type are suggestive.
1. Calculate the Sum of the series 1/1 + 1/2+ 1/3……………….+1/N for any positive integer N.
2. Write a user defined function to find the absolute value of an integer and use it to evaluate the function \((-1)^n/|n|\), for n = -2,-1,0,1,2.
3. Calculate the factorial of any natural number.
4. Read floating numbers and compute two averages: the average of negative numbers and the average of positive numbers.

5. Write a program that prompts the user to input a positive integer. It should then output a message indicating whether the number is a prime number.
6. Write a program that prompts the user to input the value of a, b and c involved in the equation \(ax^2 + bx + c = 0\) and outputs the type of the roots of the equation. Also the program should outputs all the roots of the equation.
7. Write a program that generates random integer between 0 and 99. Given that first two Fibonacci numbers are 0 and 1, generate all Fibonacci numbers less than or equal to generated number.
8. Write a program that does the following:
   a. Prompts the user to input five decimal numbers.
   b. Prints the five decimal numbers.
   c. Converts each decimal number to the nearest integer.
   d. Adds these five integers.
   e. Prints the sum and average of them.
9. Write a program that uses whiile loops to perform the following steps:
   a. Prompt the user to input two integers :firstNum and secondNum (firstNum should be less than secondNum).
   b. Output all odd and even numbers between firstNum and secondNum.
   c. Output the sum of all even numbers between firstNum and secondNum.
   d. Output the sum of the square of the odd numbers firstNum and secondNum.
   e. Output all uppercase letters corresponding to the numbers between firstNum and secondNum, if any.
10. Write a program that prompts the user to input five decimal numbers. The program should then add the five decimal numbers, convert the sum to the nearest integer, and print the result.
11. Write a program that prompts the user to enter the lengths of three sides of a triangle and then outputs a message indicating whether the triangle is a right triangle or a scalene triangle.
12. Write a value returning function *smaller* to determine the smallest number from a set of numbers. Use this function to determine the smallest number from a set of 10 numbers.

13. Write a function that takes as a parameter an integer (as a long value) and returns the number of odd, even, and zero digits. Also write a program to test your function.

14. Enter 100 integers into an array and sort them in an ascending/descending order and print the largest/smallest integers.

15. Enter 10 integers into an array and then search for a particular integer in the array.


17. Using arrays, read the vectors of the following type: A = (1 2 3 4 5 6 7 8), B = (0 2 3 4 0 1 5 6) and compute the product and addition of these vectors.

18. Read from a text file and write to a text file.

19. Write a program to create the following grid using for loops:

```
1 2 3 4 5
2 3 4 5 6
3 4 5 6 7
4 5 6 7 8
5 6 7 8 9
```

20. Write a function, *reverseDigit*, that takes an integer as a parameter and returns the number with its digits reversed. For example, the value of function reverseDigit(12345) is 54321 and the value of reverseDigit(-532) is -235.
DSE-2: Any one of the following (at least two shall be offered by the college):

DSE-2(i) Mathematical Finance

Total Marks: 100
Theory: 75
Internal Assessment: 25
5 Lectures, 1 Tutorial (per week per student)

Basic principles: Comparison, arbitrage and risk aversion, Interest (simple and compound, discrete and continuous), time value of money, inflation, net present value, internal rate of return (calculation by bisection and Newton-Raphson methods), comparison of NPV and IRR. Bonds, bond prices and yields, Macaulay and modified duration, term structure of interest rates: spot and forward rates, explanations of term structure, running present value, floating-rate bonds, immunization, convexity, putable and callable bonds.
[1]: Chapter 1, Chapter 2, Chapter 3, Chapter 4.

Asset return, short selling, portfolio return, (brief introduction to expectation, variance, covariance and correlation), random returns, portfolio mean return and variance, diversification, portfolio diagram, feasible set, Markowitz model (review of Lagrange multipliers for 1 and 2 constraints), Two fund theorem, risk free assets, One fund theorem, capital market line, Sharpe index. Capital Asset Pricing Model (CAPM), betas of stocks and portfolios, security market line, use of CAPM in investment analysis and as a pricing formula, Jensen’s index.
[1]: Chapter 6, Chapter 7, Chapter 8 (Sections 8.5--8.8).
[3]: Chapter 1 (for a quick review/description of expectation etc.)

Forwards and futures, marking to market, value of a forward/futures contract, replicating portfolios, futures on assets with known income or dividend yield, currency futures, hedging (short, long, cross, rolling), optimal hedge ratio, hedging with stock index futures, interest rate futures, swaps. Lognormal distribution, Lognormal model / Geometric Brownian Motion for stock prices, Binomial Tree model for stock prices, parameter estimation, comparison of the models. Options, Types of options: put / call, European / American, pay off of an option, factors affecting option prices, put call parity.

[1]: Chapter 10 (except 10.11, 10.12), Chapter 11 (except 11.2 and 11.8)
[2]: Chapter 3, Chapter 5, Chapter 6, Chapter 7 (except 7.10 and 7.11), Chapter 8, Chapter 9
[3]: Chapter 3

REFERENCES:

DSE-2(ii) Discrete Mathematics

Total Marks: 100
Theory: 75
Internal Assessment: 25
5 Lectures, 1 Tutorial (per week per student)

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

[1]: Chapter 1 (till the end of 1.18), Chapter 2 (Sections 2.1-2.13), Chapter 5 (Sections 5.1-5.11).
[3]: Chapter 1 (Section 1).

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.

[1]: Chapter 6.
[3]: Chapter 1 (Sections 3-4, 6), Chapter 2 (Sections 7-8).

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

[2]: Chapter 9, Chapter 10.
REFERENCES:


DSE-2(iii) CRYPTOGRAPHY AND NETWORK SECURITY

Total Marks: 100
Theory: 75
Internal Assessment: 25
5 Lectures, 1 Tutorial (per week per student)


[1] 2.1-2.3, 3.1, 3.2, 3.3.

Polynomial and modular arithmetic, Introduction to finite field of the form GF(p) and GF(2^n), Fermat theorem and Euler’s theorem(statement only), Chinese Remainder theorem, Discrete logarithm.

[1] 4.2, 4.3, 4.5, 4.6, 4.7, 8.2, 8.4, 8.5

Advanced Encryption Standard(AES), Stream ciphers. Introduction to public key cryptography, RSA algorithm and security of RSA, Introduction to elliptic curve cryptography.

[1] 5.2-5.5(tables 5.5, 5.6 excluded), 7.4, 9.1, 9.2, 10.3, 10.4

Information/Computer Security: Basic security objectives, security attacks, security services, Network security model,
1.1, 1.3, 1.4, 1.6
Cryptographic Hash functions, Secure Hash algorithm, SHA-3.

11.1, 11.5, 11.6
Digital signature, Elgamal signature, Digital signature standards, Digital signature algorithm

13.1, 13.2, 13.4
E-mail security: Pretty Good Privacy (PGP)

18.1 Page 592-596 (Confidentiality excluded)

REFERENCE:

SUGGESTED READING:
DSE-3: Any one of the following (at least two shall be offered by the college):

DSE-3(i) Probability Theory and Statistics

Total marks: 100
Theory: 75
Internal Assessment: 25
5 Lectures, 1 Tutorial (per week per student)

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, continuous distributions: uniform, normal, exponential.

[1]: Chapter 1 (Sections 1.1, 1.3, 1.5-1.9).
[2]: Chapter 5 (Sections 5.1-5.5, 5.7), Chapter 6 (Sections 6.2-6.3, 6.5-6.6).

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, bivariate normal distribution, correlation coefficient, joint moment generating
function (jmgf) and calculation of covariance (from jmgf), linear regression for two variables.

[1]: Chapter 2 (Sections 2.1, 2.3-2.5).
[2]: Chapter 4 (Exercise 4.47), Chapter 6 (Section 6.7), Chapter 14 (Sections 14.1, 14.2).

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, Markov Chains, Chapman-Kolmogorov equations, classification of states.

[2]: Chapter 4 (Section 4.4).
[3]: Chapter 2 (Section 2.7), Chapter 4 (Sections 4.1-4.3).

REFERENCES:

SUGGESTED READING:
**DSE-3(ii) Mechanics**

Total Marks: 100
Theory: 75
Internal Assessment: 25
5 Lectures, 1 Tutorial (per week per student)

Moment of a force about a point and an axis, couple and couple moment, Moment of a couple about a line, resultant of a force system, distributed force system, free body diagram, free body involving interior sections, general equations of equilibrium, two point equivalent loading, problems arising from structures, static indeterminacy.

[1]: Chapter 3, Chapter 4, Chapter 5.

Laws of Coulomb friction, application to simple and complex surface contact friction problems, transmission of power through belts, screw jack, wedge, first moment of an area and the centroid, other centers, Theorem of Pappus-Guldinus, second moments and the product of area of a plane area, transfer theorems, relation between second moments and products of area, polar moment of area, principal axes.

[1]: Chapter 6 (Sections 6.1-6.7), Chapter 7
Conservative force field, conservation for mechanical energy, work energy equation, kinetic energy and work kinetic energy expression based on center of mass, moment of momentum equation for a single particle and a system of particles, translation and rotation of rigid bodies, Chasles’ theorem, general relationship between time derivatives of a vector for different references, relationship between velocities of a particle for different references, acceleration of particle for different references.

[1]: Chapter 11, Chapter 12 (Sections 12.5-12.6), Chapter 13.

REFERENCES:


DSE-3(iii)  Bio-Mathematics
Total Marks: 100
Theory: 75
Internal Assessment: 25
5 Lectures, 1 Tutorial (per week per student)

References: Relevant sections of chapters 1, 3, 4, 5, 6, 7 and 13 of [4]

Mathematics of imaging of the Brain: Modelling of computerized tomography (CT, Magnetic resonance Imaging (MRI), Positron emission Tomography (PET), Single Photon Emission Computerized Tomography(SPECT), Discrete analogues and Numerical Implementation. Networks in Biological Sciences: Dynamics of Small world networks, scale-free networks, complex networks, cellular automata.

References: Relevant parts of [2] and [3]


References: Relevant sections of Chapters 4, 5 and 6 of [1] and chapters 3, 4, 6 and 8 of [5].

Recommended Books:

DSE-4: Any one of the following (at least two shall be offered by the college):

DSE-4(i) Number Theory

Total Marks: 100
Theory: 75
Internal Assessment: 25
5 Lectures, 1 Tutorial (per week per student)

Linear Diophantine equation, prime counting function, statement of prime number theorem, Goldbach conjecture, linear congruences, complete set of residues, Chinese remainder theorem, Fermat’s little theorem, Wilson’s theorem.

\textit{References:}
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, Euler’s theorem, reduced set of residues, some properties of Euler’s phi-function.

*References:*

[1]: Chapter 6 (Sections 6.1-6.3), Chapter 7.

[2]: Chapter 5 (Section 5.2 (Definition 5.5-Theorem 5.40), Section 5.3 (Theorem 5.15-Theorem 5.17, Theorem 5.19)).

Order of an integer modulo $n$, primitive roots for primes, composite numbers having primitive roots, Euler’s criterion, the Legendre symbol and its properties, quadratic reciprocity, quadratic congruences with composite moduli. Public key encryption, RSA encryption and decryption, the equation $x^2 + y^2 = z^2$, Fermat’s Last Theorem.

*Reference:*

[1]: Chapters 8 (Sections 8.1-8.3), Chapter 9, Chapter 10 (Section 10.1), Chapter 12.

**REFERENCES:**

DSE-4 (ii)  Linear Programming and Theory of Games

Total Marks: 100
Theory: 75
Internal Assessment: 25
5 Lectures, 1 Tutorial (per week per student)

Introduction to linear programming problem, Theory of simplex method, optimality and unboundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method, Big-M method and their comparison.

[1]: Chapter 3 (Sections 3.2-3.3, 3.5-3.8), Chapter 4 (Sections 4.1-4.4).
Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual.
[1]: Chapter 6 (Sections 6.1-6.3).

[3]: Chapter 5 (Sections 5.1, 5.3-5.4).

Game theory: formulation of two person zero sum games, solving two person zero sum games, games with mixed strategies, graphical solution procedure, linear programming solution of games.
[2]: Chapter 14.

REFERENCES:

SUGGESTED READING:
DSE-4(iii) Applications of Algebra

Total Marks: 100
Theory: 75
Internal Assessment: 25
5 Lectures, 1 Tutorial (per week per student)

Balanced incomplete block designs (BIBD): definitions and results, incidence matrix of a BIBD, construction of BIBD from difference sets, construction of BIBD using quadratic residues, difference set families, construction of BIBD from finite fields.

[2]: Chapter 2 (Sections 2.1-2.4,2.6).
Coding Theory: introduction to error correcting codes, linear codes, generator and parity check matrices, minimum distance, Hamming Codes, decoding and cyclic codes.

[2]: Chapter 4 (Sections 4.1-4.3.17).

Symmetry groups and color patterns: review of permutation groups, groups of symmetry and action of a group on a set; colouring and colouring patterns, Polya theorem and pattern inventory, generating functions for non-isomorphic graphs.

[2]: Chapter 5.

Application of linear transformations: Fibonacci numbers, incidence models, and differential equations. Least squares methods: Approximate solutions of system of linear equations, approximate inverse of an m\(\times\)n matrix, solving a matrix equation using its normal equation, finding functions that approximate data. Linear algorithms: LDU factorization, the row reduction algorithm and its inverse, backward and forward substitution, approximate substitution, approximate inverse and projection algorithms.

[1]: Chapter 9-11.

Reference:


SEC-1 LaTeX and HTML

2 Lectures + 2 Practical 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

2 Lectures + 2 Practical 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: