PROPOSED SYLLABUS

B.Sc. (H) Mathematics
CBCS-SEMESTER

DEPARTMENT OF MATHEMATICS
UNIVERSITY OF DELHI
DELHI-110007

Structure

	Core Course (14)	Ability Enhancement Compulsory Course (AECC) (2)	Skill Enhancement Course (SEC) (2)	Elective Discipline Specific DSE (4)	Elective: Generic (4)
I	C 1 Calculus (including practicals)	(English communication/MIL) /Environmental Science			GE-1
	C 2 Algebra				
II	C 3 Real Analysis	(English communication/MIL) /Environmental Science			GE-2
	C 4 Differential Equations (including practicals)				
III	C 5 Theory of Real functions		SEC-1 LaTeX and		GE-3

			HTML		
	C 6 Group Theory-I				
	C 7 Multivariate Calculus (including practicals)				
IV	C 8 Partial Differential Equations (including practicals)		SEC-2 Computer Algebra Systems and Related Softwares		GE-4
	C 9 Riemann Integration & Series of functions				
	C 10 Ring Theory & Linear Algebra-I				
V	C 11 Metric Spaces			**DSE-1 (including practicals)** **(i)** Numerical Methods **or** (ii) Mathematical Modeling and Graph Theory **or** **(iii)** C++ Programming **DSE-2** (i) Mathematical Finance or (ii) Discrete Mathematics	

				or (iii) Cryptography and Network Security	
	C 12 Group Theory-II				
VI	C 13 Complex Analysis (including practicals)			**DSE-3** (i) Probability theory & Statistics or (ii) Mechanics or (iii) Bio-Mathematics **DSE-4** (i) Number Theory or (ii) Linear Programming and Theory of Games or (iii) Applications of Algebra	
	C 14 Ring Theory and Linear Algebra-II				

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)

Introduction to vector functions and their graphs, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions. Modeling ballistics and planetary motion, Kepler's second law. Curvature, tangential and normal components of acceleration.

[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 ploting 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.
10. Computation of limit, differentiation and integration of vector functions.
11. Complex numbers and their representations, operations like addition, multiplication, division, modulus. Graphical representation of polar form.

REFERENCES:

1. M. J. Strauss, G. L. Bradley and K. J. Smith, Calculus (3rd Edition), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.
2. H. Anton, I. Bivens and S. Davis, Calculus (7th Edition), John Wiley and sons (Asia), Pt Ltd., Singapore, 2002.

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 R^n, dimension of subspaces of 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.
2. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory(3rd Edition), Pearson Education (Singapore) Pvt. Ltd., Indian Reprint, 2005.
3. David C. Lay, Linear Algebra and its Applications (3rd Edition), Pearson Education Asia, Indian Reprint, 2007.

C3- Real Analysis

Total marks: 100

Theory: 75

Internal Assessment: 25

5 Lectures, 1 Tutorial (per week per student)

Algebraic and Order Properties of *R,* d-neighborhood of a point in *R,* Idea of countable sets, uncountable sets and uncountability of *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 *R,* The Archimedean Property, Density of Rational (and Irrational) numbers in *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)

Sequences, Bounded sequence, Convergent sequence, Limit of a sequence. Limit Theorems, Monotone Sequences, Monotone Convergence Theorem. Subsequences, Divergence Criteria, Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for Sequences. Cauchy sequence, Cauchy's Convergence Criterion.
[1]: Chapter 3 (Section 3.1-3.5)

Infinite series, convergence and divergence of infinite series, Cauchy Criterion,Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy's nth root test, Integral test, Alternating series, Leibniz test, Absolute and Conditional convergence.
[2]: Chapter 6 (Section 6.2)

REFERENCES:

1. R.G. Bartle and D. R. Sherbert, *Introduction to Real Analysis* (3rd Edition), John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.

2. Gerald G. Bilodeau , Paul R. Thie, G.E. Keough, *An Introduction to Analysis,* Jones & Bartlett, Second Edition, 2010.
3. Brian S. *Thomson*, Andrew. M. *Bruckner*, and Judith B. *Bruckner*, *Elementary Real Analysis,* Prentice Hall, 2001.

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:

1. **Belinda Barnes** and **Glenn R. Fulford**, *Mathematical Modeling with Case Studies, A Differential Equation Approach Using Maple*, Taylor and Francis, London and New York, 2002.
2. **C. H. Edwards** and **D. E. Penny**, *Differential Equations and Boundary Value Problems: Computing and Modeling*, Pearson Education, India, 2005.
3. **S. L. Ross**, *Differential Equations*, John Wiley and Sons, India, 2004.

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.
[2]Art.18.1, 18.2, 18.3, 18.5, 18.6

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:

1. **R. G. Bartle & D.R. Sherbert,** Introduction to Real Analysis, John Wiley & Sons (2003)
2. **K. A. Ross,** Elementary Analysis: The Theory of Calculus, Springer (2004).

Suggestive Readings

1. **A. Mattuck,** Introduction to Analysis, Prentice Hall (1999).
2. **S. R. Ghorpade & B. V. Limaye**, A Course in Calculus and Real Analysis – Springer (2006).

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:

1. Joseph A. Gallian, *Contemporary Abstract Algebra* (4th Edition), Narosa Publishing House, New Delhi, 1999.(IX Edition 2010)

SUGGESTED READING:

1. Joseph J. Rotman, An Introduction to the Theory of Groups (4th Edition), Springer Verlag, 1995.

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)

Double integration over rectangular region, double integration over nonrectangular region. Double integrals in polar co-ordinates, Triple integrals, Triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical co-ordinates. Change of variables in double integrals and triple integrals.

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

Line integrals, Applications of line integrals: Mass and Work. Fundamental theorem for line integrals, conservative vector fields, independence of path. Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stokes' theorem, The Divergence theorem.

[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:

1. M. J. Strauss, G. L. Bradley and K. J. Smith, Calculus (3rd Edition), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.

SUGGESTED READING:

2. E. Marsden, A. J. Tromba and A. Weinstein, *Basic multivariable calculus,* Springer (SIE), Indian reprint, 2005.

***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) ,

(vi) ,

(vii) ,

(viii)

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**:

(i) ,

(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:

6. Solving systems of ordinary differential equations.

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:

1. **Tyn Myint-U** and **Lokenath Debnath,** *Linear Partial Differential Equation for Scientists and Engineers,* Springer, Indian reprint, 2006.

SUGGESTED READING:

1. **Ioannis P Stavroulakis** and **Stepan A Tersian**, *Partial Differential Equations: An Introduction with Mathematica and MAPLE*, World Scientific, Second Edition, 2004.

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:

1. K.A. Ross, Elementary Analysis: The Theory of Calculus, Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
2. R.G. Bartle D.R. Sherbert, Introduction to Real Analysis (3^{rd} edition), John Wiley and Sons (Asia) Pvt. Ltd.., Singapore, 2002.
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:

1. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra* (4th Edition), Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.
2. Joseph A. Gallian, *Contemporary Abstract Algebra* (4th Edition), Narosa Publishing House, New Delhi, 1999.

SUGGESTED READING:

1. S Lang, Introduction to Linear Algebra (2nd edition), Springer, 2005
2. Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007
3. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999.
4. Kenneth Hoffman, Ray Alden Kunze, Linear Algebra 2nd Ed., Prentice-Hall Of India Pvt. Limited, 1971

C 11 Metric Spaces

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

Metric spaces: definition and examples. Sequences in metric spaces, Cauchy sequences. Complete Metric Spaces.
[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 **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:

[1] Satish Shirali & Harikishan L. Vasudeva, Metric Spaces, Springer Verlag London (2006) (First Indian Reprint 2009)

SUGGESTED READINGS:

[1] S. Kumaresan, Topology of Metric Spaces, Narosa Publishing House, Second Edition 2011.
[2] G. F. Simmons, Introduction to Topology and Modern Analysis, Mcgraw-Hill, Edition 2004.

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), Exersices1-4 on page168, 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:
1. Joseph A. Gallian, Contemporary Abstract Algebra (4th Ed.), Narosa Publishing House, 1999.
2. David S. Dummit and Richard M. Foote, Abstract Algebra (3rd Edition), John Wiley and Sons (Asia) Pvt. Ltd, Singapore, 2004

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)

Antiderivatives, proof of antiderivative theorem, Cauchy-Goursat theorem, Cauchy integral formula. An extension of Cauchy integral formula, consequences of Cauchy integral formula, Liouville's theorem and the fundamental theorem of algebra.
[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:

1. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications (Eighth Edition), McGraw – Hill International Edition, 2009.

SUGGESTED READING:

2. Joseph Bak and Donald J. Newman, *Complex analysis* (2nd Edition), Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., New York, 1997.

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 $Z_1 + Z_2$, $Z_1 - Z_2$, $Z_1 * Z_2$, and Z_1 / Z_2

3. To find conjugate, modulus and phase angle of an array of complex numbers.

   e.g., Z = [2+ 3i   4-2i   6+11i   2-5i]

4. To compute the integral over a straight line path between the two specified end points.

   e. g., , 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 Taylors series expansion.

e.g., (i) f(z) = exp(z) around z = 0, n =40.

(ii) $f(z)=\exp(z^2)$ around z = 0, n = 160.

8. To determines 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 %.

e.g., For f(z) = exp(z) around z =0, 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 + 30 i

(ii)

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

e.g., (i) $f(z)= (\sin z -1)/z^4$ around z = 0

(ii) $f(z) = \cot(z)/z^4$ around z = 0.

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

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 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:

1. Joseph A. Gallian, Contemporary Abstract Algebra (4th Ed.), Narosa Publishing House, 1999.
2. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra* (4th Edition), Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.

SUGGESTED READING:

(Linear Algebra)

1. S Lang, Introduction to Linear Algebra (2nd edition), Springer, 2005
2. Gilbert Strang, Linear Algebra and its Applications, Thomson, 2007

3. S. Kumaresan, Linear Algebra- A Geometric Approach, Prentice Hall of India, 1999.
4. Kenneth Hoffman, Ray Alden Kunze, Linear Algebra 2nd Ed., Prentice-Hall Of India Pvt. Limited, 1971
(Ring theory and group theory)
1. John B.Fraleigh, A first course in Abstract Algebra, 7th Edition, Pearson Education India, 2003.
2. Herstein, Topics in Algebra (2nd edition), John Wiley & Sons, 2006
3. M ichael Artin, Algebra (2nd edition), Pearson Prentice Hall, 2011
4. Robinson, Derek John Scott., An introduction to abstract algebra, Hindustan book agency, 2010.

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)

Algorithms, Convergence, Bisection method, False position method, Fixed point iteration method, Newton's method, Secant method, LU decomposition, Gauss-Jacobi, Gauss-Siedel and SOR iterative methods.
[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 1/1 + 1/2 + 1/3 + 1/4 + ----------+ 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) Regulai 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:

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

SUGGESTED READING:

1. **C. F. Gerald** and **P. O. Wheatley**, *App;ied Numerical Analysis*, Pearson Education, India,7th edition, 2008

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, diagraphs, 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:

1. **Joan M. Aldous** and **Robin J. Wilson**, *Graphs and Applications*: *An Introductory Approach*, Springer, Indian reprint, 2007.
2. **Tyn Myint-U** and **Lokenath Debnath**, *Linear Partial Differential Equation for Scientists and Engineers*, Springer, Indian reprint, 2006.
3. **Frank R. Giordano**, **Maurice D. Weir** and **William P. Fox**, *A First Course in Mathematical Modeling*, Thomson Learning, London and New York, 2003.

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), Chapter3(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,.

[1] Chapter 5 (pages 181 - 236), Chapter 6, Chapter 7(pages 287- 304()Chapter 9 (pages 357 - 390), Chapter 14 (pages 594 - 600).

Reference:

[1]D. S. Malik: C++ Programming Language, Edition-<u>2009</u>, Course Technology, Cengage Learning, India Edition

Suggested Readings:

[2]E. Balaguruswami: Object oriented programming with C++, fifth edition, Tata McGraw Hill Education Pvt. Ltd.
[3]Marshall Cline, Greg Lomow, Mike Girou: C++ FAQs, Second Edition, Pearson Education.

Note: Practical programs of the following (and similar) typeare 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 ***while***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 short 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.
16. Multiplication/ Addition of two matrices using two dimensional arrays.
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:

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

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:

1. **B A. Davey** and **H. A. Priestley**, *Introduction to Lattices and Order,* Cambridge University Press, Cambridge, 1990.
2. **Edgar G. Goodaire** and **Michael M. Parmenter**, *Discrete Mathematics with Graph Theory* (2nd Edition), Pearson Education (Singapore) Pte. Ltd., Indian Reprint 2003.
3. **Rudolf Lidl** and **Günter Pilz**, *Applied Abstract Algebra* (2nd Edition), Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.

DSE-2(iii) CRYPTOGRAPHY AND NETWORK SECURITY

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

Definition of a cryptosystem, Symmetric cipher model, Classical encryption techniques-Substitution and transposition ciphers, caesar cipher, Playfair cipher. Block cipher Principles, Shannon theory of diffusion and confusion, Data encryption standard (DES).

[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, 1.3, 1.4, 1.6

Cryptographic Hash functions, Secure Hash algorithm, SHA-3.

[1] 11.1, 11.5, 11.6

Digital signature, Elgamal signature, Digital signature standards, Digital signature algorithm

[1] 13.1, 13.2, 13.4

E-mail security: Pretty Good Privacy (PGP)

[1] 18.1 Page 592-596(Confidentiality excluded)

REFERENCE:

[1] William Stallings, "Cryptography and Network Security", Principles and Practise, Fifth Edition, Pearson Education, 2012.

SUGGESTED READING:

[1] Douglas R. Stinson, "Cryptography theory and practice", CRC Press, Third edition, 2005.

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:

1. **Robert V. Hogg, Joseph W. McKean** and **Allen T. Craig**, *Introduction to Mathematical Statistics*, Pearson Education, Asia, 2007.
2. **Irwin Miller** and **Marylees Miller**, *John E. Freund's Mathematical Statistics with Applications* (7th Edition), Pearson Education, Asia, 2006.
3. **Sheldon Ross**, *Introduction to Probability Models* (9th Edition), Academic Press, Indian Reprint, 2007.

SUGGESTED READING:

1. **Alexander M**. **Mood**, **Franklin** A. **Graybill** and **Duane C. Boes**, *Introduction to the Theory of Statistics*, (3rd Edition), Tata McGraw- Hill, Reprint 2007

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:

1. I.**H. Shames** and **G. Krishna Mohan Rao**, *Engineering Mechanics: Statics and Dynamics* (4th Edition), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2009.
2. **R.C. Hibbeler** and **Ashok Gupta**, *Engineering Mechanics: Statics and Dynamics* (11th Edition), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.

DSE-3(iii) Bio-Mathematics

Total Marks: 100

Theory: 75

Internal Assessment: 25

5 Lectures, 1 Tutorial (per week per student)

Population growth, Administration of drugs, Cell division. Modelling Biological Phenomena: Heart beat, Blood Flow, Nerve Impulse transmission, Chemical Reactions, Predator-prey models. Stability and oscillations: Epidemics, the phase plane, Local Stability, Stability, Limit Cycles, Forced oscillations, Computing trajectories. Mathematics of Heart Physiology: The local model, The Threshold effect, The phase plane analysis and the heart beat model, Physiological considerations of the heart beat model, A model of the cardiac pace-maker. Mathematics of Nerve Impulse transmission: Excitability and repetitive firing, travelling waves. Bifurcation and chaos: Bifurcation, Bifurcation of a limit cycle, Discrete bifurcation, Chaos, Stability, The Poincare plane, Computer programs for Iteration Schemes.

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]

Modelling Molecular Evolution: Matrix models of base substitutions for DNA sequences, The Jukes-Cantor Model, the Kimura Models, Phylogenetic distances. Constructing Phylogenetic trees: Unweighted pair-group method with arithmetic means (UPGMA), Neighbour- Joining Method, Maximum Likelihood approaches. Genetics: Mendelian Genetics, Probability distributions in Genetics, Linked genes and Genetic Mapping, Statistical Methods and Prediction techniques.

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

Recommended Books:

1. Elizabeth S. Allman and John a. Rhodes, Mathematical Models in Biology, Cambridge University Press, 2004.
2. C. Epstein, The Mathematics of Medical Imaging, Prentice Hall, 2003 (copyright Pearson Education, 2005).
3. S. Helgason, The Radon transform, Second Edition, Birkhauser, 1997.
4. D. S. Jones and B. D. Sleeman, Differential Equations and Mathematical Biology, Cahapman & Hall, CRC Press, London, UK, 2003.
5. James Keener and James Sneyd, Mathematical Physiology, Springer Verlag, 1998, Corrected 2nd printing, 2001.

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.

References:

[1]: Chapter 2 (Section 2.5), Chapters 3 (Section 3.3), Chapter 4 (Sections 4.2 and 4.4), Chapter 5 (Section 5.2 excluding pseudoprimes, Section 5.3).

[2]: Chapter 3 (Section 3.2).

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:

1. **David M. Burton**, *Elementary Number Theory* (6th Edition), Tata McGraw-Hill Edition, Indian reprint, 2007.
2. **Neville Robinns,** *Beginning Number Theory* (2nd Edition), Narosa Publishing House Pvt. Limited, Delhi, 2007.

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).

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.
[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:

1. **Mokhtar S. Bazaraa**, **John J. Jarvis** and **Hanif D. Sherali**, *Linear Programming and Network Flows* (2nd edition), John Wiley and Sons, India, 2004.
2. **F. S. Hillier** and **G. J. Lieberman**, *Introduction to Operations Research- Concepts and Cases* (9th Edition), Tata McGraw Hill, 2010.
3. **Hamdy A. Taha**, *Operations Research, An Introduction* (9th edition), Prentice-Hall, 2010.

SUGGESTED READING:

1. G. Hadley, *Linear Programming*, Narosa Publishing House, New Delhi, 2002.

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 cods, 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. Lease squares methods: Approximate solutions of system of linear equations, approximate inverse of an $m^{x}n$ 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:

2. I.N. Herstein and D.J. Winter, *Primer on Linear Algebra,* Macmillan Publishing Company, New York, 1990.

3. S.R. Nagpaul and S.K. Jain, *Topics in Applied Abstract Algebra,* Thomson Brooks and Cole, Belmont, 2005.

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:

[1] Martin J. Erickson and Donald Bindner, A Student's Guide to the Study, Practice, and Tools of Modern Mathematics, CRC Press, Boca Raton, FL, 2011.

[2] L. Lamport, LATEX: A Document Preparation System, User’s Guide and Reference Manual. Addison-Wesley, New York, second edition, 1994.

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:

[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.