5 year Integrated M.Sc. (Mathematics)

(Exit option after 3 years with B.Sc. (Hons) degree in Mathematics)

CURRICULUM

(w.e.f. Academic Session 2017-2018)

DEPARTMENT OF MATHEMATICS,
SCHOOL OF PHYSICAL SCIENCES,
DOON UNIVERSITY DEHRADUN, UTTARAKHAND
PINCODE-248001

COURSE STRUCTURE

B. Sc. (Hons) Mathematics under the program Integrated M.Sc. Mathematics

Semester	Core Course (14)	Ability Enhancement Compulsory Course (AECC)(2)	Skill Enhancement Course (SEC)(2)	Discipline Specific Elective (DSE)(4)	Generic Elective (GE)(4)
1.	C1: Calculus (P)	AECC1			GE1
	C2: Algebra				
2.	C3: Real Analysis	AECC2			GE2
	C4: Differential Equations(P)				
3.	C5: Theory Of Real Functions		SEC1		GE3
	C6: Group Theory				
	C7: PDE and Systems of ODE(P)				
	C8: Mathematical Transforms				
4.	C9: Numerical Methods		SEC2		GE4
	C10: Riemann Integration And Series Of functions				
	C11: Ring Theory And linear Algebra- I				
5.	C12: Multivariate Calculus			DSE-1	
	C13: Group Theory II			DSE-2	
6	C14: Metric spaces And complex Analysis			DSE-3	
	C15: Ring Theory And Linear Algebra II			DSE-4	

Note: (P) *means course with practicals*

List of Generic Elective (GE),* Discipline Specific Elective(*DSE) and* Skill Enhancement Courses(*SEC):

S.No.	Discipline Specific Elective (DSE)	Generic Elective (GE)	Skill Enhancement Courses (SEC)
1	Portfolio Optimization	Applied Calculus	Logic and Sets
2	Number Theory	Econometrics	Computer Graphics
3	Analytical Geometry	Mathematical Finance	Graph Theory
4	Industrial Mathematics	Finite Element Method	Operating System: Linux
5	Boolean Algebra and Automata Theory	Cryptography and Network Security	
6	Probability and Statistics	Information Security	
7	Theory of Equations	Applications of Algebra	
8	Bio-Mathematics	Combinatorial Mathematics	
9	Linear Programming	Numerical Methods	
10	Mathematical Modelling	Object Oriented Programming in C++	
11	Mechanics		
12	Differential Geometry		

SEMESTER I						
Course Type	**Course Code**	**Course Title**	**Total credit**	**L**	**T**	**P**
Core	MAC-101	Calculus	6	4	0	2
Core	MAC-102	Algebra	6	4	2	0
AECC	EES-110	Environmental Science	2	2	0	0
Generic Elective	MAG-103	Applied Calculus	6	4	2	0
		TOTAL CREDITS	**20**			
SEMESTER II						
Course Type	**Course Code**	**Course Title**	**Total credit**	**L**	**T**	**P**

Core	MAC-151	Real Analysis	6	4	0	2
Core	MAC-152	Differential Equations	6	4	2	0
AECC	ENG-110	English	2	2	0	0
Generic Elective	MAG-152	Econometrics	6	4	2	0
		TOTAL CREDITS	**20**			
		SEMESTER III				
Course Type	**Course Code**	**Course Title**	**Total credit**	**L**	**T**	**P**
Core	MAC-201	Theory of Real Functions	6	4	2	0
Core	MAC-202	Group Theory	6	4	2	0
Core	MAC-203	PDE& System of ODE	6	4	0	2
Core	MAC-204	Mathematical Transforms	4	3	1	0
SEC	MAS-203	Special Functions	2	2	0	0
Generic Elective	MAG-201	Applications of Algebra	6	4	2	0
		TOTAL CREDITS	**30**			
		SEMESTER IV				
Course Type	**Course Code**	**Course Title**	**Total credit**	**L**	**T**	**P**
Core	MAC-251	Numerical Methods	6	4	0	2
Core	MAC-252	Riemann Integration and Series of Functions	6	4	2	0
Core	MAC-253	Ring Theory and Linear Algebra	6	4	2	0
SEC	MAS-251	Graph Theory	2	2	0	0
Generic Elective	MAG-253	Numerical Methods	6	4	2	0
		TOTAL CREDITS	**26**			
		SEMESTER V				
Course Type	**Course Code**	**Course Title**	**Total credit**	**L**	**T**	**P**
Core	MAC-301	Multivariate Calculus	6	4	2	0
Core	MAC-302	Group Theory-II	6	4	2	0
DSE	MAD-303	Analytical Geometry	6	4	2	0
DSE	MAD-306	Probability and Statistics	6	4	2	0
		TOTAL CREDITS	**24**			

	SEMESTER VI					
Course Type	**Course Code**	**Course Title**	**Total credit**	**L**	**T**	**P**
Core	MAC-351	Metric Space and Complex Analysis	6	4	2	0
Core	MAC-352	Ring Theory and Linear Algebra-II	6	4		0
DSE	MAD-353	Linear Programming	6	4	2	0
DSE	MAD-355/356	Mechanics/Differential Geometry	6	4	2	0
		TOTAL CREDITS	**24**			
	SEMESTER VII					
Course Type	**Course Code**	**Course Title**	**Total credit**	**L**	**T**	**P**
Core	MAC-401	Finite Field	4	3	1	0
Core	MAC-402	Topology	4	3	1	0
Core	MAC-403	Ordinary Differential Equation (ODE)	6	4	0	2
Core	MAC-404	Numerical Analysis	6	4	0	2
Core	MAC-405	Mathematical Modelling	4	3	1	0
Core	MAC-406	Linear Algebra	4	3	1	0
		TOTAL CREDITS	**28**			
	SEMESTER VIII					
Course Type	**Course Code**	**Course Title**	**Total credit**	**L**	**T**	**P**
Core	MAC-451	Functional Analysis	4	3	1	0
Core	MAC-452	Complex Analysis	4	3	1	0
Core	MAC-453	Partial Differential Equation (PDE)	6	4	2	0
Core	MAC-454	Measure & Integration	4	3	1	0
Core	MAC-455	Linear Programming	4	3	1	0
		TOTAL CREDITS	**22**			
	SEMESTER IX					
Course Type	**Course Code**	**Course Title**	**Total credit**	**L**	**T**	**P**
Core	MAC-501	Non-Linear Programming Problem (NLPP)	4	3	1	0
Core	MAC-502	Fluid Dynamics	4	3	1	0

Core	MAC-503	Applied Functional Analysis	4	3	1	0
Core	MAC-504	Integral Equations &Calculus of variation	4	3	1	0
Core	MAC-510	Project Work	4			
		TOTAL CREDITS	**20**			
	SEMESTER X					
Course Type	**Course Code**	**Course Title**	**Total credit**	**L**	**T**	**P**
Core	MAC-551	Fuzzy Sets and Logics	4	3	1	0
Core	MAC-552	Biomathematics	4	3	1	0
Core	MAC-553	Approximation theory	4	3	1	0
Core	MAC-560	Dissertation(based on some scientific problem)	6			
		TOTAL CREDITS	**18**			

List of Optional Courses for IX and X Semesters:

S. No.	Course Code	Group A (List of Optional Courses for IX Semester)	Credits	Course Code	Group B (List of Optional Courses for X Semester)	Credits
1.	MAC-501	Non-Linear Programming Problem (NLPP)	4	MAC-551	Fuzzy Sets and Logics	4
2.	MAC-502	Fluid Dynamics	4	MAC-552	Biomathematics	4
3.	MAC-503	Applied Functional	4	MCA-553	Approximation	4

		Analysis			theory	
4.	MAC-504	Integral Equation and Calculus of Variations	4	MAC-554	Fractal Geometry	4
5.	MAC-505	Actuarial Mathematics	4	MAC-555	Matrix Analysis	4
6.	MAC-506	Control Theory	4	MAC-556	Stochastic Modelling and Simulation	4
7.	MAC-507	Applied Discrete Mathematics	4	MAC-557	Fourier and Wavelet Analysis	4

Guidelines

1. Minimum Credit requirements

a) For 3 year B.Sc. (Hons) Mathematics

Course Type	**Number of papers**	**Credits**
Core	15 Papers	88
AECC(Ability Enhancement Compulsory Course)	2 papers of 2 credits each	$2 \times 2 = 4$
SEC (Skill Enhancement Course)	2 papers of 2 credits each	$2 \times 2 = 4$
Generic Elective(GE)	4 papers of 6 credits each	$4 \times 6 = 24$
DSE (Discipline Specific Elective)	4 papers of 6 credits each	$4 \times 6 = 24$
	Total Credits	144

b) For 5 year Integrated M.Sc. Mathematics

Course Type	**Number of papers**	**Credits**
Core	35 Papers	176
AECC(Ability Enhancement Compulsory Course)	2 papers of 2 credits each	$2 \times 2 = 4$
SEC (Skill Enhancement Course)	2 papers of 2 credits each	$2 \times 2 = 4$
Generic Elective(GE)	4 papers of 6 credits each	$4 \times 6 = 24$
DSE (Discipline Specific Elective)	4 papers of 6 credits each	$4 \times 6 = 24$
	Total Credits	232

A minimum of 144 credits and 232 credits respectively must be earned by the student for the award of B.Sc. (Hons) Mathematics and M.Sc. Mathematics (5 years Integrated Master program) degrees, respectively.

2. Generic Courses

Student must take 4 generic papers, one each in semesters I through IV. They can opt for papers from following disciplines.

a) Physics
b) Chemistry
c) Computer Science
d) Operations Research

e) Economics

Any other discipline of importance

Following is the list of generic electives courses currently offered by the department for other department students:

SEMESTER I	SEMESTER II	SEMESTER III	SEMESTER IV
MAG-103 Applied Calculus	MAG-152 Econometrics	MAG-201 Applications of Algebra	MAG-253 Numerical Methods

3. Project and Dissertation

There are one project(4 credits) and one dissertation(6 credits) in IX and X semesters respectively based on some scientific problems. These courses require individual/group effort that is overseen by your project supervisor. Weekly meetings will be held to discuss progress and review necessary documents in support of the project and dissertation. There will be monthly presentations regarding progress of the project and dissertation. A final presentation followed by viva-voce by external examiner will be held at the end of the IX and X semesters where the student must submit detailed reports.

Objective and Learning Outcomes

1. Objective of the Bachelor's degree programme in Mathematics:

The main objectives of B.Sc.(Hons) Mathematics Programme are to:

a) inculcate strong interest in learning mathematics,
b) evolve broad and balanced knowledge and understanding of definitions, key concepts, principles and theorems in Mathematics,
c) enable learners/students to apply the knowledge and skills acquired by them during the programme to solve specific theoretical and applied problems in mathematics,
d) develop in students the ability to apply relevant tools developed in mathematical theory to handle issues and problems in social and natural sciences,
e) provide students with sufficient knowledge and skills that enable them to undertake further studies in mathematics and related disciplines,
f) enable students to develop a range of generic skills which will be helpful in wageemployment, self-employment and entrepreneurship.

2. Program Specific Outcomes:

The completion of the B.Sc. (Hons.) Mathematics Programme will enable a student to:

a) Communicate mathematics effectively by written, computational and graphic means.
b) Create mathematical ideas from basic axioms.
c) Gauge the hypothesis, theories, techniques and proofs provisionally.
d) Utilize mathematics to solve theoretical and applied problems by critical understanding, analysis and synthesis.
e) Identify applications of mathematics in other disciplines and in the real-world, leading to enhancement of career prospects in a plethora of fields and research.

3. Course Details with Course Specific Outcomes

MAC-101: Calculus

Course outcomes:

(a) To introduce fundamentals of the calculus in order to enhance application skill of students and prepare them to pursue higher analytical mathematics.
(b) By the completion of the course the students will be able to analysis the relationships between quantities such as rates of changes, area, volume, properties of curves) and their mathematical equivalents.
(c) The course will be able to equip the students with the tools of calculus to measure various quantities such as curvature, torsion, point motion in space etc. One of the main objective of the course is to further deepen the fundamentals of analytical mathematics.

Course Content:

Hyperbolic functions, higher order derivatives, Leibniz rule and its applications to problems of type $e^{ax+b}\sin x$, $e^{ax+b}\cos x$, $(ax+b)^n\sin x$, $(ax+b)^n\cos x$, concavity and inflection points, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital's rule, applications in business, economics and life sciences.

Reduction formulae, derivations and illustrations of reduction formulae of the type / sin nx dx, / cos nx dx, / tan nx dx, / sec nx dx, / $(\log x)^n$ dx, / $\sin^n x \sin^m x$ dx, volumes by slicing, disks and washers methods, volumes by cylindrical shells, parametric equations, parameterizing a curve, arc length, arc length of parametric curves, area of surface of revolution. Techniques of sketching conics, reflection properties of conics, rotation of axes and second degree equations, classification into conics using the discriminant, polar equations of conics.

Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions, tangent and normal components of acceleration, modeling ballistics and planetary motion, Kepler's second law.

List of Practicals (using any software)

(i) Plotting of graphs of function $e^{ax} + {}^{b}$, log(ax + b), 1/(ax + b), sin(ax + b), cos(ax + b), |ax + b| and to illustrate the effect of a and b on the graph.
(ii) Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.
(iii) Sketching parametric curves (Eg. Trochoid, cycloid, epicycloids, hypocycloid).
(iv) Obtaining surface of revolution of curves.
(v) Tracing of conics in cartesian coordinates/ polar coordinates.
(vi) Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic, paraboloid, hyperbolic paraboloid using cartesian coordinates.
(vii) Matrix operation (addition, multiplication, inverse, transpose).

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus,* 9th Ed., Pearson Education, Delhi, 2005.

2. M.J. Strauss, G.L. Bradley and K. J. Smith, *Calculus,* 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.

3. H. Anton, I. Bivens and S. Davis, *Calculus*, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.

4. R. Courant and F. John, *Introduction to Calculus and Analysis* (Volumes I & II), Springer-Verlag, New York, Inc., 1989.

MAC-102: Algebra

Course outcomes:

This course will enable the students to:

a) Employ De Moivre's theorem in a number of applications to solve numerical problems.
b) Learn about equivalent classes and cardinality of a set.
c) Use modular arithmetic and basic properties of congruences.
d) Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix.
e) Find eigenvalues and corresponding eigenvectors for a square matrix.

Course Content:

Polar representation of complex numbers, n^{th} roots of unity, De Moivre's theorem for rational indices and its applications.

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.

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.

Books Recommended

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 Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005**.**

3. David C. Lay, *Linear Algebra and its Applications,* 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.

MAC-151: Real Analysis

Course Outcomes:

This course will enable the students to:

a) Understand many properties of the real line $\mathbb{R}$, including completeness and Archimedean properties.
b) Learn to define sequences in terms of functions from $\mathbb{N}$ to a subset of $\mathbb{R}$.
c) Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.
d) Apply the ratio, root, alternating series and limit comparison tests for convergence and absolute convergence of an infinite series of real numbers.

Course Content:

Review of Algebraic and Order Properties of *R*, ^-neighborhood of a point in *R*, Idea of countable sets, uncountable sets and uncountability of *R*. 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. Limit points of a set, Isolated points, Illustrations of Bolzano-Weierstrass theorem for sets.

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.

Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy's n^{th} root test, Integral test, Alternating series, Leibniz test, Absolute and Conditional convergence.

Books Recommended

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

2. Gerald G. Bilodeau , Paul R. Thie, G.E. Keough, *An Introduction to Analysis,* 2nd Ed., Jones & Bartlett, 2010.

3. Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, *Elementary Real Analysis*, Prentice Hall, 2001.

4. S.K. Berberian, *A First Course in Real Analysis,* Springer Verlag, New York, 1994.

MAC-152: Differential Equations

Course Outcomes:

The course will enable the students to:

a) Learn basics of differential equations and mathematical modeling.
b) Formulate differential equations for various mathematical models.
c) Solve first order non-linear differential equations and linear differential equations of higher order using various techniques.
d) Apply these techniques to solve and analyze various mathematical models.

Course Content:

Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations.

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

General solution of homogeneous equation of second order, principle of super position for 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.

List of Practicals (using any software)

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. Lake pollution model (with constant/seasonal flow and pollution concentration).
6. Case of single cold pill and a course of cold pills.
7. Limited growth of population (with and without harvesting).
8. Predatory-prey model (basic volterra model, with density dependence, effect of DDT, two prey one predator).
9. Epidemic model of influenza (basic epidemic model, contagious for life, disease with carriers).
10. Battle model (basic battle model, jungle warfare, long range weapons).
11. Plotting of recursive sequences.
12. Study the convergence of sequences through plotting.
13. Verify Bolzano-Weierstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot.
14. Study the convergence/divergence of infinite series by plotting their sequences of partial sum.

15. Cauchy's root test by plotting n^{th} roots.

16. Ratio test by plotting the ratio of n^{th} and $(n+1)^{th}$ term.

Books Recommended

1. Belinda Barnes and Glenn R. Fulford, *Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab*, 2nd Ed., Taylor and Francis group, London and New York, 2009.

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*, 3rd Ed., John Wiley and Sons, India, 2004.

4. Martha L Abell, James P Braselton, *Differential Equations with MATHEMATICA*, 3rd Ed., Elsevier Academic Press, 2004.

MAC-201: Theory of Real Functions

Course Outcomes:

This course will enable the students to:

a) Have a rigorous understanding of the concept of limit of a function.
b) Learn about continuity and uniform continuity of functions defined on intervals.
c) Understand geometrical properties of continuous functions on closed and bounded intervals.
d) Learn extensively about the concept of differentiability using limits, leading to a better understanding for applications.
e) Know about applications of mean value theorems and Taylor's theorem.

Course Content:

Limits of functions *(ε-δ* approach), sequential criterion for limits, divergence criteria. Limit theorems, one sided limits. Infinite limits and limits at infinity. Continuous functions, sequential criterion for continuity and discontinuity. Algebra of continuous functions. 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.

Differentiability of a function at a point and in an interval, Caratheodory's theorem, algebra of differentiable functions. 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 and approximation of polynomials, Taylor's theorem to inequalities.

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 and Maclaurin's series expansions of exponential and

trigonometric functions, $\ln(1 + x)$, $1/ax+b$ and $(1 +x)^n$.

Books Recommended:

1. R. Bartle and D.R. Sherbert, *Introduction to Real Analysis,* John Wiley and Sons, 2003.
2. K.A. Ross, *Elementary Analysis: The Theory of Calculus,* Springer, 2004.
3. A. Mattuck, *Introduction to Analysis,* Prentice Hall, 1999.
4. S.R. Ghorpade and B.V. Limaye, *A Course in Calculus and Real Analysis,* Springer, 2006.

MAC-202: Group Theory I

Course Outcomes:

The course will enable the students to:

a) Recognize the mathematical objects that are groups, and classify them as abelian, cyclic and permutation groups, etc.
b) Link the fundamental concepts of groups and symmetrical figures.
c) Analyze the subgroups of cyclic groups and classify subgroups of cyclic groups.
d) Explain the significance of the notion of cosets, normal subgroups and factor groups.
e) Learn about Lagrange's theorem and Fermat's Little theorem.
f) Know about group homomorphisms and group isomorphisms.

Course Content:

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. 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.

Group homomorphisms, properties of homomorphisms, Cayley's theorem, properties of isomorphisms, First, Second and Third isomorphism theorems.

Books Recommended

1. John B. Fraleigh, *A First Course in Abstract Algebra,* 7th Ed., Pearson, 2002**.**
2. M. Artin, *Abstract Algebra,* 2nd Ed., Pearson, 2011.
3. Joseph A. Gallian, *Contemporary Abstract Algebra*,4th Ed., Narosa Publishing House, New Delhi, 1999.

4. Joseph J. Rotman, *An Introduction to the Theory of Groups*,4th Ed., Springer Verlag, 1995.
5. I.N. Herstein, *Topics in Algebra*, Wiley Eastern Limited, India, 1975.

MAC-203: PDE and Systems of ODE

Course Outcomes:

The course will enable the students to:

a) Formulate, classify and transform first order PDEs into canonical form.
b) Learn about method of characteristics and separation of variables to solve first order PDE's.
c) Classify and solve second order linear PDEs.
d) Learn about Cauchy problem for second order PDE and homogeneous and nonhomogeneous wave equations.
e) Apply the method of separation of variables for solving many well-known second order PDEs

Course Content:

Partial Differential Equations - Basic concepts and Definitions, Mathematical Problems. First Order Equations: Classification, Construction and Geometrical Interpretation. Method of Characteristics for obtaining General Solution of Quasi Linear Equations. Canonical Forms of First-order Linear Equations. Method of Separation of Variables for solving first order partial differential equations.

Derivation of Heat equation, Wave equation and Laplace equation. Classification of second order linear equations as hyperbolic, parabolic or elliptic. Reduction of second order Linear Equations to canonical forms.

Systems of linear differential equations, types of linear systems, differential operators, an operator method for linear systems with constant coefficients, Basic Theory of linear systems in normal form, homogeneous linear systems with constant coefficients: Two Equations in two unknown functions, The method of successive approximations, the Euler method, the modified Euler method, The Runge-Kutta method.

List of Practical (using any software)

(i) Solution of Cauchy problem for first order PDE.
(ii) Finding the characteristics for the first order PDE.
(iii) Plot the integral surfaces of a given first order PDE with initial data.

Books Recommended

1. Tyn Myint-U and Lokenath Debnath, *Linear Partial Differential Equations for Scientists and Engineers*, 4th edition, Springer, Indian reprint, 2006.
2. S.L. Ross, *Differential equations*, 3rd Ed., John Wiley and Sons, India, 2004.
3. Martha L Abell, James P Braselton, *Differential equations with MATHEMATICA*, 3rd Ed., Elsevier Academic Press, 2004.

MAC-204: Mathematical Transforms

Course Outcome:
The course will enable the students to:

a) determine Laplace transform of functions.
b) determine Fourier and Z-Transforms for various functions.
c) use properties of Fourier and Z-Transforms to solve physical problems.
d) introduce Mellin Transform, its Shifting and scaling properties, Mellin transforms of derivatives and integrals
e) applications of transforms to solve physical problems.

Course Content:

Laplace Transform: Laplace of some standard functions, Existence conditions for the Laplace Transform, Shifting theorems, Laplace transform of derivatives and integrals, Inverse Laplace transform and their properties, Convolution theorem, Initial and final value theorem, Laplace transform of periodic functions, error functions, Heaviside unit step function and Dirac delta function, Applications of Laplace transform to solve ODEs and PDEs.

Fourier Transforms**:** Fourier integrals, Fourier sine and cosine integrals, Complex form of Fourier integral representation, Fourier transform, Fourier transform of derivatives and integrals, Fourier sine and cosine transforms and their properties, Convolution theorem, Application of Fourier transforms to Boundary Value Problems.

Mellin Transform**:** Definition and properties of Mellin transform, Shifting and scaling properties, Mellin transforms of derivatives and integrals, Applications of Mellin transform.

Z-Transform: Z–transform and inverse Z-transform of elementary functions, Shifting theorems, Convolution theorem, Initial and final value theorem, Application of Z-transforms to solve difference equations.

Books Recommended

1. I. N. Sneddon, *Fourier Transforms*, Dover.
2. Joel L. Schiff, *The Laplace Transform: Theory and Applications (Undergraduate Texts in Mathematics)*, Springer.
3. E. Kreyszig, "Advanced Engineering Mathematics**"**, 10thEdition, John & Wiley Sons, U.K., 2016/.
4. Ronald N. Bracewell,"The Fourier Transforms and its Applications", 3rd Edition, McGraw Hill Science,1999.

MAC-251: Numerical Methods

Course Outcome:
The course will enable the students to:

a) Learn some numerical methods to find the zeroes of nonlinear functions of a single variable and solution of a system of linear equations, up to a certain given level of precision.
b) Know about methods to solve system of linear equations, such as Gauss−Jacobi, Gauss−Seidel and SOR methods.
c) Interpolation techniques to compute the values for a tabulated function at points not in the table.
d) Applications of numerical differentiation and integration to convert differential equations into difference equations for numerical solutions.

Course Content:

Algorithms, Convergence, Errors: Relative, Absolute, Round off, Truncation.

Transcendental and Polynomial equations: Bisection method, Newton's method, Secant method. Rate of convergence of these methods.

System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis.

Interpolation: Lagrange and Newton's methods. Error bounds. Finite difference operators. Gregory forward and backward difference interpolation.

Numerical Integration: Trapezoidal rule, Simpson's rule, Simpsons 3/8th rule, Boole's Rule. Midpoint rule, Composite Trapezoidal rule, Composite Simpson's rule.

Ordinary Differential Equations: Euler's method. Runge-Kutta methods of orders two and four.

Note: Use of Scientific Calculator is allowed.

List of Practicals (using any software)

(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) Bisection Method.
(v) Newton Raphson Method.
(vi) Secant Method.
(vii) Regulai Falsi Method.
(viii) LU decomposition Method.
(ix) Gauss-Jacobi Method.
(x) SOR Method or Gauss-Siedel Method.
(xi) Lagrange Interpolation or Newton Interpolation.
(xii) Simpson's rule.

Note: For any of the CAS (Computer aided software) 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.

Books Recommended

1. Brian 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*, 6th Ed., New age International Publisher, India, 2007.

3. Uri M. Ascher and Chen Greif, *A First Course in Numerical Methods,* 7th Ed., PHI Learning Private Limited, 2013.

4. John H. Mathews and Kurtis D. Fink, *Numerical Methods using Matlab,* 4th Ed., PHI Learning Private Limited, 2012.

MAC-252: Riemann Integration and Series of Functions

Course outcomes.

(a) The objective of this course is to impart complete constructive and analytical knowledge of the theory of integration.
(b) The students will be able of analysis of the various type of the integrals occurring in engineering and science.
(c) After the completion of the course, the students are expected to gain capability for inquiring about questions relating to the concepts in various fields of mathematics and science.
(d) It is essentially expected that integration theory supported by the knowledge of series and sequences of functions will make a powerful tool to analyze problems of science and technology.

Course Content:

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.

Improper integrals; Convergence of Beta and Gamma functions.

Pointwise and uniform convergence of sequence of functions. Theorems on continuity, derivability and integrability of the limit function of a sequence of functions. 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.

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.

Books Recommended

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,* 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.

3. Charles G. Denlinger, *Elements of Real Analysis*, Jones & Bartlett (Student Edition), 2011.

MAC-253: Ring Theory and Linear Algebra-I

Course Outcomes:

The course will enable the students to:

a) Learn about the fundamental concept of rings, integral domains and fields.
b) Know about ring homomorphisms and isomorphisms theorems of rings.
c) Learn about the concept of linear independence of vectors over a field, and the dimension of a vector space.
d) Basic concepts of linear transformations, dimension theorem, matrix representation of a linear transformation, and the change of coordinate matrix.

Course Content:

Definition and examples of rings, properties of rings, subrings, integral domains and fields, characteristic of a ring. Ideal, 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.

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.

Books Recommended

1. John B. Fraleigh, *A First Course in Abstract Algebra,* 7th Ed., Pearson, 2002**.**
2. M. Artin, *Abstract Algebra,* 2nd Ed., Pearson, 2011.
3. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra,*4th Ed., Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.
4. Joseph A. Gallian, *Contemporary Abstract Algebra,* 4th Ed., Narosa Publishing House, New Delhi, 1999.
5. S. Lang, *Introduction to Linear Algebra,*2nd Ed., Springer, 2005.
6. Gilbert Strang, *Linear Algebra and its Applications,* Thomson, 2007.
7. S. Kumaresan, *Linear Algebra- A Geometric Approach,* Prentice Hall of India,1999.
8. Kenneth Hoffman, Ray Alden Kunze, *Linear Algebra,*2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
9. D.A.R. Wallace, *Groups, Rings and Fields,* Springer Verlag London Ltd., 1998.

MAC-301: Multivariate Calculus

Course Outcome:

The course will enable the students to:

a) Learn the conceptual variations when advancing in calculus from one variable to multivariable discussion.
b) Find partial derivatives and Jacobian of multivariable functions and use them in practicalproblems, like to find extreme values of functions having two independent variables and to solveconstrained optimization problems.
c) Apply Fundamental Theorem of Line Integrals, Green's Theorem, Stokes' Theorem, andDivergence Theorem to evaluate multiple integrals.
d) Understand the maximization and minimization of multivariable functions subject to the given constraints on variables.
e) Learn about inter-relationship amongst the line integral, double and triple integral formulations.

Course Content:

Use of Scientific calculator is allowed.

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

Double integration over rectangular region, double integration over non-rectangular 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. 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. Stoke's theorem, The Divergence theorem.

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus,* 9th Ed., Pearson Education, Delhi, 2005.

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

3. E. Marsden, A.J. Tromba and A. Weinstein, *Basic Multivariable Calculus,* Springer (SIE), Indian reprint, 2005.

4. James Stewart, *Multivariable Calculus, Concepts and Contexts,* 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001.

MAC-302: Group Theory II

Course Outcomes:

The course shall enable students to:

a) Learn about automorphisms for constructing new groups from the given group.
b) Learn about the fact that external direct product applies to data security and electric circuits.
c) Understand fundamental theorem of finite abelian groups.
d) Be familiar with group actions and conjugacy in S_n.
e) Understand Sylow theorems and their applications in checking nonsimplicity.

Course Content:

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.

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.

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 $n > 5$, non-simplicity tests.

Books Recommended

1. John B. Fraleigh, *A First Course in Abstract Algebra,* 7th Ed., Pearson, 2002**.**

2. M. Artin, *Abstract Algebra,* 2nd Ed., Pearson, 2011.

3. Joseph A. Gallian, *Contemporary Abstract Algebra,*4th Ed., Narosa Publishing House, 1999.

4. David S. Dummit and Richard M. Foote, *Abstract Algebra,* 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2004.

5. J.R. Durbin, *Modern Algebra,* John Wiley & Sons, New York Inc., 2000.
6. D. A. R. Wallace, *Groups, Rings and Fields,* Springer Verlag London Ltd., 1998.

MAC-351: Metric Spaces and Complex Analysis

Course Outcomes:

The course will enable the students to:

a) Learn various natural and abstract formulations of distance on the sets of usual or unusual entities. Become aware one such formulations leading to metric spaces.

b) Analyse how a theory advances from a particular frame to a general frame.

c) Appreciate the mathematical understanding of various geometrical concepts, viz. balls

d) Learn the significance of differentiability of complex functions leading to the understanding of Cauchy−Riemann equations.

e) Learn some elementary functions and valuate the contour integrals.

f) Understand the role of Cauchy−Goursat theorem and the Cauchy integral formula.

g) Expand some simple functions as their Taylor and Laurent series, classify the nature of singularities, find residues and apply Cauchy Residue theorem to evaluate integrals.

Course Content:

Metric spaces: definition and examples. Sequences in metric spaces, Cauchy sequences. Open and closed balls, neighbourhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set.

Continuous mappings, sequential criterion and other characterizations of continuity. Uniform continuity. Homeomorphism.

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.

Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function, derivatives of functions, definite integrals of functions. Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. Cauchy-Goursat theorem, Cauchy integral formula.

Liouville's theorem and the fundamental theorem of algebra. Convergence of sequences and series, Taylor series and its examples.

Laurent series and its examples, absolute and uniform convergence of power series.

Books Recommended

1. Satish Shirali and Harikishan L. Vasudeva, *Metric Spaces,* Springer Verlag, London, 2006.
2. S. Kumaresan, *Topology of Metric Spaces,* 2nd Ed., Narosa Publishing House, 2011.
3. G.F. Simmons, *Introduction to Topology and Modern Analysis,* McGraw-Hill, 2004.
4. James Ward Brown and Ruel V. Churchill, *Complex Variables and Applications,* 8th Ed., McGraw - Hill International Edition, 2009.
5. Joseph Bak and Donald J. Newman, *Complex Analysis,* 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., NewYork, 1997.

MAC-352: Ring Theory and Linear Algebra II

Courses Outcomes:

On completion of this course, the student will be able to:

a) Appreciate the significance of unique factorization in rings and integral domains.
b) Compute the characteristic polynomial, eigenvalues, eigenvectors, and eigenspaces, as well as the geometric and the algebraic multiplicities of an eigenvalue and apply the basic diagonalization result.
c) Compute inner products and determine orthogonality on vector spaces, including Gram−Schmidt orthogonalization to obtain orthonormal basis.
d) Find the adjoint, normal, unitary and orthogonal operators.

Course Content:

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.

Dual spaces, dual basis, double dual, transpose of a linear transformation and its matrix in the dual basis, annihilators, Eigen spaces of a linear operator, diagonalizability, invariant subspaces and Cayley-Hamilton theorem, the minimal polynomial for a linear operator.

Books Recommended

1. John B. Fraleigh, *A First Course in Abstract Algebra,* 7th Ed., Pearson, 2002**.**
2. M. Artin, *Abstract Algebra,* 2nd Ed., Pearson, 2011.
3. Joseph A. Gallian, *Contemporary Abstract Algebra*, 4th Ed., Narosa Publishing House, 1999.
4. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra,*4th Ed., Prentice-Hall of India Pvt. Ltd., New Delhi, 2004.
5. S. Lang, *Introduction to Linear Algebra,*2nd Ed., Springer, 2005.
6. Gilbert Strang, *Linear Algebra and its Applications*, Thomson, 2007.
7. S. Kumaresan, *Linear Algebra- A Geometric Approach,* Prentice Hall of India, 1999.
8. Kenneth Hoffman, Ray Alden Kunze, *Linear Algebra,*2nd Ed., Prentice-Hall of India Pvt. Ltd., 1971.
9. S.H. Friedberg, A.L. Insel and L.E. Spence, *Linear Algebra,* Prentice Hall of India Pvt. Ltd., 2004.

Discipline Specific Electives (DSE)

DSE1.1 Portfolio Optimization

Course Outcome:

This course will enable the students to:

a) know the history of portfolio optimization
b) have some idea about portfolio management in practice, what is risk and its types.
c) why optimization techniques are rarely used in practice, at least for portfolios of individual stocks and measures.
d) the opportunities for mathematical optimization to be used in practice.

Course Content:

Financial markets. Investment objectives. Measures of return and risk. Types of risks. Risk free assets. Mutual funds. Portfolio of assets. Expected risk and return of portfolio. Diversification.

Mean-variance portfolio optimization- the Markowitz model and the two-fund theorem, risk-free assets and one fund theorem, efficient frontier. Portfolios with short sales. Capital market theory.

Capital assets pricing model- the capital market line, beta of an asset, beta of a portfolio, security market line. Index tracking optimization models. Portfolio performance evaluation measures.

Books Recommended

1. F. K. Reilly, Keith C. Brown, *Investment Analysis and Portfolio Management,* 10th Ed., South-Western Publishers, 2011.
2. H.M. Markowitz, *Mean-Variance Analysis in Portfolio Choice and Capital Markets,* Blackwell, New York, 1987.
3. M.J. Best, *Portfolio Optimization,* Chapman and Hall, CRC Press, 2010.
4. D.G. Luenberger, *Investment Science,* 2nd Ed., Oxford University Press, 2013.

DSE1.2 Number Theory

Course Outcomes:

This course will enable the students to:

a) Learn about some fascinating discoveries related to the properties of prime numbers, and some of the open problems in number theory, viz., Goldbach conjecture etc.
b) Know about number theoretic functions and modular arithmetic.
c) Solve linear, quadratic and system of linear congruence equations.
d) Learn about public key crypto systems, in particular, RSA.

Course Content:

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.

Number theoretic functions, sum and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobius Inversion formula, the greatest integer function, Euler's phi-function, Euler's theorem, reduced set of residues, some properties

of Euler's phi-function.

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 $x^1 + y^2 = z^2$, Fermat'sLast theorem.

Books Recommended

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

DSE1.3 Analytical Geometry

Course Outcome:

This course will enable the students to:

- **a)** introduction to analytical geometry of 2 dimensional.
- **b)** study of lines in 2 and 3 dimension.
- **c)** finding equation in various form of line, circle, ellipse, sphere, cones etc.
- d) sketch the graphs of some special curves by using polar coordinates on the plane.

Course Content:

Techniques for sketching parabola, ellipse and hyperbola. Reflection properties of parabola, ellipse and hyperbola. Classification of quadratic equations representing lines, parabola, ellipse and hyperbola.

Spheres, Cylindrical surfaces. Illustrations of graphing standard quadric surfaces like cone, ellipsoid.

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus,* 9th Ed., Pearson Education, Delhi, 2005.
2. H. Anton, I. Bivens and S. Davis, *Calculus,* John Wiley and Sons (Asia) Pvt. Ltd. 2002.
3. S.L. Loney, *The Elements of Coordinate Geometry,* McMillan and Company, London.
4. *R.J.T. Bill,* Elementary Treatise on Coordinate Geometry of Three Dimensions, *McMillan India Ltd., 1994.*

DSE2.1 Industrial Mathematics

Course Outcome:

This course will enable the students to:

- **a)** give sufficient knowledge of fundamental principles, methods and a clear perception of the innumerous power of mathematical ideas and tools and knowledge of how to use them by modeling, solving and interpreting.
- **b)** Developing mathematical tools for continuing further study in various fields of science including medical science.
- **c)** Know the idea of inverse problems and their applications.

Course Content:

Medical Imaging and Inverse Problems. The content is based on Mathematics of X-ray and CT scan based on the knowledge of calculus, elementary differential equations, complex numbers and matrices.

Introduction to Inverse problems: Why should we teach Inverse Problems? Illustration of Inverse problems through problems taught in Pre-Calculus, Calculus, Matrices and differential equations. Geological anomalies in Earth's interior from measurements at its surface (Inverse problems for Natural disaster) and Tomography.

X-ray: Introduction, X-ray behavior and Beers Law (The fundament question of image construction) Lines in the place.

Radon Transform: Definition and Examples, Linearity, Phantom (Shepp - Logan Phantom - Mathematical phantoms).

Back Projection: Definition, properties and examples.

CT Scan: Revision of properties of Fourier and inverse Fourier transforms and applications of their properties in image reconstruction. Algorithms of CT scan machine. Algebraic reconstruction techniques abbreviated as ART with application to CT scan.

Books Recommended

1. Timothy G. Feeman, *The Mathematics of Medical Imaging, A Beginners Guide*, Springer Under graduate Text in Mathematics and Technology, Springer, 2010.
2. C.W. Groetsch, *Inverse Problems,* Activities for Undergraduates, The Mathematical Association of America, 1999.
3. *Andreas Kirsch*, An Introduction to the Mathematical Theory of Inverse Problems, *2nd Ed., Springer, 2011.*

DSE 2.2 Boolean Algebra and Automata Theory

Course Outcome:

This course will enable the students to:

- **a)** convert numbers into different systems and perform arithmetic operations there;
- **b)** identify various methods for representing characters in a computer;

c) design circuits for simple Boolean expressions, and implement basic logic gates using universal gates;
d) define Automata;
e) discuss the acceptability of a string by finite automation;
f) construct non-deterministic finite state machine.

Course Content:
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.

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.

Introduction: Alphabets, strings, and languages. Finite Automata and Regular Languages: deterministic and non-deterministic finite automata, regular expressions, regular languages and their relationship with finite automata, pumping lemma and closure properties of regular languages.

Context Free Grammars and Pushdown Automata: Context free grammars (CFG), parse trees, ambiguities in grammars and languages, pushdown automaton (PDA) and the language accepted by PDA, deterministic PDA, Non- deterministic PDA, properties of context free languages; normal forms, pumping lemma, closure properties, decision properties.

Turing Machines: Turing machine as a model of computation, programming with a Turing machine, variants of Turing machine and their equivalence.

Undecidability: Recursively enumerable and recursive languages, undecidable problems about Turing machines: halting problem, Post Correspondence Problem, and undecidability problems About CFGs.

Books Recommended

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 Ed.), Pearson Education (Singapore) P.Ltd., Indian Reprint 2003.
3. Rudolf Lidl and Gunter Pilz, *Applied Abstract Algebra,* 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004.
4. J. E. Hopcroft, R. Motwani and J. D. Ullman, *Introduction to Automata Theory, Languages, and Computation,* 2nd Ed., Addison-Wesley, 2001.
5. H.R. Lewis, C.H. Papadimitriou, C. Papadimitriou, *Elements of the Theory of Computation,* 2nd Ed., Prentice-Hall, NJ, 1997.
6. J.A. Anderson, *Automata Theory with Modern Applications,* Cambridge University Press, 2006.

DSE2.3 Probability and Statistics

Course Outcome:

At the end of the course the students will be able to:

a) Explain the basic concepts of probability, random variables and solve problems using Baye's theorem.
b) Apply probability distributions like Binomial, Poisson, Geometric, Negative binomial, Uniform and Normal distributions, and Law of Large numbers, Central limit theorem, Markov chains, Chapman –Kolmogrov equations to solve statistical problems.

Course Content:

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.

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.

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.

Books Recommended

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, *Mathematical Statistics with Applications,* 7th Ed., Pearson Education, Asia, 2006.
3. Sheldon Ross, *Introduction to Probability Models,* 9th Ed., Academic Press, Indian Reprint, 2007.

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

DSE3.1 Theory of Equations

Course Outcome:

On completion of the course, a student will be able to

- **a)** describe the graphical representation of a polynomial, maximum and minimum values of a polynomial,
- **b)** acquire the concept of symmetric functions,
- **c)** use Newton's theorem to find the sums of power of roots, homogeneous products, limits of the roots of equation,
- **d)** derive Sturm's theorem and its application.

Course Content:

General properties of polynomials, Graphical representation of a polynomial, maximum and minimum values of a polynomials, General properties of equations, Descarte's rule of signs positive and negative rule, Relation between the roots and the coefficients of equations.

Symmetric functions, Applications of symmetric function of the roots, Transformation of equations. Solutions of reciprocal and binomial equations. Algebraic solutions of the cubic and biquadratic. Properties of the derived functions.

Symmetric functions of the roots, Newton's theorem on the sums of powers of roots, homogeneous products, limits of the roots of equations.

Separation of the roots of equations, Strums theorem, Applications of Strum's theorem, Conditions for reality of the roots of an equation and biquadratic. Solution of numerical equations.

Books Recommended

1. W.S. Burnside and A.W. Panton, *The Theory of Equations*, Dublin University Press, 1954.
2. C. C. MacDuffee, *Theory of Equations*, John Wiley & Sons Inc., 1954.

DSE3.2 Bio-Mathematics

Course Outcome:

On completion of the course, a student will be able to

a) Learn the development, analysis and interpretation of bio mathematical models such as population growth, cell division, and predator-prey models.
b) Learn about the mathematics behind heartbeat model and nerve impulse transmission model.

c) Appreciate the theory of bifurcation and chaos.
d) Learn to apply the basic concepts of probability to molecular evolution and genetics.

Course Content:
Mathematical Biology and the modeling process: an overview. Continuous models: Malthus model, logistic growth, Allee effect, Gompertz growth, Michaelis-Menten Kinetics, Holling type growth, Bacterial growth in a Chemostat, Harvesting a single natural population, Prey predator systems and Lotka Volterra equations, Populations in competitions, Epidemic Models (SI, SIR, SIRS, SIC), Activator-Inhibitor system, Insect Outbreak Model: Spruce Budworm, Numerical solution of the models and its graphical representation. Qualitative analysis of continuous models: Steady state solutions, stability and linearization, multiple species communities and Routh-Hurwitz Criteria, Phase plane methods and qualitative solutions, bifurcations and limit cycles with examples in the context of biological scenario. Spatial Models: One species model with diffusion, Two species model with diffusion, Conditions for diffusive instability, Spreading colonies of microorganisms, Blood flow in circulatory system, Travelling wave solutions, Spread of genes in a population. Discrete Models: Overview of difference equations, steady state solution and linear stability analysis, Introduction to Discrete Models, Linear Models, Growth models, Decay models, Drug Delivery Problem, Discrete Prey-Predator models, Density dependent growth models with harvesting, Host-Parasitoid systems (Nicholson-Bailey model), Numerical solution of the models and its graphical representation. Case Studies: Optimal Exploitation models, Models in Genetics, Stage Structure Models, Age Structure Models.

Books Recommended

1. L.E. Keshet, *Mathematical Models in Biology*, SIAM, 1988.
2. J. D. Murray, *Mathematical Biology*, Springer, 1993.
3. Y.C. Fung, *Biomechanics*, Springer-Verlag, 1990.
4. F. Brauer, P.V.D. Driessche and J. Wu, *Mathematical Epidemiology*, Springer, 2008.
5. M. Kot, *Elements of Mathematical Ecology*, Cambridge University Press, 2001.

DSE3.3 Linear Programming

Course Outcome:

This course will enable the students to:

a) Learn about the graphical solution of linear programming problem with two variables.
b) Learn about the relation between basic feasible solutions and extreme points.
c) Understand the theory of the simplex method used to solve linear programming problems.
d) Learn about two-phase and big-M methods to deal with problems involving artificial variables.
e) Learn the role of sensitivity analysis in linear programming problem.
f) Learn about the relationships between the primal and dual problems.
g) Solve transportation and assignment problems.

h) Integer programming.

Course Content:
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.

Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual.

Sensitivity Analysis, Integer Programming. 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.

Books Recommended

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, *Linear Programming and Network Flows*, 2nd Ed., John Wiley and Sons, India, 2004.
2. F.S. Hillier and G.J. Lieberman, *Introduction to Operations Research*, 9th Ed., Tata McGraw Hill, Singapore, 2009.
3. Hamdy A. Taha, *Operations Research, An Introduction*, 8th Ed., Prentice-Hall India, 2006.
4. G. Hadley, *Linear Programming*, Narosa Publishing House, New Delhi, 2002.

DSE4.1 Mathematical Modeling

Course Outcome:

The course will enable the students to:

a) Know about power series solution of a differential equation and learn about Legendre's and Bessel's equations.

b) Use of Laplace transform and inverse transform for solving initial value problems.

c) Learn about various models such as Monte Carlo simulation models, queuing models, and linear programming models.

Course Content:

What is Mathematical Modeling? History of Mathematical Modeling, latest development in Mathematical Modeling, Merits and Demerits of Mathematical Modeling.Introduction to difference equations, Non-linear Difference equations, Steady state solution and linear stability analysis.

Introduction to Discrete Models, Linear Models, Growth models,Decay models, Newton's Law of Cooling, Bank Account Problem and mortgage problem. Equilibrium points, Interpretation of the phase plane, predatory-prey model and its analysis, epidemic model of influenza and its

analysis, battle model and its analysis.

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

List of Practicals (using any software)

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

Books Recommended

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

2. Frank R. Giordano, Maurice D. Weir and William P. Fox, *A First Course in Mathematical Modeling*, Thomson Learning, London and New York, 2003.

DSE4.2 Mechanics

Course Outcome:

The course will enable the students to:

a) Know about the concepts in statics such as moments, couples, equilibrium in both two and three dimensions.
b) Understand the theory behind friction and center of gravity.
c) Calculate moments of inertia of areas and rigid bodies.
d) Know about conservation of mechanical energy and work-energy equations.
e) Learn about translational and rotational motion of rigid bodies.

Course Content:

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.

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.

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.

Books Recommended

1. I.H. Shames and G. Krishna Mohan Rao, *Engineering Mechanics: Statics and Dynamics*,(4th Ed.), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2009.

2. R.C. Hibbeler and Ashok Gupta, *Engineering Mechanics: Statics and Dynamics*,11th Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi.

DSE 4.3 Differential Geometry

Course Outcome:

At the end of the course the students will be able to understand:

a) The theory of space curves and plane curves, properties of curves such as curvature, torsion evolutes , and involutes etc.
b) The theory of surfaces, the fundamental quadratic Forms of surfaces, intrinsic and extrinsic geometry of surfaces, and the Gauss-Bonnet theorem.
c) Developable surfaces, Geodesics.
d) Tensors, and their properties.

Course Content:

Theory of Space Curves: Space curves, Planer curves, Curvature, torsion and Serret-Frenet formulae. Osculating circles, Osculating circles and spheres. Existence of space curves. Evolutes and involutes of curves.

Theory of Surfaces: Parametric curves on surfaces. Direction coefficients. First and second

Fundamental forms. Principal and Gaussian curvatures. Lines of curvature, Euler's theorem. Rodrigue's formula, Conjugate and Asymptotic lines.

Developables: Developable associated with space curves and curveson surfaces, Minimal surfaces.

Geodesics: Canonical geodesic equations. Nature of geodesics on a surface of revolution. Clairaut's theorem. Normal property of geodesics. Torsion of a geodesic. Geodesic curvature. Gauss-Bonnet theorem. Surfaces of constant curvature. Conformal mapping. Geodesic mapping. Tissot's theorem.

Books Recommended

1. T.J. Willmore, *An Introduction to Differential Geometry*, Dover Publications, 2012.
2. B. O'Neill, *Elementary Differential Geometry*, 2nd Ed., Academic Press, 2006.
3. C.E. Weatherburn, *Differential Geometry of Three Dimensions,* Cambridge University Press 2003.
4. D.J. Struik, *Lectures on Classical Differential Geometry,* Dover Publications, 1988.
5. S. Lang, *Fundamentals of Differential Geometry*, Springer, 1999.
6. B. Spain, *Tensor Calculus: A Concise Course,* Dover Publications, 2003.

Skill Enhancement Course (SEC)

SEC1.1 Logics and Set

Course Outcome:

At the end of the course the students will be able to:

- **a)** Construct proofs of basic set-theoretic identities involving unions, intersections, and cartesian products
- **b)** Formulate the negation, converse, and contrapositive of a quantified implication, both linguistically and in symbolic form.
- **c)** Demonstrate an understanding of the concept of a "counterexample" and be able to provide appropriate instances.
- **d)** Demonstrate an understanding of the Principle of Mathematical Induction.
- **e)** Understand the concepts of propositions, truth table, predicates and quantifiers, relation ,partition etc.

Course Content:

Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.

Sets, subsets, Set operations and the laws of set theory and Venn diagrams. Examples of finite and infinite sets. Finite sets and counting principle. Empty set, properties of empty set. Standard set operations. Classes of sets. Power set of a set.

Difference and Symmetric difference of two sets. Set identities, Generalized union and intersections. Relation: Product set, Composition of relations, Types of relations, Partitions, Equivalence Relations with example of congruence modulo relation, Partial ordering relations, n-ary relations.

Books Recommended

1. R.P. Grimaldi, *Discrete Mathematics and Combinatorial Mathematics,* Pearson Education, 1998.

2. P.R. Halmos, *Naive Set Theory,* Springer, 1974.

3. E. Kamke, *Theory of Sets,* Dover Publishers, 1950.

SEC1.2 Computer Graphics

Course Outcome:

At the end of the course the students will be able to:

a) Implement various geometric algorithms, transformations, area filling, clipping.
b) Describe the importance of viewing and projections.
c) Define the fundamentals of animation, virtual reality and related technologies.
d) Apply mathematics and logic to develop programs for elementary graphic operations.

Course Content:

Development of computer Graphics: Raster Scan and Random Scan graphics storages, displays processors and character generators, colour display techniques, interactive input/output devices. Points, lines and curves: Scan conversion, line-drawing algorithms, circle and ellipse generation, conic-section generation, polygon filling anti aliasing. Two-dimensional viewing: Coordinate systems, linear transformations, line and polygon clipping algorithms.

Books Recommended

1. D. Hearn and M.P. Baker, *Computer Graphics,*2nd Ed., Prentice-Hall of India, 2004.
2. J.D. Foley, A van Dam, S.K. Feiner and J.F. Hughes, *Computer Graphics: Principals and Practices,*2nd Ed., Addison-Wesley, MA, 1990.
3. D.F. Rogers, *Procedural Elements in Computer Graphics,*2nd Ed., McGraw Hill Book Company, 2001.
4. D.F. Rogers and A.J. Admas, *Mathematical Elements in Computer Graphics,*2nd Ed., McGraw Hill Book Company, 1990.

SEC1.3 Special Functions

Course Outcomes:

Students will be able to:

a) know the solution of second order differential equations with variable coefficients.

b) find the solution of Legendre's differential equations and know about its properties.

c) determine the solution of Bessel's differential equation.

d) find the solution of Chebyshev differential equations and its properties.

Course Content:

Legendre polynomials,Series expansion, Orthogonality and Normalization, A second solution,

Rodriquez's formula, Generating function, Recursion relations.

Bessel functions, Series solution of Bessel's equation, Orthogonality of Bessel functions ™ Orthogonal series of Bessel functions, Generating function, Recursion relations.

Laguerre polynomials, Generating functions, Recurrence relations and differential equations. Orthogonality and expansion of a functions in Laguerre polynomials.

Books Recommended:

1. **N. N. Lebedev, *Special Functions and Their Applications*, Dover, 1973.**

SEC 2.1 Graph Theory

Course Outcomes:

The course will enable the students to:

a) understand the basics of graph theory and learn about social networks, Eulerian and Hamiltonian graphs, diagram tracing puzzles and knight's tour problem.
b) able to formulate problems in graph theoretic terms.
c) understand various versions of connectedness of a graph,
d) be able to formulate applied problems as coloring problems,
e) understand and be able to use different models of random graphs and (random networks).

Course Content:

Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bi-partite 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.Trees, Properties, Spanning Tee, BFS, DFS.

Books Recommended

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) P. Ltd., Indian Reprint 2003.

3. Rudolf Lidl and Gunter Pilz, Applied Abstract Algebra, 2nd Ed., Undergraduate Texts in Mathematics, Springer (SIE), Indian reprint, 2004

SEC 2.2 Operating System: Linux

Course Outcome:

On completion of this course, students will be able to understand

a) the objectives and functions of modern operating systems,
b) the basic commands of linux operating system and can write shell scripts,
c) to create file systems and directories and operate them,
d) to create processes background and fore ground etc.,by fork() system calls,
e) to create shared memory segements,pipes ,message queues and can exercise interprocess communication.

Course Content:

Linux - The Operating System: Linux history, Linux features, Linux distributions, Linux's relationship to Unix, Overview of Linux architecture, Installation, Start up scripts, system processes (an overview), Linux Security, The Ext2 and Ext3 File systems: General Characteristics of, The Ext3 File system, file permissions. User Management: Types of users, the powers of Root, managing users (adding and deleting): using the command line and GUI tools.

Resource Management in Linux: file and directory management, system calls for files Process Management, Signals, IPC: Pipes, FIFOs, System V IPC, Message Queues, system calls for processes, Memory Management, library and system calls for memory.

Books Recommended

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

Generic Electives (GE)

GE 1.1 Object Oriented Programming in C++

Course Outcome:

After completion of this course, student will be able to:

- **a)** Identify importance of object oriented programming and difference between structured
- **b)** oriented and object oriented programming features.
- **c)** make use of objects and classes for developing programs.
- **d)** use various object oriented concepts to solve different problems.

Course Content:

OOP Paradigm: Comparison of Programming paradigms, Characteristics of Object-Oriented Programming Languages, Object-based programming languages C++: Brief History of C++,Structure of a C++ program, Difference between C and C++ - cin, cout, new, delete operators, ANSI/ISO Standard C++, Comments, Working with Variables and const Qualifiers. Enumeration, Arrays and Pointer.

Implementing oops concepts in C++ Objects, Classes, Encapsulation, Data Abstraction, Inheritance, Polymorphism, Dynamic Binding, Message Passing, Default Parameter Value,Using Reference variables with Functions.

Abstract data types, Class Component, Object & Class, Constructors Default and Copy Constructor, Assignment operator deep and shallow coping, Access modifiers - private, publicand protected. Implementing Class Functions within Class declaration or outside the Class declaration. instantiation of objects, Scope resolution operator, Working with Friend Functions, Using Static Class members. Understanding Compile Time Polymorphism function overloading Rules of Operator Overloading (Unary and Binary) as member function/friend function, Implementation of operator overloading of Arithmetic Operators, Overloading Output/Input,Prefix/ Postfix Increment and decrement Operators, Overloading comparison operators, Assignment, subscript and function call Operator , concepts of namespaces.

Practicals to be performed in lab.

Books Recommended

1. A. R. Venugopal, Rajkumar, and T. Ravishanker, *Mastering C++*, TMH, 1997.
2. S. B. Lippman and J. Lajoie, *C+ + Primer*,3rd Ed., Addison Wesley, 2000.

3. Bruce Eckel, *Thinking in C++,* 2nd Ed., President, Mindview Inc., Prentice Hall.
4. D. Parasons, *Object Oriented Programming with C++,* BPB Publication.
5. Bjarne Stroustrup , *The C++ Programming Language,* 3rd Ed., Addison Welsley.

GE1.2 Finite Element Methods

Course Outcome:

At the end of the course, a student will be able to:

- **a)** apply direct stiffness, Rayleigh-Ritz, Galerkin method to solve engineering problems and outline the requirements for convergence.
- **b)** analyze linear 1D problems like bars and trusses; 2D structural problems using CST element and analyse the axi-symmetric problems with triangular elements.
- **c)** write shape functions for 4 and 8 node quadrilateral, 6 node triangle elements and apply numerical integration to solve; 1D and 2D; stiffness integrations.
- **d)** solve linear 2D structural beams and frames problems; 1D heat conduction and convection heat transfer problems.
- **e)** evaluate the Eigenvalues and Eigenvectors for stepped bar and beam, explain nonlinear geometric and material non linearity.

Course Content:

Introduction to finite element methods, comparison with finite difference methods, Methods of weighted residuals, collocations, least squares and Galerkin's method.Variational formulation of boundary value problems equivalence of Galerkin and Ritz methods.

Applications to solving simple problems of ordinary differential equations.

Linear, quadratic and higher order elements in one dimensional and assembly, solution of assembled system.

Simplex elements in two and three dimensions, quadratic triangular elements, rectangular elements, serendipity elements and isoperimetric elements and their assembly, discretization with curved boundaries

Interpolation functions, numerical integration, and modeling considerations.

Solution of two dimensional partial differential equations under different Geometric conditions.

Books Recommended

1. J.N. Reddy, *Introduction to the Finite Element Methods,* Tata McGraw-Hill, 2003.
2. K.J. Bathe, *Finite Element Procedures,* Prentice-Hall, 2001**.**
3. R.D. Cook, D.S. Malkus and M.E. Plesha, *Concepts and Applications of Finite Element Analysis,* John Wiley and Sons, 2002.
4. Thomas J.R. Hughes, *The Finite Element Method: Linear Static and Dynamic Finite Element Analysis,* Dover Publication, 2000.
5. George R. Buchanan, *Finite Element Analysis,* McGraw Hill, 1994.

GE 1.3: Applied Calculus

Course Outcome:

At the end of the course, students should be able to:

a) Identify functions as linear, exponential, or periodic, compute the change and average rate of change for given functions,
b) Interpret the concept of derivative as the rate of change, and approximate the derivative at a single point,
c) Perform analysis and computation of limits by analytic, graphical and numerical methods, and use limits to investigate continuity of functions.
d) Use techniques of differentiation, including the product, quotient, and chain rules to derive derivatives for polynomials, powers, exponentials, periodic functions and their compositions.
e) Interpret definite integrals as areas, and evaluate them by numerical approximations and by the Fundamental Theorem of Calculus. Derive indefinite integrals by using power rule, exponential rule, logarithm rule, and rules for periodic functions.
f) Use first and second derivatives to determine max/min values and locations for given functions, and to apply them to investigate the behaviors of logistic and surge functions.
g) Understand the concepts of vector triple product, introduction to vector functions, space curves , tensor, tangent plane, normal and envelope analysis, helices, etc.

Course Content:

Higher order derivatives, Leibniz rule, Curvature, Concavity and inflection points, Cartesian, Spherical, Cylindrical coordinate systems, asymptotes, curve tracing in Cartesian and polar coordinates coordinates. Maxima and Minima. L'Hospital's rule, Mean value theorems, Taylor's formula and their applications in Science, Engineering, business and economics.

Area and volumes by slicing, disks and washers methods, volumes by cylindrical shells, parametric equations, arc length, arc length of parametric curves, area of surface of revolution. Applications in science, engineering and real life.

Vector triple product, introduction to vector functions, vector-valued functions, differentiation and integration of vector functions, tangent and normal components of acceleration, modeling ballistics and planetary motion, Kepler's second law. Gradient, divergence and curl and use in fluid mechanics.

Space curve, Tangent, normal and osculating planes, Length of a curve, Seret-Frenet formulas, Curvature, circle of curvature, torsion. Curve by its intrinsic equations, Helices. Surfaces,

Parametric equations of a surface. Tangent plane, Normal and Envelope. Applications.

Books Recommended

1. N. Piskunov, *Differential and Integral Calculus*, Mir Publisher Moscow, CBS Publishers & Distributors India.
2. Deborah Hughes et al., *Applied Calculus*, 5th Edition, Wiley.
3. Shanti Narayan, P. K. Mittal, *Differential Calculus*, S. Chand.
4. J. Stewart, *Calculus: Early Transcendentals*, Nelson Publication Canada.

GE2.1 Mathematical Finance

Course outcome:

After completion of this course, student will be able to:

a) Understand the concept of time value of money.

b) Explain and compare different types of interest(simple and compound, discrete and continuous)

c) Understand the relation between a present value, a set of cash flows and interest, as well as understand the interest rate risk (duration, immunisation).

d) Develop formulae for the expected value and variance of the present values of simple insurance and annuity contracts, assuming constant deterministic interest.

e) Employ methods related to these concepts in a variety of financial applications.

Course Content:

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.

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.

Books Recommended

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

GE2.2 Econometrics

Course Outcome:

At the end of the course the students will be able to:

a) Apply basic statistical concepts like normal distribution, chi square, t, and F distributions, and test- Hypotheses to the data based problems.
b) Apply Simple linear and multilinear regression models with the application of statistical tools for estimating economic relationships, testing economic hypotheses and forecasting.

Course Content:

Statistical Concepts Normal distribution; chi-square, t and F-distributions; estimation of parameters; properties of estimators; testing of hypotheses: defining statistical hypotheses; distributions of test statistics; testing hypotheses related to population parameters; Type I and Type II errors; power of a test; tests for comparing parameters from two samples.

Simple Linear Regression Model: Two Variable Case Estimation of model by method of ordinary least squares; properties of estimators; goodness of fit; tests of hypotheses; scaling and units of measurement; confidence intervals; Gauss-Markov theorem; forecasting.

Multiple Linear Regression Model Estimation of parameters; properties of OLS estimators; goodness of fit - R2 and adjusted R2 ; partial regression coefficients; testing hypotheses - individual and joint; functional forms of regression models; qualitative (dummy) independent variables.

Violations of Classical Assumptions: Consequences, Detection and Remedies Multicollinearity; heteroscedasticity; serial correlation.

Specification Analysis Omission of a relevant variable; inclusion of irrelevant variable; tests of specification errors.

Books Recommended

1. Jay L. Devore, *Probability and Statistics for Engineers,* Cengage Learning, 2010.
2. John E. Freund, *Mathematical Statistics,* Prentice Hall, 1992.
3. Richard J. Larsen and Morris L. Marx, *An Introduction to Mathematical Statistics and its Applications,*Prentice Hall, 2011.

4. D. N. Gujarati and D.C. Porter, *Essentials of Econometrics*, McGraw Hill, 4th Ed., International Edition, 2009.
5. Christopher Dougherty, *Introduction to Econometrics*, Oxford University Press, 3rd Ed., Indian edition, 2007.

GE3.1 Cryptography and Network Security

Course Outcomes:

After the course, the student will be able to:

a) Understand the fundamentals of cryptography and computer security attacks.
b) Learn about various ciphers and data encryption standard.
c) Review basic concepts of number theory and finite fields.
d) Learn about advanced encryption standard.
e) Understand the fundamentals of RSA and elliptic curve cryptography.
f) Encrypt and decrypt messages using block ciphers, sign and verify messages using well known signature generation and verification algorithms.

Course Content:

Public Key Cryptography Principles & Applications, Algorithms: RSA, Message Authentication: One way Hash Functions: Message Digest, MD5, SHA1. Public Key Infrastructure: Digital Signatures, Digital Certificates, Certificate Authorities.

Network Attacks: Buffer Overflow, IP Spoofing, TCP Session Hijacking, Sequence Guessing, Network Scanning: ICMP, TCP sweeps, Basic Port Scans; Denial of Service Attacks: SYN Flood, Teardrop attacks, land, Smurf Attacks.IP security Architecture: Overview, Authentication header, Encapsulating Security Pay Load, combining Security Associations, Key Management. Virtual Private Network Technology: Tunneling using IPSEC.

Requirements, Secure Socket Layer, and Secure Electronic Transactions, Network Management Security: Overview of SNMP Architecture- SNMPV1, SNMPV3.Firewall Characteristics & Design Principles, Types of Firewalls: Packet Filtering Router, Application Level Gateway or Proxy, Content Filters, Bastion Host.

Books Recommended

1. W. Stallings, *Networks Security Essentials: Application & Standards*,Pearson Education, 2000.
2. TCP/IP Protocol Suite , Behrouz A. Forouzan, *Data Communication and Networking,* Tata McGraw Hill.
3. W. Stallings, *Cryptography and Network Security, Principles and Practice*, Pearson Education, 2000.

GE 3.2 Information Security

Course Outcome:

After the completion of the course, the students will be able to:

a) develop basic understanding of security, cryptography, system attacks and defences against them,

b) Cryptography tools usage

c) understand the methods and techniques for information security,

d) have knowledge of data security and secure system development.

Course Content:

Overview of Security: Protection versus security; aspects of security-data integrity, data availability, privacy; security problems, user authentication, Orange Book.

Security Threats: Program threats, worms, viruses, Trojan horse, trap door, stack and buffer over flow; system threats- intruders; communication threats- tapping and piracy.

Cryptography: Substitution, transposition ciphers, symmetric-key algorithms- DataEncryptionStandard, advanced encryption standards, public key encryption - RSA; Diffie-Hellman key exchange, ECC cryptography, Message Authentication- MAC, hash functions.

Digital signatures: Symmetric key signatures, public key signatures, message digests, public key infrastructures.

Security Mechanisms: Intrusion detection, auditing and logging, tripwire, system-call monitoring.

Books Recommended

1. W. Stallings, *Cryptography and Network Security Principles and Practices,*4th Ed., Prentice-Hall of India, 2006.
2. *C. Pfleeger and S.L. Pfleeger,* Security in Computing,*3rd Ed.*, *Prentice-Hall of India, 2007.*
3. D. Gollmann, *Computer Security*, John Wiley and Sons, NY, 2002.
4. J. Piwprzyk, T. Hardjono and J. Seberry, *Fundamentals of Computer Security,*Springer-Verlag Berlin, 2003.
5. J.M. Kizza, *Computer Network Security,* Springer, 2007.
6. M. Merkow and J. Breithaupt, *Information Security: Principles and Practices,*Pearson Education, 2006.

GE4.1 Applications of Algebra

Course Outcome:

At the end of the course the students will be able to use and apply:

a) Balance incomplete Block design (BIBD), in design of experiments in science, engineering and technology, symmetric theory in development of designs,

b) Coding theory in information technology,

c) Theory of matrices in remote sensing in image processing, and in constraint optimization problems and

d) Theory of linear transformations in Least square method and to find approximate solution of system of linear equations finding inverse of rectangular matrices

Course Content:

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.

Coding Theory: introduction to error correcting codes, linear cods, generator and parity check matrices, minimum distance, Hamming Codes, decoding and cyclic codes.

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.

Special types of matrices: idempotent, nilpotent, involution, and projection tri diagonal matrices, circulant matrices, Vandermonde matrices, Hadamard matrices, permutation and doubly stochastic matrices, Frobenius- Konig theorem, Birkhoff theorem. Positive Semi-definite matrices: positive semi-definite matrices, square root of apositive semi-definite matrix, a pair of positive semi-definite matrices, and their simultaneous diagonalization. Symmetric matrices and quadratic forms: diagonalization of symmetric matrices, quadratic forms, constrained optimization, singular value decomposition, and applications to image processing and statistics.

Applications 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 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 inverse and projection algorithms.

Books Recommended

1. I. N. Herstein and D. J. Winter, *Primer on Linear Algebra,* Macmillan Publishing Company,

New York, 1990.
2. S. R. Nagpaul and S. K. Jain, *Topics in Applied Abstract Algebra,* Thomson Brooks and Cole, Belmont, 2005.
3. Richard E. Klima, Neil Sigmon, Ernest Stitzinger, *Applications of Abstract Algebra with Maple*, CRC Press LLC, Boca Raton, 2000.
4. David C. Lay, *Linear Algebra and its Applications.*3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
5. Fuzhen Zhang, *Matrix theory*, Springer-Verlag New York, Inc., New York, 1999.

GE4.2 Combinatorial Mathematics

Course outcome:

Students will develop skills for:

- **a)** problem solving**, c**ounting, permutations and combinations, generating functions, recurrence relations, partitions, Binomial theorem etc.,
- **b)** Many fundamental mathematical objects, such as sets and functions,
- **c)** Specialized mathematical objects, such as Fibonacci numbers and permutations
- **d)** Communicating about math with their peers.

Course Content:

Basic counting principles, Permutations and Combinations (with and without repetitions), Binomial theorem, Multinomial theorem, Counting subsets, Set-partitions, Stirling numbers

Principle of Inclusion and Exclusion, Derangements, Inversion formulae

Generating functions: Algebra of formal power series, Generating function models, Calculating generating functions, Exponential generating functions.

Recurrence relations: Recurrence relation models, Divide and conquer relations, Solution of recurrence relations, Solutions by generating functions.

Integer partitions, Systems of distinct representatives.

Polya theory of counting: Necklace problem and Burnside's lemma, Cyclic index of a permutation group, Polya's theorems and their immediate applications.

Latin squares, Hadamard matrices, Combinatorial designs: *t*designs, BIBDs, Symmetric designs.

Books Recommended

1. J.H. van Lint and R.M. Wilson, *A Course in Combinatorics,* 2nd Ed., Cambridge University Press, 2001.
2. V. Krishnamurthy, *Combinatorics, Theory and Application,* Affiliated East-West Press 1985.
3. P.J. Cameron, *Combinatorics, Topics, Techniques, Algorithms,* Cambridge University Press,

1995.

4. M. Jr. Hall, *Combinatorial Theory,* 2nd Ed., John Wiley & Sons, 1986.
5. S.S. Sane, *Combinatorial Techniques,* Hindustan Book Agency, 2013.
6. R.A. Brualdi, *Introductory Combinatorics,* 5th Ed., Pearson Education Inc., 2009.

GE 4.3 Numerical Methods

Course Outcome:
The course will enable the students to:

e) Learn some numerical methods to find the zeroes of nonlinear functions of a single variable and solution of a system of linear equations, up to a certain given level of precision.
f) Know about methods to solve system of linear equations, such as Gauss−Jacobi, Gauss−Seidel methods.
g) Interpolation techniques to compute the values for a tabulated function at points not in the table.
h) Applications of numerical differentiation and integration to convert differential equations into difference equations for numerical solutions.

Course Content:

Difference Operators, Interpolation: Forward, Backward, Shift, Central, Averaging and Differential Operators, Divided difference Operator, Newton-Gregory Forward and Backward Interpolation Formula,Gauss Forward and Gauss backward Interpolation Formula,Bessel's and Stirling's Interpolation Formula,Newton's Divided Difference Interpolation Formula,Lagrange's Interpolation Formula.

Solution of Algebraic & Transcendental Equations: Bisection Method,Fixed Point Iteration,Regula Falsi Method,Secant Method,Newton-Raphson Method,Horner's Method,Graffe's Root squaring Method.

Solution of Simultaneous Linear Equations: Gauss Elimination and Gauss Jordan Methods,LU Decomposition Methods (Crout, Doolittle and Choleski),Gauss Jacobi and Gauss-Seidel Methods

Solution of Ordinary Differential Equations: Picard's Method, Euler's and Modified Euler's Methods, Taylor Series Method, Second order Runge - Kutta Method, Milne's Predictor-Corrector Method

Book Recommended

1. S. S. Sastry, *Introductory Methods of Numerical Analysis, 5th Ed*, PHI India.
2. Yang, Cao, Chung, Morris, *Applied Numerical Methods Using Matlab*, John Wiley & Sons, 2007.

3. Anthony Ralston, Philip Rabinowitz, *A First Course in Numerical Analysis*,Courier Corporation, 2001.