UNDERGRADUATE CURRICULUM FRAMEWORK -2022
BASED ON
NATIONAL EDUCATION POLICY 2020

PROPOSED SYLLABUS AND SCHEME OF EXAMINATION

FOR

B.Sc. (Hons.) / B.A.(Hons.) / B.Com (Hons.) Mathematics

Submitted to

Dhanamanjuri University,Manipur

August 2022

DESIGN OF QUESTION PAPER

MATHEMATICS

Full Marks: 80 Marks

1. Weightage of Objectives:

Objectives	**Knowledge**	**Understanding**	**Application**	**Skill**	**Total**
Percentage of Marks	15	45	35	5	100
Marks	12	36	28	4	80

2. Weightage to Forms of questions:

Form of Questions	**LA 6 marks**	**SA1 3 marks**	**VSA 1 mark**	**Objective 1 mark**	**Total**
No. of Questions	6	10	10	4	30
Marks Allotted	36	30	10	4	80
Estimated Time(in minutes)	84	75	15	6	180

3. Weightage of Contents (Example for Calculus-CMA 101):

Unit	**Name of Unit**	**No of lectures**	**Marks**
I	Successive Differentiation	15	21
II	Derivatives and its Applications	25	36
III	Reduction, Volume and Areas of Surfaces	16	23

4. Scheme of Section : NIL

5. Scheme of option : Internal option may be given in Essay/ Long Answer type questions testing the same objective/ level of difficulties / same unit.

6. Difficulty level : Easy-25%, Average-40%, Difficulty-35%

7. N.B. : If skill questions are not available in some papers, the marks for skill question should be added to application questions.

COURSE STRUCTURE FOR FOUR-YEAR UNDERGRADUATE PROGRAMMES

Semester wise Details of B.Sc. (Hons.) /B.A(Hons.)/B.Com(Hons) Mathematics Course & Credit Scheme

Semester	Core course(14) (DSC)(4)	Discipline Specific Elective (DSE) (4)	Generic Elective (GE)(4)	Ability Enhancement Compulsory Course (AECC) (2	Skill Enhancement Course (SEC)(2)	Internship/Apprenticeship/ Academic project	VAC (Value added course)	Total Credits
I	CMA101: Calculus CMA102: Algebra CMA103: Analytical Geometry		GMA(select any one) GMA-101: Analytical Geometry GMA-102: Calculus	English Communication	(select any one) SMA-001: Linear Programming and its application SMA-002: Graph Theory		VAC-1	
L+T/P	3+1=4,3+1=4,3+1=4		3+1=4	2	2		2	22
II	CMA104: Real Analysis CMA105: Differential Equations CMA106: Vector analysis and Solid Geometry		GMA(select any one) GMA-103: Linear Programming and its applications GMA-104: Vector Analysis and Solid Geometry	Environmental Science	(select any one) SMA-003: Transportation and Game Theory SMA-004: Laplace Transform		VAC-2	
L+T/P	3+1=4,3+1=4, 3+1=4		3+1=4	2	2		2	22
							Total	44
	EXIT OPTION WITH BACHELOR'S CERTIFICATE IN A DISCIPLINE ON COMPLETION OF COURSES EQUAL TO A MINIMUM OF 44 CREDITS							

III	CMA-207: Theory of Real Functions CMA208: Partial Differential Equations CMA209: Group Theory-I		GMA(select any one) GMA-205:Differential Equation GMA-206:Fuzzy sets and its applications		(choose any one) SMA-005: LaTeXand HTML SMA-006: Fuzzy sets and its applications		VAC-3	
L+T/P	3+1=4,3+1=4, 3+1=4		3+1=4		2		2	22
IV	CMA210: Riemann Integration and Series of Functions CMA211: Mechanics CMA 212: Numerical Analysis		GMA(select any one) GMA-307: Algebra GMA-308:Probability Theory and Statistics		(Choose any one) SMA-007: Computer Algebra system and R software SMA-008: MATLAB		VAC-4	
L+T/P	3+1=4,3+1=4		4		2		2	22
							Total	88
	EXIT OPTION WITH BACHELOR'S DIPLOMA IN A DISCIPLINE ON COMPLETION OF COURSES EQUAL TO A MINIMUM OF 88 CREDITS							
V	CMAT313: Multivariate Calculus CMA314: Ring Theory and Linear Algebra-I CMA315: Group Theory-II	EMA-001 Metric Space	GMA(select any one) GMA-309:Discrete Mathematics GMA-310:Operations Research		(choose any one) SMA-009:C Programming SMA-010:Inventoryand Marketing Management			
L+T/P	3+1=4, 3+1=4.3+1=4	3+1=4	3+1=4,		2			22
VI	CMA316: Ring Theory and Linear Algebra-II CMA317: Network analysis and project ManagementCMA318:Probability Theory and Statistics	EMA-002 **:** Number theory	GMA(select any one) GMA-311:Network analysis and Project management GMA-312: Inventory and Marketing Management		(Choose any one) SMA-611:Python programming SMA-612: $C^{++}programming$			
L+T/P	3+1=4, 3+1=4,3+1=4	3+1=4	3+1=4		2		2	22
							Total	132

	EXIT OPTION WITH BACHELOR'S DEGREE IN A DISCIPLINE ON COMPLETION OF COURSES EQUAL TO A MINIMUM OF 132 CREDITS						
VII	CMA419: Topology	EMA-003: Operations Research(OR) EMA-004: Advanced Diff. Eqn. EMA-005: Differential Geometry & Tensor				Academic project/Dissertation/Field work	
L+T/P	3+1=4,	3+1=4, 3+1=4, 3+1=4				6	
VIII	CMA420: Complex Analysis	EMA-006: Advanced Abstract Algebra EMA-007: Advanced Real Analysis (Select any one) Optional EMA-008 A: Biomathematics EMA-008B: Spherical Trigonometry and Astronomy EMA-008C: Cryptography and Network Security EMA-008D: Logistics and Supply Chain Management				Academic project/Dissertation/Field work	
L+T/P	3+1=4,	3+1=4, 3+1=4, 3+1=4				6	
						Total	176
	EXIT OPTION WITH BACHELOR'S DEGREE WITH HONOURS IN A DISCIPLINE ON COMPLETION OF COURSES EQUAL TO A MINIMUM OF 176 CREDITS						

Note -1: L: Lecture Class; T: Tutorial Class; P: Practical Class

Note-2: One-hour lecture per week equals 1 Credit; 2 Hours practical class per week equals 1 credit. 'Generic Elective (GE)' Course is an elective course may be chosen generally from an unrelated discipline/subject, with an intention to seek exposure to other disciplines.

List of Discipline Specific Elective (DSE) Courses:

EMA-001: Metric Space

EMA-002: Number Theory

EMA-003: Operations Research (OR)

EMA-004: Advanced Differential Equation

EMA-005: Differential Geometry and Tensor

EMA-006: Advanced Abstract Algebra

EMA-007: Advanced Real Analysis

EMA-008: Any one of the following

(A). Biomathematics

(B) Spherical Trigonometry and Astronomy

(C) Cryptography and Network Security

(D) Logistics and Supply Chain Management

Skill Enhancement Course (SEC)

Choices for SEC 1 (choose one)

SMA-001: Linear programming and its applications

SMA-002: Graph Theory

Choices for SEC 2 (choose one)

SMA-003: Transportation and Game Theory

SMA-004: Laplace Transform

Choices for SEC3 (choose one)

SMA-005: LaTeX and HTML

SMA-006: Fuzzy sets and its applications

Choices for SEC4 (choose one)

SMA-007: Computer Algebra Systems and R Software.

SMA-008: MATLAB

Choices for SEC 5 (choose one)

SMA-009: Inventory and Marketing Management

SMA-010: C Programming

Choices for SEC 6 (choose one)

SMA-011: Python Programming

SMA-011: C^{++}Programming

1.Course Wise Content Details for B.Sc. (Hons.) Math/B.A.(Hons)Math

FIRST YEAR MATHEMATICS

Discipline Specific Course (DSC)

CMA101: SEMESTER-I

[CALCULUS]

Total Marks: 100(External-80, Internal-20)
Workload: 4 Lectures (per week), Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: The primary objective of this course is to introduce the basic tools of calculus and geometric properties of different conic sections which are helpful to the real-world problems. .

Course Learning Outcomes: This course will enable the students to:

i) Sketch curves in a plane using its mathematical properties in the different coordinate systems of reference.
ii) Apply derivatives in Optimization, Social sciences, Physical sciences and Life sciences etc.
iii) Compute area of surfaces of revolution and the volume of solids by integrating over cross-sectional areas.

Course Contents:

Unit-I: Successive Differentiation: (Lectures:15)/21marks

Successive differentiation, Leibnitz theorem. Hyperbolic functions, higher order derivatives, Leibniz rule and its applications to problems of type e^{ax+b}sinx,

e^{ax+b}cosx, $(ax+b)^n$sinx, $(ax+b)^n$cosx, Rolle's theorem, Lagrange's and Cauchy's mean value theorems, Taylor's and Maclaurin's theorems with Lagrange's and Cauchy's forms of remainder, Expansion of standard functions: e^x, sin*x*, cos*x*, log(1+x), $(1+x)^n$, $\tan^{-1}x$, Indeterminate forms and L. Hospital's Rule,[1-Ch 8,Ch 9,Ch 11]

Unit -II: Derivatives and its applications: (Lectures: 25)/36marks

Function of Two and three variables, Limit and Continuity for functions of two and three variables[2-Ch11], Partial differentiation, successive partial differentiations, Euler's theorem on Homogeneous functions of two and three variables,[1-Ch 12] Maxima and Minima of functions of two variables.[1-Ch 13]

Curvature, Radius of curvature for the Cartesian equation, parametric equation, implicit equation and polar equation,[1-Ch 15] Asymptotes[1-Ch 16].The first-derivative test for relative extrema, Concavity and inflection points, Second derivative test for relative extrema, Curve sketching using first and second derivative tests, concavity and inflection points, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves.[1-Ch 19]

Unit –III: Reduction, Volume and Area of Surfaces: (Lectures: 16)/23 marks

Reduction formulae, derivations and illustrations of reduction formulae of the type $\int sinnxdx, \int cosnxdx, \int tannxdx, \int secnxdx, \int (logx)^n dx, \int sin^n x sin^m xdx$.[3-Ch7] Evaluation of double integrals[3-Ch21], Change of the order of integration, Change of variables in double integrals [4-Ch12], Areas and lengths of curves in the plane, Volumes and Surface areas of solid of revolution [3-Ch 10,11,12 and 4-Ch 8,9,10] .

Books Recommended:

1. Das and Mukherjee - Differential Calculus, U.N. Dhur and Sons Pvt. Ltd, Kolkata.
2. Shanti Narayan and PK Mittal - Differential Calculus, S.Chand and Company Ltd.
3. Das and Mukherjee-Integral Calculus, U.N. Dhur and Sons Pvt. Ltd, Kolkata.
4. Shanti Narayan and PK Mittal - Integral Calculus, S.Chand and Company Ltd.

References:

1. Anton, Howard, Bivens, Irl, & Davis, Stephen (2013). Calculus (10th ed.). John Wiley & Sons Singapore Pte.Ltd. Indian Reprint (2016) by Wiley India Pvt. Ltd. Delhi.

2. Prasad, Gorakh (2016). Differential Calculus (19th ed.). PothishalaPvt. Ltd. Allahabad.

3. Strauss, Monty J., Bradley, Gerald L., & Smith, Karl J. (2007). Calculus (3rd ed.). Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Delhi. Indian Reprint 2011.

4. Thomas, Jr. George B., Weir, Maurice D., & Hass, Joel (2014). Thomas' Calculus (13th ed.). Pearson Education, Delhi. Indian Reprint 2017.

CMA102: SEMESTER-I

[ALGEBRA]

Total Marks: 100(External -80, Internal-20)
Workload:4 Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: The primary objective of this course is to introduce the basic tools of theory of equations, complex numbers, number theory and matrices to understand their linkage to the real-world problems.

Course Learning Outcomes: This course will enable the students to:

i) Apply Euclid's algorithm and backwards substitution to find greatest common divisor.
ii) Recognize consistent and inconsistent systems of linear equations by the row echelon form of the augmented matrix, using rank.
iii) Find eigenvalues and corresponding eigenvectors for a square matrix.

Course Contents:

Unit -I: De Moivre's theorem and its application: (Lectures:18)/26marks

Polar representation of complex numbers, The nth roots of unity, De Moivre's theorem for integer and rational indices and its applications. Expansion of sinx and cosx in powers of x,, Exponential values for circular functions, Complex argument, Gregory's series, Hyperbolic functions, Summation of series including C+iS method.

Unit-II: Inequalities and Theory of Equations; (Lectures; 20)/28 marks

Arithmetic mean, Geometric mean, Harmonic mean, mean of the m^{th} powers, Cauchy-Schwartz inequality, Holder's inequality, Minkowski's inequality.Polynomials,Fundamental theorem of Algebra (Statement only).properties of equations,Descartes rule of signs, , Relations between the roots and the coefficients of polynomial equations, Symmetric functions of roots, Reciprocal equations, Transformation of the cubic equation to standard form, Solution of cubic equations by Cardan's method and of biquadratic equation by Ferrari's method.

Unit -III: Theory of Matrices and its Applications (Lectures: 18)/26marks

Hermitian and Skew- Hermitian matrices, inverse of a square matrix, Rank of a matrix, Nullity of a matrix, Reduction to Echelon forms, Linear independence and dependence of

vectors (column and row matrices), Row rank, column rank, and equivalence of column and row ranks, Eigen values, Eigen vectors, and characteristic equation of a matrix, Cayley Hamilton theorem and its use in finding inverse of a matrix.

Books Recommended:

1. Das and Mukherjee, Higher trigonometry, U.N. Dhur and sonspvt. Ltd. Kolkata
2. Chandrika Prasad- Algebra and Theory of Equations, Pothisala Private Limited.
3. Shanti Narayan and P.K. Mittal- A text Book of Matrices, S. Chand and Co. New Delhi

References:

1. Andreescu, Titu&AndricaDorin. (2014). Complex Numbers from A to...Z. (2nd ed.). Birkhäuser.

2. Dickson, Leonard Eugene (2009). First Course in The Theory of Equations. The Project Gutenberg EBook (http://www.gutenberg.org/ebooks/29785)

3. Goodaire, Edgar G., &Parmenter, Michael M. (2005). Discrete Mathematics with Graph Theory (3rd ed.). Pearson Education Pvt. Ltd. Indian Reprint 2015.

CMA103: SEMESTER-I

[Analytical Geometry]

Total Marks: 100(External-80, Internal-20)
Workload: 4 Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: The goal of this paper is to acquaint students with certain ideas about conic sections, polar equation of Conics.

Course Learning Outcomes: After completion of this paper, the students will be able to:

i) Transformation of Co-ordinates, pair of straight lines.
ii) Classify different types of conic sections – the circle, the ellipse, the hyperbola and the parabola – in Cartesian and polar coordinates.

Course Contents:

Unit-I: Transformation of Co-ordinates and Pair of Straight lines:

(Lectures-20)/28 marks

Transformation of axes: Change of Origin without changing the direction of axes, Rotation of axes: Change of Direction of axes of co-ordinates without changing the origin, Invariants, removal of the xy-term. Pair of straight lines: Homogeneous equation of second degree,

Angle between pair of lines given by the homogeneous equation, Bisectors of angles between the pair of lines, Condition for the general equation of second degree to represent a pair of straight lines, Point of intersection, Equation of the pair of straight lines joining the origin to the point of intersection of lines and a curve.

Unit-II: Systems of conics: (Lectures: 24)/35marks

To find the equation of the tangent to the Circle, to find the equation of the chord of the circle, Chord of contact, pole and polar, to find the pole of straight line, to find the equation of the pair of tangents drawn from a given point to the circle, orthogonal circles, System of conics: Parabola, Ellipse and Hyperbola. general equation of second degree in two variables , Centre of a conic, Reduction of the general equation of second degree into central and non- central conics, Equation of tangent at a point on a conic, Condition that a line be a tangent to a conic, pair of tangents, Chord of contact, Co-normal points, pole and polar, Chord in terms of its middle point, Diameters and Conjugate diameters, Intersection of two conics, Conics through the points of intersection of two given conics, pair of tangents, Director circle,

Unit-III: Polar equation of conics: (Lectures: 12)/17marks

Polar equation of conics: Polar equation of a conic with respect to focus as pole, Equation of chord, tangent and normal, confocal conics: Equations and properties of confocal conics.

Recommened Books:

1. B Das, Analytical Geometry with Vector Analysis, Orient Book Company, Kolkata.
2. S L Loney, Co-Ordinate Geometry of Two Dimensions, Macmillan and Co.

Reference Books:

1 J.G.Chakravorty, P.R. Ghosh, Analytical Geometry and vector Analysis.

2 Shanti Narayan and P K Mittal, Analytical Solid Geometry, S Chand & Co.

Skill Enhancement Paper SEC-1:

SMA-001: Semester-1

[Linear Programming and its Applications]

Total Marks: 50(External-40, Internal-10)

Workload: 2 Lectures, (per week) Credits: 2 Duration: 14 Weeks (28 Hrs.)
Examination: 2 Hrs.

Course Objectives: This course develops the ideas underlying the Simplex Method for Linear Programming Problem, as an important branch of Operations Research. The course covers Linear Programming with applications to Transportation, and Assignment.

Course Learning Outcomes: This course will enable the students to learn:

i) Solve linear programming models of real life situations.
ii) Simplex method for solution of LPP.

Course Contents: (Lectures-28)/40marks

The Linear Programming Problem: Standard, Canonical and matrix forms, Graphical solution. Hyperplanes, Extreme points, Convex and polyhedral sets.Basic solutions; Basic Feasible Solutions; Reduction of any feasible solution to a basic feasible solution; Correspondence between basic feasible solutions and extreme points.

Simplex Method: Optimal solution, Termination criteria for optimal solution of the Linear Programming Problem, Unique and alternate optimal solutions, Unboundedness; Simplex Algorithm and its Tableau Format; Artificial variables, Two-phase method, Big-M method.

Books recommended: P.K Gupta and Man Mohan, Linear Programming and Theory of Games

Reference Books:

1. Bazaraa, Mokhtar S., Jarvis, John J., &Sherali, Hanif D. (2010). Linear Programming and Network Flows (4th ed.). John Wiley and Sons.

2. Hadley, G. (1997). Linear Programming.Narosa Publishing House. New Delhi.

3. Taha, Hamdy A. (2010). Operations Research: An Introduction (9th ed.). Pearson.

4.KantiSwarup, P.K. Gupta and Man Mohan(2020), Operations research, Sultan chand& Sons, New Delhi

SMA-002(SEMESTER-I)

[Graph Theory]

Total Marks: 50(External-40, Internal-10)

Workload: 2 Lectures, (per week) Credits: 2 Duration: 14 Weeks (28 Hrs.)
Examination: 2 Hrs.

Course Objectives: The main objective of this course is to teach students how to model physical problems.

Course Learning Outcomes: The course will enable the students to learn the following:

The basic concepts of graph theory, simulation and formation of mathematical models.

Course Contents: **(Lectures-28)/40marks**

Definition, examples and basic properties of graphs, pseudo graphs, complete graphs, bi-partite graphs, types of graphs, null graph, subgraph, operations of graph, Connected graphs, isomorphism of graphs, paths and circuits, Eulerian circuits, Hamiltonian cycles

Representation of graphs, Trees, Spanning tree, binary tree, Matrix representation, , the adjacency matrix, weighted graph, travelling salesman's problem, konigsberg's bridge problem, shortest path, Dijkstra's algorithm, Floyd-Warshall algorithm, minimal spanning tree, transport network.

Books Recommended

C. Vasudev, Graph Theory with Application, New age international (p) Limited

References:

1. B.A. Davey and H.A. Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge, 1990.

2. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 2nd Edition, Pearson Education (Singapore) 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.

CMA-104: SEMESTER-II

[Real Analysis]

Total Marks: 100(External-80, Internal-20)
Workload: 4 Lectures (per week), Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives:

The course will develop a deep and rigorous understanding of real line and of defining terms to prove the results about convergence and divergence of sequences and series of real numbers. These concepts have wide range of applications to the real-world problems.

Course Learning Outcomes: This course will enable the students to:

i) Understand many properties of the real line.
ii) Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.

iii) Apply the ratio test, root test, comparison tests for convergence and absolute convergence of an infinite series of real numbers.

Course Contents:

Unit-I: Properties of R (Lectures: 18)/26marks

Finite and infinite sets, definition and examples of countable and uncountable sets, bounded and unbounded sets, supremum and infimum of a non-empty set.The order completeness property in R (statement only), Archimedean property of R,

Definition and types of Intervals, Neighbourhood of a point, Limit point of a set , Bolzano-Weierstrass theorem on set, Open and closed sets, their related properties. Concept of Compactness, Heine Borel Theorem.

Unit-II: Sequence in R (Lectures: 18)/26marks

Real Sequence, Bounded, unbounded and oscillatory sequence, limit point of a sequence, Bolzano-Weierstrass theorem of sequence , Limit superior and limit inferior of a sequence, related properties, Cauchy sequence, Cauchy convergence criterion, monotonic sequence and their properties, ,subsequence, nested interval theorem,

Unit-III: Series in R (Lectures: 20)/28marks

Infinite series,a necessary condition for convergence of infinite series, convergence and divergence of geometric series and p- series, Comparison test, limit comparison test, D'Alembert's ratio test, Cauchy's root test, alternating series, , Definition and examples of absolute and conditional convergence, Leibnitz's test

Books Recommended

. 1. S.C. Malik and Savita Arora, Mathematical Analysis, New Age International (P) Limited.

2. Shanti Narayan and M.D. Raisinghania, Elements of Real Analysis, S. Chand & Company

References:

1. R.G. Bartle and D. R Sherbert, Introduction to Real Analysis, 1John Wiley and Sons (Asia) P. Ltd., 2000.

2. K.A. Ross, Elementary Analysis- The Theory of Calculus Series- Undergraduate Texts in Mathematics, Springer Verlag, 2003.

3. E. Fischer, Intermediate Real Analysis, Springer Verlag, 1983.

4. K.C. Maity& R.K. Ghosh, An Introduction to Analysis, Differential Calculus Part-I ,

CMA105: **SEMESTER-II**

[**Differential Equations]**

Total Marks: 100(External-80, Internal-20)
Workload: 4 Lectures (per week), Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: The main objectives of this course are to introduce the students to the exciting world of Differential Equations, Mathematical Modeling and their applications.

Course Learning Outcomes: The course will enable the students to:

i) Formulate Differential Equations for various Mathematical models.

ii) Solve first order non-linear differential equation and linear differential equations of higher order using various techniques.

iii) Apply these techniques to solve and analyse various mathematical models.

Course Contents:

Unit – I: First order and First degree differential equations: (Lecture - 20)/28marks

Order and degree of a differential equations; Exact differential equation and integrating factors of first order differential equations; Linear equations and equations reducible to linear form; Equations of first order and first degree; Linear equations and equations reducible to linear form; Solutions of simultaneous equations of the form $\frac{dx}{P}=\frac{dy}{Q}=\frac{dz}{R}$; Total differential equations of the form $Pdx+Qdy+Rdz=0$; Method of solutions and their geometric interpretations; Orthogonal trajectories.

Unit – II: Mathematical Modelling with Differential Equations:

(Lecture - 18)/26marks

Equations of first order but not of first degree: Equations solvable for *x*, *y* and *p*; Clairaut's equations and the singular solutions. Application of first order differential equations to equations to acceleration-velocity model; Growth and decay model; Introduction to compartmental models; Drug assimilation into the blood (case of a single cold pill, case of alcohol in the bloodstream); Exponential growth of population; Limited growth of population.

Unit – III: Second Order and Higher Order Differential Equations:
(Lecture - 18)/26marks

General solution of homogeneous equation of second order, 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.

Books Recommended:

1. M.D. Raisinghania- Ordinary and Partial Differential Equations, S.Chand, New Delhi
2. Piaggio – *An Elementary Treatise on Differential Equation and Their Applications,* C.B.S.Publishers& Distributors, New Delhi
3. Barnes, Belinda &Fulford, Glenn R. (2015). Mathematical Modelling with Case Studies, Using Maple and MATLAB (3rd ed.). CRC Press, Taylor & Francis Group.

References:

1. Arup Mukherjee &Naba Kumar Bej (Reprint 2017): Ordinary & Partial Differential Equations. ShreedharPrakashani, Publishers & Book Selles; 203/4D BidhanSarani, Kolkata.
2. Edwards, C. Henry, Penney, David E., &Calvis, David T. (2015). Differential Equation and Boundary Value Problems: Computing and Modeling (5th ed.). Pearson Education.
3. R.K.Gosh and K.C. Maity-An introduction to Differential Equations NCBA (P) Ltd Kolkata.
4. Zafar Ahsan-Differential Equations and their Applications,Prentice Hall of India, New Delhi

CMA-106: Semester-II

[Vector analysis and Solid Geometry]

Total Marks: 100(External -80, Internal-20)
Workload: 4 Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: The goal of this paper is to acquaint students with certain ideas about three dimensional geometry and vectors in coordinate system.

Course Learning Outcomes: After completion of this paper, the students will be able to:

i) Visualize three dimensional objects – spheres and cylinders.
ii) Having Techniques for sketching parabola, ellipse and hyperbola. Reflection properties of parabola, ellipse and hyperbola by using software say Mathematica/MATLAB.

Contents:

Unit1:Vector Analysis: (Lecture - 18)/26marks

Scalar product of three vectors and four vectors. Vector product of three vectors, and four vectors, Reciprocal vectors, Differentiation of Vectors, Gradient, Divergence and Curl of a vector, Vector integration, Ordinary integrals of vectors. Line integrals, Surface integrals and Volume integrals, Gauss's Theorem, Green's Theorem, Stoke's Theorem and related problems.

Unit 2: Sphere, Cone and Cylinder: (Lectures: 20)/28marks

Sphere: To find the Equation of sphere, Condition for the general equation of second degree to represent a sphere, section of a sphere by a plane, Intersection of two spheres, Equation of a tangent plane, Condition for a plane to be a tangent plane to a sphere.To find the equation of the sphere described on the join of two points as diameter, Cone: Equation of a cone with a conic as guiding curve, To find the equation of a cone with its vertex as origin is homogeneous of second degree, Enveloping cone of a sphere, Quadratic cones with vertex at origin, Condition for the general equation of second degree to represent a cone, Reciprocal cone, Right circular cone. Cylinder: Equation of cylinder, Enveloping cylinder, Right circular cylinder. To find the equation of the right circular cylinder whose axis is the line.

Unit 3: Conicoid: (Lectures: 18)/26marks

Central Conicoids, Ellipsoid, The hyperboloid of one sheet, the hyperboloid of two sheets, Intersection of a line with a Conicoid, condition for tangent planes, Tangent lines and tangent plane at a point, Director sphere, Enveloping Cone and Cylinder, locus of chords bisected at a given point, locus of mid-points of a system of parallel chords, Conjugate diameters, : Plane section of Conicoids,Paraboloids, Elliptic paraboloid, Hyperbolic paraboloid, Equations and their properties.

Recommended Books:

1. Shanti Narayan and P K Mittal, Analytical Solid Geometry, S Chand & Co.
2. Ghosh and Maity, Vector Analysis, New Central Book Agency.

Reference Books:

1. B Das, Analytical Geometry with Vector Analysis, Orient Book Company, Kolkata.
2. S L Loney, Co-Ordinate Geometry of Three Dimensions, Macmillan and Co.

3. R J T Bell, An Elementary Treatise on Co-Ordinate Geometry of Three Dimensions, Macmillan and Co.

SMA-003(SEMESTER-II)

[Transportation and Game Theory]

Total Marks: 50(Internal-40, Internal-10)

Workload: 2 Lectures, (per week) Credits: 2 Duration: 14 Weeks (28 Hrs.)
Examination: 2 Hrs.

Course Objectives: This course develops the ideas underlying Transportation problem, as an important branch of Operations Research. The course covers Linear Programming with applications to Transportation, Assignment and Game Theory.

Course Learning Outcomes: This course will enable the students to learn:

iii) Solve Transportation models of real life situations.
iv) Solve Assignment models of real life situations.
v) Solve Game Theory models of real life situations.

Contents: (Lectures-28)/40marks

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(MODI Method),Moving towards Optimality, Improving the solution, MODI Method/U-V method: Assignment problem and its mathematical formulation, Hungarian method for solving assignment problem.

Game theory: formulation of two persons zero sum games, solving two persons zero sum games, Algebraic method, games with mixed strategies, graphical solution procedure.

Books Recommended:

P.K Gupta and Man Mohan, Linear Programming and Theory of Games

Reference Books:

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, 200

4. KantiSwarup, P.K. Gupta and Man Mohan(2020), Operations research, Sultan chand& Sons, New Delhi

SMA-004 :(SEMESTER-II)

[Laplace Transform]

Total Marks: 50(External -40, Internal-10)

Workload: 2 Lectures, (per week) Credits: 2: Duration: 14 Weeks (28 Hrs.)
Examination: 2 Hrs.

Course Objectives: This course develops the ideas underlying Integral Transforms such as Laplace transforms and Fourier Transforms. The course covers theory and its applications.

Course Learning Outcomes: This course will enable the students to learn:

i) Solve Differential equation by using Laplace transforms
ii) Solve Partial Differential equation by using Laplace transforms
iii) Solve Circuit problems by using Laplace transforms

Contents: (Lectures-28)/40marks

Definition of Laplace Transformations, Kernel of the Integral transformation, Existence of Laplace Transformation Transformations of some elementary functions such as $f(t) = e^{-at}$, cos at, sin at, cosh at, sinh at, t^n etc. Properties of Laplace Transformation, First Translation or Shifting Theorem, Second Translation or Heaviside's shifting Theorem, Differentiation property, Change of scale property with examples, Laplace Transformation of Derivatives of order n with Theorems, Inverse Laplace transformations, Theorems on multiplication by s and 1/s, First and Second Shifting properties with examples, Convolution Theorem, Properties of Convolution, Examples and Application of Laplace Transformation in solving PDE.

Books recommended:

1. J.k.Goyal, K.P.Gupta (2019). Integral Transforms (28^{th} ed.), PragatiPrakashan, Meerut

Reference Books:

1. Schaum's Outline of Laplace Transforms, McGraw-Hill Education

SECOND YEAR MATHEMATICS

CMA207: SEMESTER-III

[Theory of Real Functions]

Total Marks: 100(External -80, Internal-20)
Workload:
4 Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: It is a basic course on the study of real valued functions.

Course Learning Outcomes: This course will enable the students to learn:

i) To have an understanding of the concept of limit of a function.
ii) The applications of mean value theorem and Taylor's theorem.

Course Contents:

Unit-I: Limits of Functions (Lectures:20)/28marks

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, Properties of continuous functions on closed and bounded intervals; Uniform continuity, Non-uniform continuity criteria, Uniform continuity theorem.

Unit -II: Derivability and its Applications (Lectures: 20)/28marks

Differentiability of a function, Algebra of differentiable functions, Carathéodory's theorem and chain rule; Relative extrema, Interior extremum theorem, Rolle's theorem, Mean- value theorem and its applications, Intermediate value property of derivatives - Darboux's theorem.

Unit-III: Taylor's Theorem and its Applications (Lectures:16)/24marks

Taylor polynomial, Taylor's theorem with Lagrange form of remainder, Application of Taylor's theorem in error estimation; Relative extrema, and to establish a criterion for convexity; Taylor's series expansions of , sin x e x and cos . x

Books Recommended:

1. S.C. Malik and Savita Arora, Mathematical Analysis, New Age International (P) Limited.

2. Bartle, Robert G., & Sherbert, Donald R. (2015). Introduction to Real Analysis (4th ed.). Wiley India Edition. New Delhi.

References:

1. Ghorpade, Sudhir R. &Limaye, B. V. (2006). A Course in Calculus and Real Analysis. Undergraduate Texts in Mathematics, Springer (SIE). First Indian reprint.
2. Mattuck, Arthur. (1999). Introduction to Analysis, Prentice Hall.
3. Ross, Kenneth A. (2013). Elementary Analysis: The Theory of Calculus (2nd ed.). Undergraduate Texts in Mathematics, Springer. Indian Reprin

CMA-208: SEMESTER-III

[Partial Differential Equations]

Total Marks: 100(External -80, Internal-20)
Workload:
4 Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: The main objectives of this course are to teach students to form and solve partial differential equations.

Course Learning Outcomes:

This course will enable the students to:

i) Formulate, classify and transform partial differential equations into canonical form.
ii) Solve linear and non-linear partial differential equations using various methods; and apply these methods in solving some physical problems.

Course Contents:

Unit-I: First order PDE (Lectures:18)/26marks

Introduction, Formation of PDE by eliminating arbitrary constants and arbitrary functions, Classification, Construction and geometrical interpretation of first order partial differential equations (PDE), Method of characteristic and general solution of first order PDE, Cauchy's problem of First order equation, Canonical form of first order PDE,

Method of separation of variables for first order PDE. Definitions of (i) Complete Integral (ii) Particular Integral (iii) Singular Integral (iv) General Integral

Unit-II : Non-linear PDE of order one (Lectures:18)/26marks

Different Standard Forms (i) Only p and q present (ii) Only p, q and z present (iii) f(x, p) = F(y, q) (iv) Analogous to Clairaut's form. Partial differential equations of 1^{st} order but of any degree: (i) Two independent variables - Charpit's method and (ii) Three or more independent variables-Jacobi's method.

Unit-III: Secondand Higher Order PDE (Lectures: 20)/28marks

Classification of second order PDE, Reduction to canonical forms, Equations with constant coefficients, General solution Introduction to Higher Order PDEs (constant coefficients only), Origin of second order equations**.** Solution of Linear Homogeneous PDE with constant coefficients, To find the complete solution of the equations namely (i) f(D, D')z = 0 and (ii) f(D, D')z = F(x, y), Equations reducible to linear form with constant coefficients, Monge's method of integrating (i) Rr + Ss + Tt = V (ii) Rr + Ss + Tt +U($rt-s^2$) = V.

Books recommended:

1. M.D. Raisinghania- Ordinary and Partial Differential Equations, S.Chand, New Delhi
2. Linear Partial Differential Equations for Scientist and Engineers, TynMyint-U, LokenathDebnath, Birkhauser

Referrence:

1. Sneddon, I. N. (2006). Elements of Partial Differential Equations, Dover Publications. Indian Reprint
2. H.T.H. Piaggio, An elementary treatise on differential equations and their applications.
3. Stavroulakis, Ioannis P &Tersian, Stepan A. (2004). Partial Differential Equations:
4. K. Sankara Rao, Introduction to partial differential equation.
5. Pundir&Pundir, Advanced partial differential equations (with Boundary value
6. problems).
7. W.E. Williams, Partial Differential Equations, Oxford.
8. Phoolan Prasad and RenukaRavindran, Partial Differential Equations, Wiley Eastern, New Delhi.

CMA209: SEMESTER-III

[Group Theory-I]

Total Marks: 100(External -80, Internal-20)
Workload: 4 Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: The objective of the course is to introduce the fundamental theory of groups and its applications.

Course Learning Outcomes: The course will enable the students to:

i) understand the mathematical concepts about the groups, and classify them as abelian, cyclic and permutation groups, etc;
ii) Explain the significance of the notion of subgroups, cyclic groups, cosets, normal subgroups, and factor groups.

Course Contents:

Unit-I: Groups and its Elementary Properties (Lectures: 12)/17marks

Definition and examples of groups including permutation groups and quaternion groups (illustration through matrices), Elementary properties of groups.

Unit-II: Subgroups and Cyclic Groups (Lectures:18)/26marks

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.

Unit-III: Permutation Groups and Lagrange's Theorem (Lectures: 26)/37marks

Cycle notation for permutations, Properties of permutations, Even and odd permutations, alternating groups; Properties of cosets, Lagrange's theorem and consequences including, Normal subgroups, factor groups, Cauchy's theorem for finite abelian groups.

Group homomorphisms, Properties of homomorphisms, Group isomorphisms, Cayley's theorem, Properties of isomorphisms,

Books recommended:

1. V.K. Khanna & S.K. Bhambri, A Course in Abstract Algebra, Vikas Publishing House, New Delhi.
2. Surjeet Singh and QaziZameerudin, Modern Algebra, Vikas Publishing House.

References:

1. Gallian, Joseph. A. (2013). Contemporary Abstract Algebra (8th ed.). Cengage Learning India Private Limited, Delhi. Fourth impression, 2015.
2. S. Kumaresan, Linear Algebra, Prentice Hall of India.
3. Shanti Narayan & P.K. Mittal, A Text Book of Matrices, S Chand & Co., New Delhi.

Skill Enhancement Paper SEC-3: SEMESTER-III

SMA-005

[LaTeX and HTML]

Total Marks: 50(External -40, Practical-10)

Workload: 1 Lectures, 2Practical (per week) Credits: 2 (1+1) Duration: 14 Weeks (14 Hrs. Theory + 28 Hrs. Practical) Examination: 2 Hrs.

Course Objectives: The purpose of this course is to acquaint students with the latest typesetting skills, which shall enable them to prepare high quality typesetting, beamer presentation and webpages.

Course Learning Outcomes: After studying this course the student will be able to: i) Typeset mathematical formulas, use nested list, tabular & array environments. ii) Create or import graphics. iii) Use beamer to create presentation and HTML to create a web page.

Course Contents: (Lectures-28)/40marks

Introduction to TeX and LaTeX, Typesetting a simple document, Adding basic information to a document, Environments, Footnotes, Sectioning and displayed material.

Accents and symbols, Mathematical Typesetting (Elementary and Advanced): Subscript/ Superscript, Fractions, Roots, Ellipsis, Mathematical Symbols, Arrays, Delimiters, Multiline formulas, Spacing and changing style in math mode. Graphics in LaTeX, Simple pictures using PS Tricks, Plotting of functions, Beamer presentation. HTML basics, Creating simple web pages, Images and links, Design of web pages.

Books recommended:

1. Bindner, Donald & Erickson, Martin. (2011). A Student's Guide to the Study, Practice, and Tools of Modern Mathematics.CRC Press, Taylor & Francis Group, LLC.

2. Lamport, Leslie (1994). LaTeX: A Document Preparation System, User's Guide and Reference Manual (2nd ed.). Pearson Education.Indian Reprint.

References:

1. Dongen, M. R. C. van (2012). LaTeX and Friends. Springer-Verlag.
2. Robbins, J. N. (2018). Learning Web Design: A Beginner's Guide to HTML (5th ed.). O'Reilly Media Inc.Department of Mathematics, University of Delhi 32 Practical/Lab work to be performed in Computer Lab.

Practicals: [1] Chapter 9 (Exercises 4 to 10), Chapter 10 (Exercises 1 to 4 and 6 to 9), Chapter 11 (Exercises 1, 3, 4, and 5), and Chapter 15 (Exercises 5, 6 and 8 to 11).

Skill Enhancement Paper SEC-3:Semester-III

SMA-006

[FUZZY SETS]

Total Marks: 50(External -40, Internal-10)

Workload: 2 Lectures, (per week) Credits: 2 Duration: 14 Weeks (28 Hrs.)
Examination: 2 Hrs

Objectives and Outcome: The objective of this course is to explore various important areas of fuzzy set theory and Mathematical programming algorithms to solve real life problems.

Contents: **(Lectures-28)/40marks**

An overview of Crisp Sets, Basics of Fuzzy sets, Types of Fuzzy Sets, characteristics of Fuzzy Sets, Developing Membership Functions, Operations on Fuzzy sets, Extension principle for Fuzzy sets, Yager's Union and Intersection of two Fuzzy sets, Union and Intersection of two Fuzzy setsby Dubois and Prade, Union and Intersection of two Fuzzy setsby Hamachar, Fuzzy numbers and Fuzzy Arithmetic, Algebraic operations with Fuzzy numbers, Binary operations on two fuzzy numbers, Arithmetic operations on fuzzy numbers in the form of $\alpha - cuts,$ Fuzzy logic, Fuzzy Graphs, Possibility Theory, Fuzzy Control system models, Uncertainty based informations, , Defuzzification, Decision making in fuzzy Environment,

Books Recommended:

1. HJ Zimmermann, Fuzzy Set Theory and its Applications Springer Science, New York.

References:

1. RajjanShingal, Introduction to Fuzzy Logic: PHI Learning Private Limited, Delhi.
2. SK Pundir and R Pundir, Fuzzy Sets and their Applications, PragatiPrakashan.

CMA-210: **SEMESTER-IV**

[Riemann Integration & Series of Functions]

Total Marks: 100(External -80, Internal-20)
Workload: 4 Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: To understand the integration of bounded functions on a closed and bounded interval and its extension to the cases where either the interval of integration is infinite, or the integrand has infinite limits at a finite number of points on the interval of integration.

Course Learning Outcomes: The course will enable the students to learn about:

i) Some of the families and properties of Riemann integrable functions, and the applications of the fundamental theorems of integration.

ii) Beta and Gamma functions and their properties.

iii) The valid situations for the inter-changeability of differentiability and integrability with infinite sum, and approximation of transcendental functions in terms of power series.

Course Contents:

Unit -I: Riemann Integration (Lectures: 26)/37marks

Definition of Riemann integration, Inequalities for upper and lower Darboux sums, Necessary and sufficient conditions for the Riemann integrability, Definition of Riemann integration by Riemann sum and equivalence of the two definitions, Riemann integrability of monotone functions and continuous functions, Properties of Riemann integrable functions, Definitions of piecewise continuous and piecewise monotone functions and their Riemann integrability, intermediate value theorem for integrals, Fundamental theorems (I and II) of calculus, and the integration by parts.

Improper integrals of Type-I, Type-II and mixed type, Convergence of Beta and Gamma functions, and their properties.Abel's test(Statement only) and Dirichilet's test (Statement only), Frullani's Integral.

Unit-II: Sequence and Series of Functions (Lectures: 20)/28marks

Pointwise and uniform convergence of sequence of functions, Theorem on the continuity of the limit function of a sequence of functions, Theorems on the interchange of the limit and derivative, and the interchange of the limit and integrability of a sequence of functions. Pointwise and uniform convergence of series of functions, Theorems on the

continuity, Derivability and integrability of the sum function of a series of functions, Cauchy criterion and the Weierstrass M-Test for uniform convergence.

Unit-III: Power Series (Lectures: 10)/15marks

Definition of a power series, Radius of convergence, Absolute convergence (CauchyHadamard theorem), Uniform convergence, Differentiation and integration of power series, Abel's Theorem.

Books Recommended:

1. S.C. Malik and Savita Arora, Mathematical Analysis, New Age International (P) Limited.
2. K.C. Maity& R.K. Ghosh, An Introduction to Analysis, Differential Calculus Part-II ,

Referrences:

1. Bartle, Robert G., &Sherbert, Donald R. (2015). Introduction to Real Analysis (4th ed.). Wiley India Edition. Delhi.
2. Denlinger, Charles G. (2011). Elements of Real Analysis. Jones & Bartlett (Student Edition). First Indian Edition. Reprinted 2015.
3. Shanti Narayan and M.D. Raisinghania, Elements of Real Analysis, S. Chand & Company

CMA-211(Semester-IV)

[Mechanics]

Total Marks: 100(External -80, Internal-20)
Workload: 4 Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: The course aims at understanding the various concepts of physical quantities and the related effects on different bodies using mathematical techniques.

Course Learning Outcomes: The course will enable the students to understand:

i) Motion of particles in resisting medium, Equilibrium of forces in two and three dimensions

ii) Foundations of Frictional force.

ii) Moment of inertia of a rigid body about an arbitrary axis.

iii) Course Contents:

Contents:

Unit-I: **Motion in resisting medium (Lectures: 20)/28marks**

Simple Harmonic Motions.Motion in resisting medium including projectile, Motion of varying mass.Radial and Cross-Radial Components of velocities and accelerations.Tangential and Normal Components of velocities and accelerations.Dynamics of a particle: Motion of a particle on smooth and rough plane curves, Central orbit, Apses.

Unit-II: Forces in Equilibrium (Lectures: 16)/24marks

Coplanar force systems; Three-dimensional force systems; Moment of a force about a point and an axis, Principle of moments, Couple and couple moment, Moment of a couple about a line, Resultant of a force system, Distributed force system, Rigid-body equilibrium, Equilibrium of forces in two and three dimensions, Free-body diagrams, General equations of equilibrium.

Unit-III: Friction, Centre of Gravity: (Lectures:20)/28marks

Equations of equilibrium and friction, Laws of Friction, Equilibrium of particle constrained to rest on a rough curve under any given forces.Center of gravity, Center of mass and Centroid of a body and composite bodies;

Books recommended:

1. B.C. Das, B.N. Mukherjee, Dynamics, U.N.Dhur & Sons (private Ltd.),Kolkata
2. B.C. Das, B.N. Mukherjee, Statics, U.N.Dhur & Sons (private Ltd.),Kolkata
3. S.L. Loney, An Elementary Treatise on Statics, Cambridge University Press.
4. S.L. Loney, An Elementary Treatise on dynamics of a particle and of Rigid Bodies,Cambridge University Press.

Referrence:

1. Nelson, E. W., Best, Charles L. & McLean, W. G. (1998). Theory and Problems of Engineering Mechanics: Statics and Dynamics (5th ed.). McGraw-Hill,
2. M. Ray, Dynamics, S. Chand & Co.
3. R.S. Verma,Text book on Statics, Pothisala Private Ltd.
4. H. Goldstein: Classical Mechanics, Narosa Publishing House, New Delhi
5. .C.R. Mondal: Classical Mechanics, Prentice Hall of India, New Delhi.

CMA-212:Semester-IV

[Numerical Analysis]

Total Marks: 100(External -80, Internal-20)
Workload: 4 Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives:

i) to find approximate value for possible root(s) of non-algebraic equations,
ii) to find the approximate solutions of system of linear equations and ordinary differential equations.
iii) Also, the use of Computer Algebra System (CAS) by which the numerical problems can be solved both numerically and analytically, and to enhance the problem solving skills.

Course Learning Outcomes: The course will enable the students to learn the following:

i) 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.
ii) Interpolation techniques to compute the values for a tabulated function at points not in the table.

iii) Applications of numerical differentiation and integration to convert differential equations into difference equations for numerical solutions

Course Contents:

Unit-I: Interpolation (Lectures: 18)/26marks

Finite difference operators. Gregory forward and backward difference interpolation. Lagrange and Newton's methods.Piecewise linear interpolation.

Unit-II: Numerical Differentiation and Integration (Lectures: 20)/28marks

First order and higher order approximation for first derivative, Approximation for second derivative. Numerical Integration: Trapezoidal rule, Simpson's rule, Simpsons 3/8th rule, Ordinary Differential Equations: Euler's method. Runge-Kuttamethods of orders two and four.

Unit -III:Methods for Solving Algebraic and Transcendental Equations (Lectures: 18)/26marks

Algorithms, Convergence, Bisection method, False position method, Fixed point iteration method, Newton's method, Secant method
System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Partial and scaled partial pivoting, LU decomposition and its applications, Iterative methods: Jacobi, Gauss-Seidel

Books recommended:

1. Gupta, Malik & Chauhan, Calculus of Finite Differences & Numerical Analysis, Krishna Prakashan Media P. Ltd.-Meerut

2. Bradie, Brian. (2006). A Friendly Introduction to Numerical Analysis. Pearson Education, India. Dorling Kindersley (India) Pvt. Ltd. Third impression 2011.

References:

1. Jain, M. K., Iyengar, S. R. K., & Jain, R. K. Numerical Methods for Scientific and Engineering Computation. (6th ed.). New Age International Publisher, India, 2016.
2. H.C. Saxena, Finite differences and numerical analysis, S Chand & Co. Ltd, New Delhi.
3. D.C. Sanyal& K. Das, A Textbook of Numerical Analysis, U.N. Dhur& Sons Private Ltd.
4. James B. Scarborough, Numerical Mathematical Analysis, Oxford and IBH Publishing Co. Pvt. Ltd.

Skill Enhancement Paper SEC-4: SEMESTER-IV

SMA-007

[Computer Algebra Systems and R Software]

Total Marks: 50(External -40, Practical-10)

Workload: 1 Lectures, 2 Practical (per week) Credits: 2 (1+1) Duration: 14 Weeks (14 Hrs. Theory + 28 Hrs. Practical) Examination: 2 Hrs.

Course Objectives: This course aims at familiarizing students with the usage of computer algebra systems (/Mathematica/MATLAB/Maxima/Maple) and the statistical software R.

Course Learning Outcomes: This course will enable the students to:

i) Use CAS as a calculator, for plotting functions, animations and various applications of matrices.

ii) Understand the use of the software R for entry, summary calculation, pictorial representation of data and exploring relationship between data.

iii) Analyse, test, and interpret technical arguments on the basis of geometry.

Course Contents: (Lectures: 28)/40marks

Computer Algebra System (CAS), Use of a CAS as a calculator, Computing and plotting functions in 2D, Plotting functions of two variables using Plot3D and ContourPlot, Plotting parametric curves surfaces, Customizing plots, Animating plots, Producing tables of values, working with piecewise defined functions, Combining graphics.

Simple programming in a CAS, Working with matrices, Performing Gauss elimination, operations (transpose, determinant, inverse), Minors and cofactors, Working with large matrices, Solving system of linear equations, Rank and nullity of a matrix, Eigenvalue, eigenvector and diagonalization.

R as a calculator, Explore data and relationships in R. Reading and getting data into R: Combine and scan commands, Types and structure of data items with their properties. Manipulating vectors, Data frames, Matrices and lists. Viewing objects within objects. Constructing data objects and conversions.

Books recommended:

1. Bindner, Donald & Erickson, Martin. (2011). A Student's Guide to the Study, Practice, and Tools of Modern Mathematics. CRC Press, Taylor & Francis Group, LLC.Department of Mathematics, University of Delhi 42
2. Torrence, Bruce F., &Torrence, Eve A. (2009). The Student's Introduction to Mathematica®: A Handbook for Precalculus, Calculus, and Linear Algebra (2nd ed.). Cambridge University Press.
3. Gardener, M. (2012). Beginning R: The Statistical Programming Language, Wiley.

References:

1. Verzani, John (2014). Using R for Introductory Statistics (2nd ed.). CRC Press, Taylor & Francis Group.

Note: Theoretical and Practical demonstration should be carried out only in one of the CAS: Mathematica/MATLAB/Maxima/Scilab or any other.

Skill Enhancement Paper SEC-4: SEMESTER-IV

SMA-008

[**MATLAB**]

Total Marks: 50(External -40, Practical-10)

Workload: 1 Lectures, 2Practicals (per week) Credits: 2 (1+1) Duration: 14 Weeks (14 Hrs. Theory + 28 Hrs. Practical) Examination: 2 Hrs.

Course Objectives: The purpose of this course is to acquaint students with the use of MATLAB.

Course Learning Outcomes: After studying this course the student will be able to:

i) Data analysis and curve fitting by using the software.

ii) 2-D graphics and 3-D graphics-general purpose graphic functions, colour maps and colour functions

Course Contents: **(Lecture-18)/28marks**

Simple arithmetical operations, variables, round-off errors, formatting printing, common mathematical functions, script M-files, File Input-Output. Two-dimensional graphics, three-dimensional graphics. Generating matrices, colon operator, manipulating matrices, simple arithmetical operations, operator procedure, common mathematical functions, data manipulation commands, sparse matrices.Solving linear system of equations-square linear system, Catastrophic round-off error, over determined and undetermined linear system, Initial-valued ordinary differential equations.Programming in MATLAB-Flow control and logic variables, matrix relational operators and logical operators, function M-files.

PRACTICAL - 50 MARKS (List of practical topics based on MATLAB)

1. Plotting of functions
2. Matrix operations, vector and matrix manipulation, matrix function
3. Data analysis and curve fitting
4. Use of FFT algorithm
5. Numerical Integration
6. Differential equations
7. 2-D graphics and 3-D graphics-general purpose graphic functions, colour maps and colour functions
8. Sparse matrices-Iterative methods for sparse linear equations, eigenvalues of sparse matrices.

Books Recommended:

1. Y.Kirani Singh &B.B.Chaudhury- MATLAB Programming

Reference:

1. Ram N.Patel and Ankush Mittal-Programming in MATLAB-A Problem Solving Approach
2. S.Swapana Kumar &Lenina SVB- MATLAB-Easy Way of Learning

THIRD YEAR MATHEMATICS

CMA-313: SEMESTER V

[Multivariate Calculus]

Total Marks: 100(External -80, Internal-20)
Workload: 4 Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: To understand the extension of the studies of single variable differential and integral calculus to functions of two or more independent variables.
Course Learning Outcomes: This course will enable the students to learn:

i) The conceptual variations when advancing in calculus from one variable to multivariable discussions.

ii) Inter-relationship amongst the line integral, double and triple integral formulations.

Course Contents:

Unit -I: Calculus of Functions of Several Variables (Lectures: 20)/28marks

Functions of several variables, Level curves and surfaces, Limits and continuity, Partial differentiation, Higher order partial derivative, Tangent planes, Total differential and differentiability, Chain rule, Directional derivatives, The gradient, Maximal and normal property of the gradient, Tangent planes and normal lines.

Extrema of functions of two variables, Method of Lagrange multipliers, Constrained optimization problems; Definition of vector field, Divergence and curl.

Unit-II: Double and Triple Integrals (Lectures: 18)/26marks

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

Unit-III: Green's, Stokes' and Gauss Divergence Theorem (Lectures: 18)/26marks

Line integrals, Applications of line integrals: Mass and Work, Fundamental theorem for line integrals, Conservative vector fields, Green's theorem, Area as a line integral; Surface integrals, Stokes' theorem, The Gauss divergence theorem.

Books recommended:

1. Strauss, Monty J., Bradley, Gerald L., & Smith, Karl J. (2007). Calculus (3rd ed.). Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). Delhi. Indian Reprint 2011.

References:

1. Marsden, J. E., Tromba, A., & Weinstein, A. (2004). Basic Multivariable Calculus. Springer (SIE). First Indian Reprint.

CMA-314: SEMESTER-V

[Ring Theory & Linear Algebra-I]

Total Marks: 100(External -80, Internal-20)

Workload: 4 Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: The objective of this course is to introduce the fundamental theory of two objects, namely - rings and vector spaces, and their corresponding homomorphisms.

Course Learning Outcomes: The course will enable the students to learn about:

i) The fundamental concept of Rings, Fields, subrings, integral domains and the corresponding morphisms.
ii) The concept of linear independence of vectors over a field, the idea of a finite dimensional vector space, basis of a vector space and the dimension of a vector space.
iii) Basic concepts of linear transformations, the Rank-Nullity Theorem, matrix of a linear transformation, algebra of transformations and the change of basis. Course Contents:

Course Contents:

Unit -I: Introduction of Rings (Lectures: 20)/28marks

Definition and examples of rings, Properties of rings, Subrings, Integral domains and fields, characteristic of a ring. Ideals, Ideal generated by a subset of a ring, Factor rings, Operations on ideals, Prime and maximal ideals.

Ring homomorphisms, Properties of ring homomorphisms, First, Second and Third Isomorphism theorems for rings, The Field of quotients.

Unit -II: Introduction of Vector Spaces (Lectures: 18)/26marks

Vector spaces, Subspaces, Algebra of subspaces, Quotient spaces, Linear combination of vectors, Linear span, Linear independence, Basis and dimension, Dimension of subspaces.

Unit -III: Linear Transformations (Lectures: 18)/26marks

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 the change of coordinate matrix.

Books recommended:

1. Herstein, I. N. (2006). Topics in Algebra (2nd ed.). Wiley Student Edition. India.
2. Hoffman, Kenneth, &Kunze, Ray Alden (1978). Linear Algebra (2nd ed.). PrenticeHall of India Pvt. Limited. Delhi. Pearson Education India Reprint, 2015.
3. V.K. Khanna & S.K. Bhambri, A Course in Abstract Algebra, Vikas Publishing House, New Delhi.

References:

1. Dummit, David S., & Foote, Richard M. (2016). Abstract Algebra (3rd ed.). Student Edition. Wiley India.
2. Goyal& Gupta, Advanced Course in Modern Algebra, Pragati Prakashan, Meerut

CMA-315 :(SEMESTER-V)

[Group Theory-II]

Total Marks: 100(External -80, Internal-20)
Workload: 4 Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: The course will develop an in-depth understanding of one of the most important branch of the abstract algebra.

Course Learning Outcomes: The course shall enable students to learn about:

i) Automorphisms for constructing new groups from the given group, External direct product.
ii) Group actions, Sylow theorems and their applications to check nonsimplicity.

Course Contents:

Unit -I: Automorphisms and Properties (Lectures: 15)/21marks

Automorphism, inner automorphism, Automorphism groups, Automorphism groups of finite and infinite cyclic groups, Characteristic subgroups, Commutator subgroup and its properties; Applications of factor groups to automorphism groups.

Unit-II: External and Internal Direct Products of Groups (Lectures: 16)/23marks

External direct products of groups and its properties, The group of units modulo n as an external direct product, Applications to data security and electric circuits; Internal direct products, Classification of groups of order 2 p , where p is a prime; Fundamental theorem of finite Abelian groups and its isomorphism classes.

Unit-III: Group Action (Lectures: 25)/36marks

Group actions and permutation representations; Stabilizers and kernels of group actions; Groups acting on themselves by left multiplication and consequences; Conjugacy in .n S

Conjugacy classes, The class equation, p-groups, The Sylow theorems and consequences, Applications of Sylow theorems; Finite simple groups, Nonsimplicity tests; Generalized Cayley's theorem, Index theorem, Embedding theorem and applications. Simplicity of 5 A .

Books recommended:

1. V.K. Khanna & S.K. Bhambri, A Course in Abstract Algebra, Vikas Publishing House, New Delhi.
2. Surjeet Singh and QaziZameerudin, Modern Algebra, Vikas Publishing House.
3. P.B. Bhattacharya, S.K. Jain and S. R. Nagpaul: Basic Abstract Algebra, CUP.

References:

1. Dummit, David S., & Foote, Richard M. (2016). Abstract Algebra (3rd ed.). Student Edition. Wiley India.
2. Gallian, Joseph. A. (2013). Contemporary Abstract Algebra (8th ed.). Cengage Learning India Private Limited. Delhi. Fourth impression, 2015.
3. Shanti Narayan & P.K. Mittal, A Text Book of Matrices, S Chand & Co., New Delhi.

Discipline Specific Elective (DSE-001)

EMA-001 : (Semester-V)

Total Marks: 100(External -80, Internal-20)
Workload: 4 Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

DSE-1 : Metric Space

Course Objectives: The course will develop an in-depth understanding of one of the most important branch of the Topology say Metric space.

Course Learning Outcomes: The course shall enable students to learn about:

i) Basic concepts of metric space, open sphere, open sets, imterior pints, closure of a set.
ii) Convergence of a Cauchy Sequence,Bolzano Weirstrass propertyand their applications in Topology.

Unit-I: Metric Spaces (Lectures: 20)/28marks

Definition and example of a metric space, Diameter and boundedness of sets, Distance between two subsets of a Metric space, Fundamental inequalities (Holder and Minkowski), some function spaces, Subspace of a metric space. Open spheres/balls, Open sets and properties, closed sets, neighbourhood of a point, limit points, adherent point, Interior, Exterior and Frontier points, closure of a set, Dense subsets.

Unit-II: Complete Metric Spaces **(Lectures: 18)/26marks**

Convergent sequences, Cauchy sequences, Convergence of a Cauchy Sequence, Complete spaces, Examples of complete and in-complete metric spaces, Cantor's intersection theorem, Continuous functions, Characterization of continuous functions, Uniform Continuity, Homeomorphism.

Unit-III: Compactness **(Lectures: 18)/26marks**

Compact metric spaces, Sequential Compactness, Bolzano Weirstrass property, Totallyboundedness, Finite intersection property, equivalence among the kinds of compactness, Continuous functions and compact sets.

Books Recommended:

1. P.K. Jain and K. Ahmad: Metric Spaces, Narosa Publishing House, New Delhi

References:

1. G. F. Simmons: Introduction to Topology and Modern Analysis, Tata McGraw Hill Education Pvt. Ltd. New Delhi
2. S. Lipchutz: General Topology, Schaum's Outline Series, McGraw Hill Book
3. S.C. Malik, Savita Arora: Mathematica Analysis, New Age International(P)
4. E.T. Copson: Metric Spaces, Universal Book Stall, 5 Ansari Road, New Delhi-11

Skill Enhancement Paper SEC-5: SEMESTER-V

SMA-009

[C Programming]

Total Marks: 50(External -40, Practical-10)

Workload: 1 Lectures, 2Practicals (per week) Credits: 2 (1+1) Duration: 14 Weeks (14 Hrs. Theory + 28 Hrs. Practical) Examination: 2 Hrs.

Course Objectives: This course aims at familiarizing students with the usage of basic computer programming.

Course Learning Outcomes: This course will enable the students to:

i) Understand and apply the programming concepts of C which is important to mathematical investigation and problem solving.
ii) Use mathematical libraries for computational objectives.

Course Contents:

Unit-I: C-programming **(Lectures: 8)/11marks**

Introduction to C-programming: Basic model of a computer, Algorithm, Flow Chart, Programming language, Compilers and operating system, character set, identifiers and keyword, constant, variables and data type, operations and expressions, operator precedence and associativity, Basic input/output statement, simple C-programs.

Unit-II: C-programming with conditional operators (Lectures: 8)/11marks

Conditional statements and loops, Decision making with a program, logical and conditional operators, if statement, nested if else statement, loops, while loop, do-while loop, for loop, nested loops, break statement, switch statement, continue statement, go-to statement, the comma operator.

Unit-III: Arrays: (Lectures:12)/18marks

Arrays: One dimensional arrays, declaration and initialization of one dimensional array, searching, insertion and deletion of an element from an array, sorting an array, Two dimensional arrays.

Function: Defining a function, accessing a function, function declaration/prototype, function parameters, return values, passing arguments to a function, call by reference, call by value, function calls, recursion, passing arrays to function.

Practical:

Programs for practical:

1. To convert octal to decimal, decimal to octal, binary to decimal, decimal to binary
2. To find the sum of the series
   (i) $\frac{x}{1!}-\frac{x^3}{3!}+\frac{x^5}{5!}-.....$ (ii) $1-\frac{x^2}{2!}+\frac{x^4}{4!}-.....$
3. To read a positive number from the keyboard and check whether the number is prime or not.
4. To generate prime numbers up to n terms.
5. To generate multiplication tables of 2,3,4,,…,10.
6. To find GCD and LCM of two given numbers.
7. To find GCD of two given numbers using recursion.
8. To find the factorial of a positive integer using and without using function.
9. To generate Fibonacci series of numbers up to n terms whose leading terms are 0, 1 and 1,1.
10. To implement Matrix – Addition, Multiplication, Transpose.
11. Searching: (i) Linear Search (ii) Binary Search
12. Insertion: (i) Sorted array (ii) Unsorted array
13. Deletion of an element from an array.
14. Sorting : (i) Selection Sort (ii) Bubble Sort (iii) Insertion Sort
15. Linear equation (i) Gauss Elimination method.
16. Non-linear equation: (i) Bisection (ii) Secant and (iii) Newton-Raphson method
17. Numerical Integration: (i) Trapezoidal rule and (ii) Simpson's 1/3 rule.
18. Ordinary differential equation: (i) Euler's method and (ii) Runge-Kutta method.

Books Recommended:

1. E. Balaguruswami, Programming with ANSI-C, Tata McGraw Hill.
2. Byron Gottfried, Programming with C, Tata McGraw Hill.

References:

1. RG Dromey, How to solve it by computer, Prentice Hall of India.
2. K.E. Atkinson, An introduction to numerical analysis, John Wiley and Sons.
3. M.K. Jain, S.R.K. Iyenger, R.K. Jain, Numerical method, New Age International (P) Ltd.
4. R.Y. Rubinstein, Simulation and Monte-Carlo method, John Wiley.
5. C.E. Froberg, Introduction to numerical analysis, Addison Wesley.

Skill Enhancement Paper SEC-5: SEMESTER-V

SMA-010

[**Inventory systems and Marketing management**]

Total Marks: 50(External -40, Internal-10)

Workload: 2 Lectures (per week) ,Credits: 2 Duration: 14 Weeks (28 Hrs.)
Examination: 3 Hrs.

Course Objectives: This course aims at introducing the concepts of Inventory systems and marketing management.

Course Learning outcomes: After the course, the student will be able to understand the concepts of:

i) Different Inventory models

ii) Applications of the models in real life situations.

Course Contents:

Unit 1: Inventory systems (Lectures: 8)/11marks

Concepts and problems in Inventory Systems, Objectives of Scientific Inventory Control, classification of Inventory Systems, different costs in Inventory Systems and method of their estimation. The concept of EOQ

Unit 2: Deterministic Inventory models (Lectures: 15)/21marks

Deterministic Inventory models with and without lead time. Deterministic Inventory models with and without shortages.

Unit 3: Concepts of marketing management and related models
(Lectures: 05)/8marks

Concept of marketing and its role in organization. Marketing decisions, scientific marketing analysis. Uses and limitations of mathematical models in marketing , classification of market structure in competitive conditions.

Books Recommended:

1. G. Hadley, T.M. Whitin, Analysis of Inventory Systems, D.B. Taraporevala and Sons, Published by arrangement with Prentice Hall Inc., 1979.
2. Zipkin, Foundations of Inventory Management, McGraw Hall Inc., 2000.

3. KantiSwarup, P.k. Gupta and Man Mohan(2020), Operations research, Sultan chand& Sons, New Delhi

References:

1. Donald Waters, Inventory Control, John Wiley, 2003.
2. Philip Kotler, Marketing Management, 13th Ed., Prentice Hall of India, 2008.

CMA-316: SEMESTER VI

[Ring Theory and Linear Algebra-II]

Total Marks: 100(External -80, Internal-20)
Workload:4Lectures (per week),Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: This course introduces the basic concepts of ring of polynomials and irreducibility tests for polynomials over ring of integers, used in finite fields.

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

i) Appreciate the significance of unique factorization in rings and integral domains.

ii) Compute with 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.

Course Contents:

Unit -I: Polynomial Rings and Unique Factorization Domain (UFD)

(Lectures: 16)/24marks

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, Irreducible, Primes, Unique factorization domains, Euclidean domains.

Unit-II: Dual Spaces and Diagonalizable Operators (Lectures: 15)/21marks

Dual spaces, Double dual, Dual basis, Transpose of a linear transformation and its matrix in the dual basis, Annihilators; Eigenvalues, Eigenvectors, Eigenspaces and

characteristic polynomial of a linear operator; Diagonalizability, Invariant subspaces and Cayley-Hamilton theorem; The minimal polynomial for a linear operator.

Unit -III: Inner Product Spaces (Lectures: 25)/35marks

Inner product spaces and norms, Orthonormal basis, Gram-Schmidt orthogonalization process, Orthogonal complements, Bessel's inequality.

The adjoint of a linear operator, Least squares approximation, Minimal solutions to systems of linear equations, Normal, Self-adjoint, Unitary and orthogonal operators and their properties.

Books recommended:

1. V.K. Khanna & S.K. Bhambri, A Course in Abstract Algebra, Vikas Publishing House, New Delhi.
2. Surjeet Singh and QaziZameerudin, Modern Algebra, Vikas Publishing House.
3. P.B. Bhattacharya, S.K. Jain and S. R. Nagpaul: Basic Abstract Algebra, CUP.

Referrences:

1. Friedberg, Stephen H., Insel, Arnold J., & Spence, Lawrence E. (2003). Linear Algebra (4th ed.). Prentice-Hall of India Pvt. Ltd. New Delhi.
2. Gallian, Joseph. A. (2013). Contemporary Abstract Algebra (8th ed.). Cengage Learning India Private Limited. Delhi. Fourth impression, 2015.

CMA-317: SEMESTER VI

[Network Analysis and Project Management]

Total Marks: 100(External -80, Internal-20)
Workload:4Lectures (per week),Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs

Students are expected to carry out independent project in the industry on a topic assigned to him/her under the supervision of faculty member. At the completion of project students are expected to write a report and make a presentation.

Course Objectives: This course aims at familiarizing students with the Network analysis.

Course Learning Outcomes: This course will enable the students to:

Acquire special/advanced knowledge, such as supplement study/support study to a project work, and a candidate studies such a course on his own with an advisory support by a teacher/faculty member.

Contents:

UNIT-I: **(Lectures: 06)/10marks**

Project Management Objective: This course offers practical approach to managing projects, focusing on organizing, planning, and controlling the efforts in the project.

UNIT-II: **(Lectures-25)/35marks**

Basics of project management, feasibility and technical analysis: materials and equipment, project costing & financing, financial aspects, cost benefit analysis, success criteria and success factors, risk management Mathematical models: project selection, project planning, cost-time trade-off, resource handling.Project management through PERT/CPM, Network Scheduling by PERT/CPM, Updating of PERT Charts. Project Crashing,

UNIT-III: (Lectures-25)/35marks

Network Analysis , Network notations and definitions, nodes, links and flows, Paths, Cycles, Trees, Construction of minimal spanning tree and its applications, Shortest path, Shortest route problems, and travelling salesman problem, Flows in networks, Maximal flow. Monte-Carlo Simulation.

Books recommended:

1. Ravi Ravindran: Operations Research and Management Science Handbook, CRC Press, 2008.

2. KantiSwarup, P.k. Gupta and Man Mohan(2020), Operations research, Sultan chand& Sons, New Delhi

References:

1. Harold Kerzner: Applied Project Management: Best Practices on Implementation, John Wiley & Sons, Inc., 2000.
2. J.C. Goodpasture: Quantitative Methods in Project Management, J Ross Publishing, Boca Raton, Florida, USA, 2003.
3. J.R. Meredith and S.J. Mantel Jr.: Project Management: A Managerial Approach, John Wiley,New York. 2004.

CMA-318 :Semester-VI

[Probability Theory and Statistics]

Total Marks: 100(External -80, Internal-20)
Workload: 4 Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: To make the students familiar with the basic statistical concepts and tools which are needed to study situations involving uncertainty or randomness.

Course Learning Outcomes: This course will enable the students to learn:

i) Distributions to study the joint behaviour of two random variables.
ii) To establish correlation and linear regression.
iii) Central limit theorem, which helps to understand the remarkable fact that: the empirical frequencies of so many natural populations, exhibit a bell shaped curve.

Course Contents:

Unit -I: Probability Functions and Moment Generating Function

(Lectures: 18)/26marks

Sample space, Probability set function, Real random variables - Discrete and continuous, Cumulative distribution function, Probability mass/density functions, Transformations, Mathematical expectation, Moments, Moment generating function, Characteristic function.

Unit-II: Univariate Discrete and Continuous Distributions (Lectures: 18)/26marks

Discrete distributions: Uniform, Bernoulli, Binomial, Negative binomial, Geometric and Poisson; Continuous distributions: Uniform, Gamma, Exponential, Chi-square, Beta and normal; Normal approximation to the binomial distribution.

Joint cumulative distribution function and its properties, Joint probability density function, Marginal distributions, Expectation of function of two random variables, Joint moment generating function, Conditional distributions and expectations.

Unit-III: Correlation, Regression and Central Limit Theorem

(Lectures: 20)/28marks

The Correlation coefficient, Covariance, Calculation of covariance from joint moment generating function, Independent random variables, Linear regression for two variables, The method of least squares, Bivariate normal distribution, Chebyshev's theorem, Strong law of large numbers, Central limit theorem and weak law of large numbers.

Books recommended:

1. D.Biswas, Probability and Statistics, New Central Book Agency(P) Ltd.
2. ParimalMukhopadhyay, Theory of Probality, New Central Book Agency (P0, Ltd.

References:

1. Hogg, Robert V., McKean, Joseph W., & Craig, Allen T. (2013). Introduction to Mathematical Statistics (7th ed.). Pearson Education, Inc.
2. Ross, Sheldon M. (2014). Introduction to Probability Models (11th ed.). Elsevier Inc.
3. S.C. Gupta, V.k.Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons.
4. Kapur J.N., Saxena H.C., Mathematical Statistics, S Chand & Company

EMA-002(Semester-VI)

[Number Theory]

Total Marks: 100(External -80, Internal-20)
Workload: 4 Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: In number theory there are challenging open problems which are comprehensible at undergraduate level, this course is intended to build a micro aptitude of understanding aesthetic aspect of mathematical instructions and gear young minds to ponder upon such problems.

Course Learning Outcomes: This course will enable the students to learn:

i) Some of the open problems related to prime numbers, viz., Goldbach conjecture etc.

ii) About number theoretic functions and modular arithmetic.

ii) Public crypto systems, in particular, RSA.

Course Contents:

Unit -I: Distribution of Primes and Theory of Congruencies (Lectures: 20)/28marks

Linear Diophantine equation, Prime counting function, Prime number theorem, Goldbach conjecture, Fermat and Mersenne primes, Congruence relation and its properties, Linear congruence and Chinese remainder theorem, Fermat's little theorem, Wilson's theorem.

Number theoretic functions for sum and number of divisors, Multiplicative function, The Mobius inversion formula, The greatest integer function. Euler's phi-function and properties, Euler's theorem.

Unit-II: Primitive Roots (Lectures:18)/26marks

The order of an integer modulo n, Primitive roots for primes, Composite numbers having primitive roots; Definition of quadratic residue of an odd prime, and Euler's criterion.

Unit-III: Quadratic Reciprocity Law and Public Key Encryption
(Lectures: 18)/26marks

The Legendre symbol and its properties, Quadratic reciprocity, Quadratic congruencies with composite moduli; Public key encryption, RSA encryption and decryption.

Books recommended:

1. Burton, David M. (2012). Elementary Number Theory (7th ed.). Mc-Graw Hill Education Pvt. Ltd. Indian Reprint.

2. Jones, G. A., & Jones, J. Mary. (2005). Elementary Number Theory. Undergraduate Mathematics Series (SUMS). First Indian Print.

Referrence:

1. Neville Robinns. (2007). Beginning Number Theory (2nd ed.). Narosa Publishing House Pvt. Limited, Delhi.

Skill Enhancement Paper SEC-6: SEMESTER-VI

SMA-011

[Python Programming]

Total Marks: 50(External -40, Practical-10)

Workload: 1 Lectures, 2Practicals (per week) Credits: 2 (1+1) Duration: 14 Weeks (14 Hrs. Theory + 28 Hrs. Practical) Examination: 2 Hrs.

Course Objectives: The purpose of this course is to acquaint students with the use of Python programming.

Course Learning Outcomes: After studying this course the student will be able to:

iii) Data analysis and curve fitting by using the software.

iv) 2-D graphics and 3-D graphics-general purpose graphic functions, colour maps and colour functions

Contents: Programming with Python **(Lectures-28)/40marks**

Introduction to python and its Installation, Introduction to python andits history, Understanding the basic structure of a python program, Flow charts and algorithms, Identifiers and Data types, Operators and Expressions, Managing Input and Output Operations, Control structures and functions.Decision making and Branching, Looping Functions, List, Dictionaries, Tuples and File handling.

Introduction to Operating Systems (Unix/Linux)

Books recommended:

1. Think Python: Allen B. Downey (Green Tea Press, 2014)
2. A Primer on Scientific Programming with Python: Hans Peter Langtangen (Springer, 2012)

Skill Enhancement Paper SEC-6: SEMESTER-VI

SMA-012

Total Marks: 50(External -40, Practical-10)

Workload: 1 Lectures, 2Practicals (per week) Credits: 2 (1+1) Duration: 14 Weeks (14 Hrs. Theory + 28 Hrs. Practical) Examination: 2 Hrs.

[C++ Programming for Mathematics]

Course Objectives:

This course introduces C++ programming in the idiom and context of mathematics and imparts a starting orientation using available mathematical libraries, and their applications.

Course Learning Outcomes: After completion of this paper, student will be able to:

iii) Understand and apply the programming concepts of C++ which is important to mathematical investigation and problem solving.
iv) Use mathematical libraries for computational objectives.
v) Represent the outputs of programs visually in terms of well formatted text and plots.

Course Contents:

Unit-I: C++ Essentials (Lectures: 8)/11marks

Fundamentals of programming, Organization of logic flow in stored program model of computation, C++ as a general purpose programming language, Structure of a C++ program, Common compilers and IDE's, Basic data-types, Variables and literals in C++, Operators, Expressions, Evaluation precedence, and Type compatibility. Outline of program development in C++, Debugging and testing. Applications: Greatest common divisor, and Random number generation.

Unit -II: Working with Structured Data (Lectures: 12)/18marks

Structured data-types in C++, Arrays and manipulating data in arrays with applications in factorization of an integer and finding Euler's totient; Objects and classes: Information hiding, Modularity, Constructors and Destructors, Methods and Polymorphism. Applications: Cartesian geometry using points (2 & 3-dimensional), and Pythagorean triples.

Containers and Template Libraries: Sets, Iterators, Multisets, Vectors, Maps, Lists, Stacks and Queues. Applications: Basic set algebra, Modulo arithmetic, Permutations, and Polynomials.

Unit-III: Using Mathematical Libraries and Packages (Lectures: 8)/11marks

Arbitrary precision arithmetic using the GMP package; Linear algebra: Two-dimensional arrays in C++ with applications in finding Eigenvalues, Eigenvectors, Rank, Nullity, and Solving system of linear equations in matrices. Features of C++ for input/output and visualization: Strings, Streams, Formatting methods, Processing files in a batch, Commandline arguments, Visualization packages and their use in plots.

Books recommended:

1. Scheinerman, Edward (2006). C++ for Mathematicians: An Introduction for Students and Professionals. Chapman & Hall/CRC. Taylor & Francis Group, LLC.

Referrences:

1. Dale, Nell & Weems, Chip (2013). Programming and Problem Solving with C++ (6th ed.). Comprehensive Edition. Jones & Bartlett Learning.
2. Gottschling, Peter (2016). Discovering Modern C++: An Intensive Course for Scientists, Engineers, and Programmers. Addison-Wesley. Pearson Education, Inc.
3. Josuttis, Nicolai M. (2012). The C++ Standard Library: A Tutorial and Reference (2nd ed.). Addison-Wesley. Pearson Education, Inc.

Practical / Lab work to be performed in Computer Lab:

A: Preparatory (Practical Sessions: 8 Hrs.)

1. Setting up of C++ programming environment on Linux/Windows/Mac-OS; gcc/g++/mingw/cc, Program-development methodology and use IDE's or other tools.

2. Demonstration of sample programs for a. "Hello World" b. Sum of an arithmetic progression. c. Value of sin x using series expansion.

3. Finding/demonstrating: a. Machine epsilon. b. Integer and float overflow/underflow. c. Iteration and selection based logic. (provide a list of 8-10 problems suitable to learners needs)

B: Evaluative:

Set-I: (Practical Sessions: 8 Hrs.)

1. Greatest common divisor (including Euclid's Method).

2. Random number generation (including a Monte Carlo Program).

Set-II: (Practical Sessions: 12 Hrs.)

1. Factorization of an integer, and Euler's totient.

2. Cartesian geometry using points (2 & 3-dimensional).

3. Pythagorean triples.

Set-III: (Practical Sessions: 16 Hrs.)

1. Basic set algebra.

2. Modulo arithmetic.

3. Permutations.

4. Polynomials.

Set-IV: (Practical Sessions: 12 Hrs.)

1. Arbitrary precision arithmetic using the GMP package.

2. Finding Eigenvalues, Eigenvectors, Rank, Nullity, and Solving system of linear equations in matrices.

3. Plots (using the GNU plotutils package).

Note. Exception handling in lab-exercises (SET-I to IV), Comments/Documentation using Doxygen may be emphasized.

CMA-419: SEMESTER VII

[TOPOLOGY]

Total Marks: 100(External -80, Internal-20)
Workload: 4Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: This course introduces the basic concepts Metric Spaces, Topological Spaces, Closed sets, Dense subsets.

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

ii) Appreciate the significance of Metric Space.

ii) Compute with the characteristic of Continous functions, Homomorphism, Topological Spaces.

Course Contents:

Unit-I **(Lectures:18)/26marks**

Metric Spaces, Topological Spaces, Closed Sets, Closure. Dense Subsets, Neighborhoods, Interior, Exterior and Boundary.Accumulation Points and Derived Sets.Bases and Subbases; Subspaces and Relative Topology.

Unit-II **(Lectures:18)/26marks**

Continuous Functions and Homomorphism (Metric Space/Topological Spaces continued). First and Second Countable Spaces.Lindelof's Theorem, Separable Spaces, Continuity and Separability, Separation Axioms: $T_0, T_1, T_2, T_3, T_{3\frac{1}{2}}, T_4, T_5, T_6$. Their Charac- terization and Basic Properties, Urysohn's Lemma; Tietze Extension Theorem.

Unit-III **(Lectures:20)/28marks**

Compactness, Continuous Functions and compact Sets.Basic Properties of Compactness and Finite Intersection Property; Sequentially and Countably Compact Sets; Local Compactness and One Point Compactification; Stone-Cech Compactification.Compactness in Metric Space; Equivalence of Compactness; Countable compactness and sequential Compactness in Metric Spaces.

Books Recommended:

1. James R Munkres; Topology, Pearson Education Asia,2002
2. Schaum's- Theory and problems of General topology

References:

1. James R Munkres; Topology, A first Course, Prentice hall of India Pvt. Ltd., New Delhi2000.
2. J Dugundji; Topology, Allyn and Bacon, 1966.
3. GF Simmons; Introduction to Topology and Modern Analysis, McGraw-Hill and Company, 1963.

Discipline Specific Elective (DSE-003) Course -1

DSE-003:(Semester-VII)

[Operations Research]

Total Marks: 100(External -80, Internal-20)
Workload: 4Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: This course develops the ideas underlying the Simplex Method for Linear Programming Problem, as an important branch of Operations Research. The course covers Linear Programming with applications and Non-Linear programming.

Course Learning Outcomes: This course will enable the students to learn:

iv) Solve linear programming models of real life situations.
v) The graphical solution of LPP with only two variables, and illustrate the concept of convex set and extreme points.

Course Contents:

Unit-I: (Lectures: 18)/26marks

Operations research and its scope, features of Operations research,Operations research Methodology, Structure of Mathematical model. Linear programming, Convex sets and their properties,Simplex method, Duality in linear programming and Sensitivity analysis.

Unit-II: (Lectures: 18)/26marks

Simplex Method: Optimal solution, Integer programming, Gomory'sall integer Cutting plane algorithm, Branch and Bound Technique, Applications of zero one integer programming, Dual Simplex method, Goal programming, Parametric linear programming.

Unit-III: (Lectures: 20)/28marks

Non-linear Programming, Convex function, Concave function, Pseudo convex function, Quasiconvex function, Quasiconcave function, Lagrangian method, Kuhn Tucker theory, Quadratic programming- Beale's method, Wolfe's method.

Books recommended:

1. KantiSwarup, P.k. Gupta and Man Mohan(2020), Operations research, Sultan chand& Sons, New Delhi

Referrences:

1. Hillier, Frederick S. & Lieberman, Gerald J. (2015). Introduction to Operations Research (10th ed.). McGraw-Hill Education (India) Pvt. Ltd.

2. Hadley, G. (1997). Linear Programming.Narosa Publishing House. New Delhi.

3. . Taha, Hamdy A. (2010). Operations Research: An Introduction (9th ed.). Pearson.

Discipline Specific Elective (DSE-004) Course - 4

EMA: 004(Semester-VII)

[Advanced Differential equation]

Total Marks: 100(External -80, Internal-20)
Workload: 4Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: The main objectives of this course are to introduce the students to the exciting world of Differential Equations, Mathematical Modeling and their applications.

Course Learning Outcomes: The course will enable the students to:

i) Formulate Differential Equations for various Mathematical models.

ii) Solve first order non-linear differential equation and linear differential equations of higher order using various techniques.

iii) Apply these techniques to solve and analyse various mathematical models.

Unit-I: **(Lectures-18)/26marks**

Initial value problem and the equivalent integral equation, Existence, Uniqueness and continuity of the solution of ordinary differential equation of first order, Picard's method of successive approximation, Lipschitz condition, Picard's theorem of Existence and uniqueness, Existence and uniqueness of the solution of system of differential equations of first order and ordinary differential equation of higher order with examples.

Unit-II: **(Lectures-18)/26marks**

Linear dependence and linear independence of solutions of linear differential equations, The Wronskian, Theorems on linearly independent solutions and linearly dependent set of functions, Homogeneous linear systems, non-homogeneous linear systems, linear systems with constant coefficient.

Unit-III: **(Lectures-20)/28marks**

Oscillation theory, Adjoint equation, Self-Adjoint linear homogeneous second order differential equation, Abel's formula, oscillatory and non-oscillatory functions, Sturm separation theorem, Sturm comparison theorem, Sturm Picone theorem, Condition under which solution of a differential equation in self adjoint form may be oscillatory or non-oscillatory, Sturm- Liouville systems, Orthogonal set of functions and Orthonormal set of functions, Eigen (or characteristic) values and Eigen (or characteristic) functions.

Books Recommended:

1. M.D. Raisinghania; Advanced differential equation, S.Chand and company ltd.
2. R.K. Gupta, J.N. Sharma; Advanced Differential Equations, Krishna PrakashanMedia(P) Ltd.
3. G.F. Simmons; Ordinary Differential Equations with applications and historical notes, McGraw hill.

References:

1. EA Coddington; An Introduction to Ordinary Differential Equation, Prentice Hall of India, Pvt., Ltd., New Delhi.
2. EL Ince; Ordinary Differential Equations, Dover Publishing Inc.

1. Discipline Specific Elective (DSE-5)

EMA-005: (Semester-VII)

[Differential Geometry and Tensor]

Total Marks: 100(External -80, Internal-20)
Workload:4Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: This course aims at introducing the concepts of Differential Geometry and Tensor.

Course Learning outcomes: After the course, the student will be able to understand the concepts of:

i) Differential Geometry and their properties.

ii) Tensor and its applications

Course Contents:

Unit-I:Differential equation of a geodesic (Lectures:20)/28marks

Geodesics, Differential equation of a geodesic, Single differential equation of a geodesic, Geodesic on a surface of revolution, Geodesic curvature and torsion, Gauss-Bonnet theorem, Gauss's formulae, Gauss's characteristic equation, Weingarten equations, Mainardi-Coddazi equations, Fundamental existence theorem for surfaces.

Unit-II: Tensor analysis **(Lectures: 18)/26marks**

Tensor analysis, Tensor and their transformation laws, Contraction, Quotient law, Reciprocal tensors, Kronecker delta, symmetric and skew-symmetric tensors, metric tensors, Riemann space, Christoffel symbols and their transformation laws,

Unit-III: Covariant differentiation **(Lectures: 18)/26marks**

Covariant differentiation of tensors, Ricci's theorem,Intrinsic derivative. Geodesic co-ordinates.

Riemann-Christoffel tensor and its properties, Covariant curvature tensor,

Books recommended:

1. **TJ Wilmore**, An Introduction to Differential Geometry, Dover Publication.
2. **CE Weatherburn**, An Introduction to Riemann Geometry & Tensor, Cambridge University Press.

References:

1. **Ruchard S Millman& George D Parker**, Elements of Differential Geometry, Pearson Publication.
2. **Brain F Doolin**, An Introduction to Differential Geometry for Engineers, Dover Pub. Inc.

CMA420: SEMESTER VIII

COMPLEX ANALYSIS-I

Total Marks: 100(External -80, Internal-20)
Workload: 4Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: This course introduces the basic concepts of ring of polynomials and irreducibility tests for polynomials over ring of integers, used in finite fields.

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

iii) Appreciate the significance of unique factorization in rings and integral domains.

ii) Compute with 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.

Course Contents:

Unit-I: **(Lecture-18)/26marks**

Limit, Continuity and Differentiabilityof *f*(z); Necessary and sufficient condition for $w = f(z)$ to be analytic. Construction of regular function, Polar form of Cauchy-Riemann equations. Complex Integration; Cauchy-Gaursat Theorem; Cauchy's Integral Formula; Poison's Integral Formula; Higher Order Derivatives; Morera's Theorem. Cauchy's Inequality and Liouville's Theorem; The Fundamental Theorem of Algebra.

Unit-II: **(Lecture-18)/26marks**

Definitions and Examples of Conformal Mappings; Necessary and Sufficient condition for $w = f(z)$ to be Conformal. Bilinear Transformations,Their Properties and Classification.

Unit-III: **(Lecture-20)/28marks**

Taylor's Theorem; Laurent's Series; Maximum Modulus Principle. Isolated Singularity; Zeros of Analytic Function, Meromorphic Function; Schwarz Lemma; The Argument Principle; Rouche's Theorem; Residues; Cauchy's Residue Theorem; Evaluation of Integrals.

Books recommended:

1. **HA Priestly**; Introduction to Complex Analysis, Clarendon Press, Oxford.

References:

1. **JB Conway**; Functions of One Complex Variable, Springer Verlag, International Student-Edition, Narosa Publishing House.
2. **Liang-Shin Hahn and Bernard Epstein**; Classical Complex Analysis, Jones and Bertlett Pub. International, London.

Discipline Specific Elective (DSE-6)

EMA-006: (Semester-VIII)

[Advanced Abstract Algebra]

Total Marks: 100(External -80, Internal-20)
Workload:4Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: The objective of the course is to introduce the fundamental theory of groups and its applications.

Course Learning Outcomes: The course will enable the students to:

iii) understand the mathematical concepts about the groups, and classify them as abelian, cyclic and permutation groups, etc;

iv) Explain the significance of the notion of subgroups, cyclic groups, cosets, normal subgroups, and factor groups.

Unit-IGroups: **(Lectures-18)/26marks**

Normal and Subnormal Series, Composition Series, Jordan-Holder Theorem, Solvable Groups, Nilpotent Groups.

Unit-IIField Theory: **(Lectures-20)/28marks**

Extension Fields, Algebraic and Transcendental Extensions, Separable and Inseparable Extensions; Normal Extensions.Perfect Fields; Finite Fields; Primitive Elements; Algebraically Closed Fields; Automorphisms of Extensions.

Unit-IIIGalois Theory: **(Lectures-18)/26marks**

Galois Extensions, Fundamental Theorem ofGalois Theory, Solution of Polynomial Equations by Radicals, Insolvability of the General Equation of Degree 5 by Radicals.

Books Recommended:

1. **PB Bhattacharya**, **SK Jain and SR Nagpaul**; Basic Abstract Algebra (2^{nd} Edition) Cambridge University Press.

References:

1. **M Artin**; Algebra, Prentice Hall of India, 1991.
2. **PM Cohn**; Algebra, Vols. I, II & III, John Wiley and Sons, 1982, 1989, 1991.
3. **N Jacobson**; Basic Algebra, Vols. I & II, W.H. Freeman 1980.

Discipline Specific Elective (DSE-7) Course - 4

EMA-007: (Semester-VIII)

[Advanced Real Analysis]

Total Marks: 100(External -80, Internal-20)
Workload:4Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: The course will develop a deep and rigorous understanding of real line and of defining terms to prove the results about convergence and divergence of sequences

and series of real numbers. These concepts have wide range of applications to the real-world problems.

Course Learning Outcomes: This course will enable the students to:

i) Understand many properties of the real line.
ii) Recognize bounded, convergent, divergent, Cauchy and monotonic sequences and to calculate their limit superior, limit inferior, and the limit of a bounded sequence.
iii) Apply the ratio test, root test, comparison tests for convergence and absolute convergence of an infinite series of real numbers.

The course will develop a deep and rigorous understanding of real line and of defining terms to prove the results about convergence and divergence of sequences and series of real numbers. These concepts have wide range of applications to the real-world problems.

Unit-I: (Lectures-18)/26marks

Definition and Existence of Riemann-Stieltjes Integral, Properties of the Integrals; Integration and Differentiation; Fundamental Theorem of Calculus; Integration of Vector Valued Functions; Rectifiable Curves.

Unit-II: (Lectures-20)/28marks

Rearrangement of Terms of a Series; Riemann's Theorem; Sequence and Series of Functions; Pointwise and Uniform Convergence, Cauchy's Criterion for Uniform Convergence; Weierstrass M-Test, Abel's Test and Diritchlet's Test for Uniform Convergence and Continuity, Uniform Convergence and Riemann-Stieltjes Integration; Uniform Convergence and Differentiation; Weierstrass Approximation Theorem.

Unit-III; (Lectures-18)/26marks

Functions of Several Variables, Linear Transformations; Derivativesinan Open Set R^n; Chain Rule, Partial Derivatives, Interchange of the Order of Differentiation, Derivatives of Higher Order, Taylor's Theorem, Inverse Function Theorem, Implicit Function Theorem, Jacobians; Extremum Problems with Constraints, Lagrange's Multiplier Method, Differentiation of Integrals.

Books Recommended:

1. **Walter Rudin**; Principles of Mathematical analysis (3rd Edition) Mc Graw-Hill, Kogakusha, 1976, International student Edition.

References:

1. **TM Apostol**; Mathematical analysis, Narosa Publishing House, New Delhi, 1985.
2. **AW White**; Real Analysis an Introduction, Addison-Wesley Publishing Co., Inc., 1968.

3. **G de Barra**; Measure Theory and Integration, Wiley Eastern Ltd., 1981.
4. **PK Jain and VP Gupta**; Lebesgue Measure and Integration, New Age International Pvt. Ltd., New Delhi, 2000.

Discipline Specific Elective (DSE-8) Course - 4

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

EMA-008A: **Biomathematics**

EMA-008B: Spherical Trigonometry and Astronomy

EMA-008C: **Cryptography and Network Security**

EMA-008D: **Logistics and Supply Chain Management**

Discipline Specific Elective (DSE-8) Course - 8

EMA-008A: (Semester-VIII)

[Biomathematics]

Total Marks: 100(External -80, Internal-20)
Workload:4Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: The focus of the course is on scientific study of normal functions in living systems.

Course learning outcomes: The course will enable the students to understand

i) Analysis and interpretation of bio mathematical models.

ii) Develop the skills in mathematical modelling.

Course Contents:

Unit-I: Modelling Biological Phenomenon (Lectures: 11)/17marks

Population growth, Administration of drugs, Cell division, Systems of linear ordinary differential equations, Heartbeat, Nerve impulse transmission, Chemical reactions, Predatorprey models.

Unit-II: Mathematics of Heart Physiology and Nerve Impulse Transmission
(Lectures: 25)/35marks

Stability and oscillations: Epidemics, The phase plane and the Jacobian matrix, Local stability, Stability, Limit cycles, Forced oscillations; Mathematics of Heart Physiology: The local model, The Threshold effect, The phase plane analysis and the heartbeat

model, A model of the cardiac pacemaker; Mathematics of Nerve Impulse Transmission: Excitability and repetitive firing, Travelling waves.
Bifurcation, Bifurcation of a limit cycle, Discrete bifurcation and period-doubling, Chaos, Stability of limit cycles, The Poincaré plane.

Unit-IV: Modeling Molecular Evolution and Genetics (Lectures: 20)/28marks

Modelling Molecular Evolution: Matrix models of base substitutions for DNA sequences, The Jukes-Cantor model, The Kimura models, Phylogenetic distances; Constructing Phylogenetic Trees: Phylogenetic trees, Unweighted pair-group method with arithmetic means (UPGMA), Neighbour joining method; Genetics: Mendelian genetics, Probability distributions in genetics.

Books recommended:

1. Allman, Elizabeth S., & Rhodes, John A. (2004). Mathematical Models in Biology: An Introduction. Cambridge University Press.
2. Jones, D. S., Plank, M. J., &Sleeman, B. D. (2009). Differential Equations and Mathematical Biology (2nd ed.). CRC Press, Taylor & Francis Group, LLC.

Referrences:

1. Murray, J. D. (2002). An Introduction to Mathematical Biology (3rd ed.). Springer.
2. Myint-U, Tyn (1977). Ordinary Differential Equations. Elsevier North-Holland, Inc.
3. Simmons, George F., &Krantz, Steven G. (2015). Differential Equations. McGrawHill Education. Indian Reprint.

EMA-008B : (Semester-VIII)

[Spherical Trigonometry and Astronomy]

Total Marks: 100(External -80, Internal-20)
Workload:4Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: This course helps the students to develop skills and knowledge of standard concepts in Spherical Trigonometry and demonstrates how Spherical Trigonometry plays an important role in the present Celestial Sphere.

Course Learning Outcomes: After the course, the student will be able to:

i) Understand the fundamentals of Spherical triangle, Polar triangle, properties of Polar and Spherical triangle.

ii) Understand three systems of celestial co-ordinates, Rectangular co-ordinates, Sidereal time

Course Contents:

Unit-1: Spherical Trigonometry **(Lectures-18)/26marks**

Spherical triangle, Polar triangle, properties of Polar and Spherical triangle, Sine formula, Cosine formula, Four parts formula, Sine Cosine formula, Cotangent formula, Napier's analogies, DeAambre's analogies, Right angled spherical triangle. Formulas relating to the right spherical triangle. Area of a spherical triangle, Area of an spherical polygon.

Unit-II: Celestial sphere **(Lectures-18)/26marks**

Three systems of celestial co-ordinates, Rectangular co-ordinates, Sidereal time, Rising and setting of stars, Circumpolar stars, Rate of change of zenith distance and azimuth, Twilight, Motion of the Sun, Vernal and Autumnal Equinox, Summer and Winter Solstice, Different kinds of time seasons.

Unit-III: Refraction, Precession and Nutation: **(Lectures-20)/28marks**

Laws of refraction, Cassini's hypothesis, Simpson's hypothesis, Bradely's formula, Effect of refraction on (1) sunrise and sunset (2) the right ascension and declination of a star (3) in the distance between two neighbouring stars (4) on the shape of the disc of the sun. Precession on the right ascension and declination of a star, Nutation in the right ascension and declination of a star, Precession and nutation both on the right ascension declination of a star. Kepler's laws, Deduction of Kepler's laws from Newton's laws of Gravitation.

Books Recommended:

1. M.Ray- Spherical Trigonometry
2. M.Ray- Spherical Astronomy
3 K.K.De- Text Book of Astronomy, Book Syndicate Pvt. Kolkata

References:

1. W.M.Smart: Text Book of Spherical Astronomy, CUP-VIKAS student's Edition
2. W.M. Smart: Foundation of Astronomy, CUP-VIKAS student's Edition
3. Gorakh Prasad: Text Book on Spherical Astronomy, Pothisala's Edition

EMA-008C: (Semester-VIII)

[Cryptography and Network Security]

Total Marks: 100(External -80, Practical-20)
Workload:4Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: This course helps the students to develop skills and knowledge of standard concepts in cryptography and demonstrates how cryptography plays an important role in the present digital world by knowing encryption and decryption techniques and secure data in transit across data networks.

Course Learning Outcomes: After the course, the student will be able to:

ii) Understand the fundamentals of Cryptography,Public-key Cryptography and Network Security.

ii) Encrypt and decrypt messages using block ciphers

Course Contents:

Unit -I: Cryptography and Data Encryption Standard (DES)

(Lectures: 20)/28marks

Overview of Cryptography, Computer security concepts, Security attacks, Symmetric cipher model, Cryptanalysis and brute-force attack, Substitution techniques, Caesar cipher, Monoalphabetic ciphers, Playfair cipher, Hill cipher, Polyalphabetic ciphers, One-time pad, Transposition techniques, Binary and ASCII, Pseudo-random bit generation, Stream ciphers and Block ciphers, The Feistal cipher, The data encryption standard (DES), DES example.

Unit -II: Algorithms and Advanced Encryption Standard (AES)

(Lectures: 20)/28marks

Review of basic concepts in Number theory and Finite Fields: Divisibility, Polynomial and modular arithmetic, Fermat's and Euler's theorems, The Chinese remainder theorem, Discrete logarithm., Finite fields of the form GF(p) and GF(2n). Advanced encryption standard (AES), AES transformation functions, AES key expansion, AES example.

Unit -III: Public-key Cryptography (Lectures: 15)/22marks

Principles of public-key cryptosystems, The RSA algorithm and security of RSA, Elliptic curve arithmetic, Elliptic curve cryptography, Cryptographic Hash functions, Secure Hash algorithm.

Unit--IV: Digital Signatures and Network Security (Lectures: 15)/22marks

Digital signatures, Elgamal and Schnorr digital signature schemes, Digital signature algorithm.Wireless network and mobile device security, Email architecture, formats, threats and security, Secure/Multipurpose Internet Mail Extension (S/MIME) and Pretty Good Privacy (PGP).

Books recommended:

1. Stallings, William (2017). Cryptography and Network Security, Principles and Practice (7th ed.). Pearson Education Limited. England.
2. Trappe, Wade & Washington, Lawrence C. (2006). Introduction to Cryptography with Coding Theory (2nd ed.). Pearson Education International.

Referrence:

1. Stinson, Douglas R. (2005). Cryptography Theory and Practice (3rd ed.). CRC Press.
2. Hans Delfs and Helmut Knebl: Introduction to cryptography, (Principles & Applications), Springer verlag, revised 3rd Edition, 2002.
3. David M Burton : Elementary Number Theory, Tata McGraw Hill Educational Pvt. Ltd., New Delhi, Sevent Reprint, 2009.

EMA-008D: (Semester-VIII)

[Logistics and Supply Chain Management]

Total Marks: 100(External -80, Internal-20)
Workload:4Lectures (per week) ,Credits: 4 Duration: 14 Weeks (56 Hrs.)
Examination: 3 Hrs.

Course Objectives: In **Supply Chain Management**there are challenging open problems which are comprehensible at undergraduate level, this course is intended to build a micro aptitude of understanding aesthetic aspect of mathematical instructions and gear young minds to ponder upon such problems.

Course Learning Outcomes: This course will enable the students to learn:

i) Some of the open problems related to importance, value chain, components of supply chain
ii) About Control of Inventory
iii)Distribution Resource Planning (DRP)

Contents:

Unit-1: **(Lectures-16)/24marks**

Supply Chain management: Introduction and development, objectives and needs, importance, value chain, components of supply chain, participants in supply chain and customer focus, global applications.

Unit-2 **(Lectures-20)/28marks**

Logistics: Origin and Definition, Logistics Management, types of logistics,
Transportation- role of transportation in logistics, Application of IT in logistics. Warehousing – nature and importance, warehousing functions, layout and design of warehouse, role of packaging.

Unit-3 **(Lectures-20)/20marks**

Inventory: Control of Inventory, Distribution Resource Planning (DRP), Material Requirement Planning (MRP-I), Manufacturing Resource Planning (MRP-II). Supply chain performance drivers, Key enablers in supply chain improvement, Outsourcing and 3PLs, Fourth party logistics, Coordination and Lack of Supply chain management and Bullwhip effect in supply chain, Benchmarking.

Books recommended:. S. Chopra and P. Meindl: Supply Chain Management, Upper Saddle River, N.J.: Pearson Prentice Hall, 2007.

References /Suggested Readings:

1. D. Simchi-Levi: Designing and Managing the Supply Chain. McGraw-Hill Companies, 2005.
2. V. V. Sople: Supply Chain Management: Text and Cases. Pearson Education India, 2011.
3. A. R..Ravindran, and D.P. Warsing Jr.: Supply Chain Engineering: Models and Applications. CRC Press, 2012.
4. A. Rushton, P. Croucher, and P. Baker: The handbook of logistics and distribution management: Understanding the supply chain. Kogan Page Publishers, 2014.