SYLLABUS FOR UNDERGRADUATE PROGRAMME IN MATHEMAYICS

(Bachelor of Science and Arts (B.Sc. & B.A.) Examination)

UNDER
CHOICE BASED CREDIT SYSTEM (CBCS)

with
Learning Based Outcomes
(2019-2020)

School of Mathematics
Gangadhar Meher University
Sambalpur-768004

VISION

To take the leadership in setting the standard of Mathematics Education in terms of Teaching and Research in the State and in the Country that will have a transformative impact on society through continual innovation in education, research and creativity.

MISSION

M-1-To excel in providing high quality Mathematical skills to undergraduate

M-2-To attend the mathematical needs of the institute and the community.

M-3-To provide students (UG/PG) with a wide spectrum of valuable courses with rigorous training/tutorials that enables them to pursue their future.

M-4-To encourage both research scholars and faculty members of the department to be the exposures of different research environments in India and abroad

PROGRAMME OUTCOMES

The programme outcomes and attributes are attained by the graduate students of Gangadhar Meher University through learning acquired on completion of a programme of study. Individual programmes of study has a defined programme specific learning outcomes which needs to be attained for the award of a specific degree. The programme learning outcomes of Gangadhar Meher University focus on various aspects of knowledge and skills that prepare students for further study, employment, and citizenship. Therefore, the UG programme of the Gangadhar Meher University has been designed with the objective to develop in-depth knowledge of students in frontier areas of concerned subject and seeks to achieve the following:

PO-1: Disciplinary Knowledge: Undergraduate students will demonstrate knowledge and understanding of one or more discipline knowledge**.**

PO-2: Critical Thinking: Apply their analytical thoughts to evaluate evidences, claims, theories and arguments of the discipline; formulate coherent arguments, evaluate practices and policies in the academic field

PO-3: Problem solving: Solve the non-familiar problems based upon his/her knowledge and understanding about the discipline knowledge, including real life problems

PO-4: Communication skills: Ability to express thoughts and ideas effectively verbally and written. Develops the capacity to listen patiently, express himself or herself.

PO-5: Research Related Skills: A sense of Enquiry, and capacity for asking relevant/appropriate questions. Ability to recognize cause-effect relationship, define problem, formulate hypothesis, analyze, interpret and draw conclusions; generate and test hypothesis; conduct experiment and draw conclusion from findings scientifically.

PO-6: Co-Operative/Team Work: Ability to work effectively and respectfully with diverse team;facilitate or co-ordinate efforts within group activities; work together within a team

PO-7: Multicultural competencies: Possess knowledge of the values and beliefs of multiple culture anda global perspective; capacity to work effectively in multiple socio-cultural contexts and interact respectfully with diverse social groups

PO-8: Digital Literacy: Capacity to use ICT in a variety of learning situations; demonstrate ability to access, evaluate and use variety of relevant information sources; use appropriate software for data analysis

PROGRAMME OBJECTIVES

(Set by School of Mathematics)

- Create deep interest in learning mathematics;
- To develop broad and balanced knowledge, and understanding of definitions, concepts, principles and theorems;
- To familiarize the students with suitable tools of mathematical analysis to handle issues and problems in mathematics and related sciences;
- To enhance the ability of learners to apply the knowledge and skills acquired by them during the programme to solve specific theoretical and applied problems in mathematics;
- To provide students sufficient knowledge and skills enabling them to undertake further studies in mathematics and its allied areas on multiple disciplines concerned with mathematics;
- To encourage the students to develop a range of generic skills helpful in employment, internships and social activities.

PROGRAMME SPECIFIC OUTCOMES

(Set by School of Mathematics)

PSO-1: A student should be able to recall basic facts about mathematics and should be able to display knowledge of conventions such as notations, terminology.

PSO-2: A student should get adequate exposure to global and local concerns that explore them many aspects of mathematical sciences.

PSO-3: Student is equipped with mathematical modeling ability, problem solving skills, creative talent and power of communication necessary for various kinds of employment.

PSO-4: Student should be able to apply their skills and knowledge that is translate information presented verbally into mathematical form, select and use appropriate mathematical formulae or techniques in order to process the information and draw the relevant conclusion.

PSO-5: Enabling students to develop a positive attitude towards mathematics as an interesting and valuable subject of study.

MATCHING

Matching Percentage	Level Indicator
> 70%	3
= 60 %	2
< 50%	1

MISSION TO PO MAPPING

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
M1	3	3	3	3	3	3	3	3
M2	3	2	3	3	3	2	2	3
M3	3	2	2	3	2	2	3	2
M4	1	2	1	3	1	1	1	2

PSO TO PO MAPPING

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
PSO1	3	3	2	3	3	3	3	2
PSO2	1	3	3	2	3	3	2	3
PSO3	3	2	2	2	2	3	3	3
PSO4	1	2	3	3	3	2	1	3
PSO5	2	3	3	2	3	2	2	2

A Brief Overview of Syllabus

Semester	Course	Course Name	Credits	Marks	Total Marks
I	AECC-I	AECC-I	04		100
	C-I(Theory)	Calculus	04	75	100
	C-I(Practical)		02	25	
	C-II(Theory)	Discrete Mathematics	05	75	100
	C-II(Practical)		01	25	
	GE-I(Theory)	Calculus and Differential Equations	05	75	100
	GE-I(Practical)		01	25	
		Total	22		400
II	AECC-II	AECC-II	04		100
	C-III(Theory)	Real Analysis	05	75	100
	C-III(Practical)		01	25	
	C-IV (Theory)	Differential Equations	04	75	100
	C-IV(Practical)		02	25	
	GE-II (Theory)	Algebra	05	75	100
	GE-II(Practical)		01	25	
		Total	22		400
III	C-V(Theory)	Theory of Real Functions	05	75	100
	C-V(Practical)		01	25	
	C-VI(Theory)	Group Theory-I	05	75	100
	C-VI(Practical)		01	25	
	C-VII(Theory)	Partial Differential Equations And System of ODEs	04	75	100
	C-VII(Practical)		02	25	
	GE-III(Theory)	Real Analysis	05	75	100
	GE-III(Practical)		01	25	
	SECC-I*	SECC-I	04	100	100
		Total	28		500
IV	C-VIII(Theory)	Numerical Methods and Scientific Computing	04	75	100
	C-VIII(Practical)		02	25	
	C-IX(Theory)	Topology of Metric Spaces	05	75	100
	C-IX(Practical)		01	25	
	C-X(Theory)	Ring Theory	05	75	100
	C-X(Practical)		01	25	
	GE-IV(Theory)	Numerical Methods	05	75	100
	GE-IV(Practical)		01	25	
	SECC-II*	SECC-II	04	100	100
		Total	28		500
V	C-XI(Theory)	Multivariable Calculus	05	75	100
	C-XI(Practical)		01	25	
	C-XII(Theory)	Linear Algebra	05	75	100
	C-XII(Practical)		01	25	
	DSE-I(Theory)	Linear Programming	05	75	100
	DSE-I(Practical)		01	25	

	DSE-II (Theory)	Probability and Statistics	05	75	100
	DSE-II(Practical)		01	25	
		Total	24		400
VI	C-XIII(Theory)	Complex Analysis	05	75	100
	C-XIII(Practical)		01	25	
	C-XIV(Theory)	Group Theory-II	05	75	100
	C-XIV(Practical)		01	25	
	DSE-III(Theory)	Differential Geometry	05	75	100
	DSE-III(Practical)		01	25	
	DSE-IV	Number Theory/Project	06	100	100
		Total	24		400
		Grand Total	148		2600

*** SECC papers may be offered by University**

1. Modern Office Management
2. Leadership and Personality Development
3. Financial Literacy and Banking
4. Data Analysis and Computer Application

Red-Employability **Green- Entrepreneurship** **Blue-Skill Development**

SEMESTER-I

CORE PAPER-1(CC-1)
CALCULUS
(Credits-4) Full Marks-75 (Mid Term-15+ End Term-60)

Course Objectives:

1.To equip the student with necessary analytic and technical skills to handle problems of mathematical nature as well as practical problems
2.To explore the different tools for higher order derivatives
3.To plot the various curves
4.To solve the problems associated with differentiation and integration of vector functions.

SYLLABUS:

UNIT-I: (12 Hours)

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

UNIT-II: (12 Hours)

Riemann integration as a limit of sum, integration by parts, Reduction formulae, derivations and illustrations of reduction formulae of the type $\int \sin^n x\,dx$, $\int \cos^n x\,dx$, $\int \tan^n x\,dx$, $\int \sec^n x\,dx$, $\int (\log x)^n dx$, $\int \sin^n x \cos^n x\,dx$, definite integral, integration by substitution.

UNIT-III: (12 Hours)

Volumes by slicing, disks and washers' methods, volumes by cylindrical shells, parametric equations, parameterizing a curve, arc length, arc length of parametric curves, area of surface of revolution, techniques of sketching conics, reflection properties of conics, rotation of axes and second-degree equations, classification into conics using the discriminant, polar equations of conics.

UNIT-IV: (12 Hours)

Triple product, introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions, tangent and normal components of acceleration.

LIST OF PRACTICALS

(To be performed using Computer with aid of MATLAB or such software)

1. Plotting the graphs of the functions e^{as+b}, $\log(ax+b)$, $1/(ax+b)$, $\sin(ax+b)$, $\cos(ax+b)$ and $|ax+b|$ to illustrate the effect of a and b on the graph.
2. Plotting the graphs of the polynomial of degree 4and5.
3. Sketching parametric curves (e.g. Trochoid, cycloid, hypocycloid).
4. Obtaining surface of revolution of curves.
5. Tracing of conics in Cartesian coordinates/polar coordinates.
6. Sketching ellipsoid, hyperboloid of one and two sheets (using Cartesian co-ordinates).

Books Recommended:

1. H. Anton, I. Bivens and S. Davis, *Calculus*, 10th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore,2002.
2. Shanti Narayan, P. K. Mittal, *Differential Calculus*, S. Chand,2014.
3. Shanti Narayan, P. K. Mittal, *Integral Calculus*, S. Chand,2014.

Books For Reference:

1. James Stewart, *Single Variable Calculus*, Early Transcendentals, Cengage Learning,2016.
2. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.

Course Outcomes:

CO1. Students are expected to be able to use Leibnitz's rule to evaluate derivatives of higher order,
CO2. Students will be able to study the geometry of various types of functions, evaluate the area,volume using the techniques of integrations
CO3. Students will be able to identify the difference between scalar and vector
CO4. Students acquired knowledge on some the basic properties of vector functions.

CO-PO Mapping (CC-1)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	3	2	1	1	2	1	1	2
CO2	3	1	3	2	2	1	2	3
CO3	2	3	3	3	2	2	3	2
CO4	2	2	3	2	3	2	2	3

Programme articulation Matrix row for CC-1

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course CC-1	3	2	3	2	3	2	3	2

CO-PSO Mapping (CC-1)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	3	3	3	3	3
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	2	3	3	2	3

CORE PAPER-1I (CC-1I)
DISCRETE MATHEMATICS
(Credits-4) Full Marks-75 (Mid Term-15+End Term-60)

Course Objectives:
1.To acquaint students with basic counting principles.
2.To acquaint students with set theory and logic.
3.To acquaint students with basic matrix theory.
4.To acquaint students with basic graph theory.

SYLLABUS:

UNIT-I: **(12 Hours)**
Sets, relations, Equivalence relations, partial ordering, well ordering, axiom of choice, Zorn's lemma, Functions, cardinals and ordinals, countable and uncountable sets, statements, compound statements, proofs in Mathematics, Truth tables, Algebra of propositions, logical arguments, Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm, Congruence relation between integers, modular arithmetic, Chinese remainder theorem, Fermat's little theorem.

UNIT-II: **(12 Hours)**
Principles of Mathematical Induction, pigeonhole principle, principle of inclusion and exclusion Fundamental Theorem of Arithmetic, permutation combination circular permutations binomial and multinomial theorem, Recurrence relations, generating functions, generating function from recurrence relations.

UNIT-III: **(12 Hours)**
Matrices, algebra of matrices, determinants, fundamental properties, minors and cofactors, product of determinant, adjoint and inverse of a matrix, Rank and nullity of a matrix, Systems of linear equations, row reduction and echelon forms, solution sets of linear systems, applications of linear systems, Eigen values, Eigen vectors of a matrix.

UNIT-IV: **(12 Hours)**
Graph terminology, types of graphs, subgraphs, isomorphic graphs, Adjacency and incidence matrices, Paths, Cycles and connectivity, Eulerian and Hamiltonian paths, Planar graphs.

Books Recommended:

1.Edgar G. Goodaire and Michael M. Parmenter, *Discrete Mathematics with Graph Theory*, 3rdEd., Pearson Education (Singapore) P. Ltd., Indian Reprint,2005.
2.Kenneth Rosen, *Discrete mathematics and its applications*, Mc Graw Hill Education 7thedition., 2011
3.V Krishna Murthy, V. P. Mainra, J. L. Arora, *An Introduction to Linear Algebra*,Affiliated East-West Press Pvt. Ltd.

Books For Reference:

J. L. Mott, A. Kendel and T.P. Baker: *Discrete mathematics for Computer Scientist and Mathematicians*, Prentice Hall of India Pvt Ltd, 2008.

Course Outcomes:
CO1.The acquired knowledge will help students in simple mathematical modeling
CO2.They can study advance courses in mathematical modeling
CO3. Students can develop skill and knowledge on computer science, statistics
CO4. Students can acquire knowledge on physics, chemistry etc.

CO-PO Mapping (CC-1I)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	3	2	1	1	2	1	1	2
CO2	3	1	3	2	2	1	2	2
CO3	2	3	3	3	2	2	3	3
CO4	2	2	3	2	3	2	2	3

Programme articulation Matrix row for CC-1I

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course CC-1I	3	2	3	2	3	2	3	3

CO-PSO Mapping (CC-1I)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	3	3	3	3	3
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	2	3	3	2	3

SEMESTER-II

CORE PAPER-III (CC-III)
REAL ANALYSIS
(Credits-4) Full Marks-75 (Mid Term-15+End Term-60)

Course Objectives:

1.To have the knowledge on basic properties of the field of real numbers, studying Bolzano-Weierstrass Theorem
2 To know about sequences and convergence of sequences
3.To know on series of real numbers and its convergence etc
4.To know application of sequence and series

SYLLABUS:

UNIT-I: **(12 Hours)**

Review of Algebraic and Order Properties of *R*, ε-neighborhood of a point in *R*, Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets, Suprema and Infima, The Completeness Property of *R*, The Archimedean Property, Density of Rational (and Irrational) numbers in *R*., Intervals, Interior point, Open Sets, Closed sets, , Limit points of a set, Illustrations of Bolzano-Weierstrass theorem for sets, closure, interior and boundary of a set.

UNIT-II: **(12 Hours)**

Sequences and Subsequences, Bounded sequence, Convergent sequence, Limit of a sequence. Limit Theorems, Monotone Sequences, Divergence Criteria, Bolzano Weierstrass Theorem for Sequences, Cauchy sequence, Cauchy's Convergence Criterion. Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy's nth root test, Integral test, Alternating series, Leibniz test, Absolute and Conditional convergence.

UNIT-III: **(12 Hours)**

Limits of functions (epsilon-delta approach), sequential criterion for limits, divergence criteria. Limit theorems, one sided limits, Infinite limits and limits at infinity, Continuous functions, sequential criterion for continuity &discontinuity. Algebra of continuous functions, Continuous functions on an interval, Boundedness Theorem, Maximum Minimum Theorem, Bolzano's Intermediate value theorem, location of roots theorem, preservation of intervals theorem. Uniform continuity, non-uniform continuity criteria, uniform continuity theorem, Monotone and Inverse Functions.

UNIT-IV: **(12 Hours)**

Differentiability of a function at a point & in an interval, Caratheodory's theorem, chain Rule, algebra of differentiable functions, Mean value theorem, interior extremum theorem. Rolle's theorem, intermediate value property of derivatives, Darboux's theorem. Applications of mean value theorem to inequalities.

Books Recommended:

1.R.G. Bartle and D. R. Sherbert, *Introduction to Real Analysis* (3rd. Edition), John Wileyand Sons (Asia) Pvt. Ltd., Singapore,2002.
2.G. Das and S. Pattanayak, *Fundamentals of Mathematical Analysis*, TMH Publishing Co.

Books for Reference:

1. S.C. Mallik and S. Arora, *Mathematical Analysis*, New Age International Publications.
2. A. Kumar, S. Kumaresan, *A basic course in Real Analysis*, CRC Press,2014.
3. Brians *Thomson*, Andrew. M. *Bruckner*, and Judith B. Bruckner, *Elementary Real Analysis*, Prentice Hall, 2001
4. Gerald G. Bilodeau,Paul R. Thie, G.E. Keough, *An Introduction to Analysis*, Jones &Bartlett, 2nd Edition,2010.

Course Outcomes:

CO1. Students will be able to handle fundamental properties of the real numbers that lead to theformal development of real analysis.

CO2. Understand limits and their use in sequences, series, differentiation and integration.

CO3. Students will appreciate how abstract ideas.

CO4. Students will be able to handle rigorous methods in mathematical analysis can be appliedto important practical problems.

CO-PO Mapping (CC-1II)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	3	2	1	1	2	1	1	2
CO2	3	1	3	2	2	1	2	2
CO3	2	3	3	3	2	2	3	3
CO4	2	2	3	2	3	2	2	3

Programme articulation Matrix row for CC-1II

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course CC-1II	3	2	3	2	3	2	3	3

CO-PSO Mapping (CC-1II)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	3	3	3	3	3
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	2	3	3	2	3

CORE PAPER-IV(CC-IV)
DIFFERENTIAL EQUATIONS
(Credits-4) Full Marks-75 (Mid Term-15+End Term-60)

Course Objective:

1.To familiarize the students with various methods of solving differential equations.
2.To have a qualitative application through models.
3.To solve problems to understand the methods.
4.To solve practical problems employing various methods.

SYLLABUS:

UNIT-I: **(10 Hours)**

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

UNIT-II: **(13 Hours)**

Introduction to compartmental models, Exponential decay radioactivity (case study of detecting art forgeries), lake pollution model (with case study of Lake Burley Griffin), drug assimilation into the blood (case study of dull, dizzy and dead), exponential growth of population, Density dependent growth, Limited growth with harvesting.

UNIT-III: **(13 Hours)**

General solution of homogeneous equation of second order, principle of superposition, Wronskian, its properties and applications, method of undetermined coefficients, Method of variation of parameters, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation.

UNIT-IV: **(12 Hours)**

Equilibrium points, Interpretation of the phase plane, predatory-pray model and its analysis, epidemic model of influenza and its analysis, battle model and its analysis.

Practical / Lab work to be performed on a computer:

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

1.Plotting of second & third order solution family of differential equations.
2.Growth & Decay model (exponential case only).
3.(a) Lake pollution model (with constant/seasonal flow and pollution concentration)/
(b) Case of single cold pill and a course of cold pills.
(c) Limited growth of population (with and without harvesting).
4.(a) Predatory-prey model (basic Volterra model, with density dependence, effect of DDT,two prey one predator).
(b) Epidemic model of influenza (basic epidemic model, contagious for life, disease withcarriers).
Battle model (basic battle model, jungle warfare, long range weapons).
5.Plotting of recursive sequences.

Books Recommended:

1.J. Sinha Roy and S Padhy, A Course of Ordinary and Partial Differential Equation,Kalyani Publishers, New Delhi.
2.Belinda Barnes and Glenn R. Fulford, *Mathematical Modeling with Case Studies, A Differential Equation Approaching Maple and Matlab*, 2nd Edition., Taylor and Francis group, London and NewYork,2009.

Books For Reference:

1. Simmons G F, *Differential Equation*, Tata Mc Graw Hill,1991.
2. Martin Braun, *Differential Equations and their Applications*, Springer International, Student Ed.
3. S. L. Ross, *Differential Equations*, 3rd Edition, John Wiley and Sons, India.
4. C.Y. Lin, Theory and Examples of Ordinary Differential Equations, WorldvScientific,2011.

Course Outcomes:

CO1.A student completing the course is able to solve differential equations

CO2. Students can able to model problems in nature using Ordinary Differential Equations

CO3. This course is prerequisite for studying the course in Partial Differential Equations

CO4. This is also models dealing with Partial Differential Equations.

CO-PO Mapping (CC-1V)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	3	2	1	1	2	1	1	2
CO2	3	1	3	2	2	1	2	3
CO3	2	3	3	3	2	2	3	1
CO4	2	2	3	2	3	2	2	2

Programme articulation Matrix row for CC-1V

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course CC-1V	3	2	3	2	3	2	2	3

CO-PSO Mapping (CC-1V)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	3	3	3	3	3
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	2	3	3	2	3

SEMESTER-III

CORE PAPER-V (CC-V)

THEORY OF REAL FUNCTIONS

(Credits-4) Full Marks-75 (Mid Term-15+End Term-60)

Course Objectives:

1.To have knowledge on limit theorems on functions, limits of functions, continuity of functionsand its properties

2.To have knowledge on uniform continuity, differentiability of functions, algebra of functionsand Taylor's theorem and, its applications

3.The student how to deal with real functions and understands uniform continuity, mean value theorems also

4. Students will able to understand integration method of real valued functions

SYLLABUS:

UNIT-I: **(12 Hours)**

L' Hospital's Rules, other Intermediate forms, Cauchy's mean value theorem, Taylor's theorem with Lagrange's form of remainder, Taylor's theorem with Cauchy's form of remainder, application of Taylor's theorem to convex functions, Relative extrema, Taylor's series and Maclaurin's series, expansions of exponential and trigonometric functions.

UNIT-II: **(12 Hours)**

Riemann integration; inequalities of upper and lower sums; Riemann conditions of integrability. Riemann sum and definition of Riemann integral through Riemann sums; equivalence of two definitions; Riemann integrability of monotone and continuous functions; Properties of the Riemann integral; definition and integrability of piecewise continuous and monotone functions. Intermediate Value theorem for Integrals; Fundamental theorems of Calculus.

UNIT-III: **(12 Hours)**

Improper integrals: Convergence of Beta and Gamma functions. Pointwise and uniform convergence of sequence of functions, uniform convergence, Theorems on continuity, derivability and integrability of the limit function of a sequence of functions**.**

UNIT-IV: **(12 Hours)**

Series of functions; Theorems on the continuity and derivability of the sum function of a seriesof functions; Cauchy criterion for uniform convergence and Weierstrass M-Test Limit superior and Limit inferior, Power series, radius of convergence, Cauchy Hadamard Theorem, Differentiation and integration of power series; Abel's Theorem; Weierstrass Approximation Theorem.

Books Recommended:

1. R.G. Bartle & D. R. Sherbert, *Introduction to Real Analysis*, 3rd Edition, JohnWiley&Sons.,2000
2. G. Das and S. Pattanayak, *Fundamentals of Mathematics Analysis*, Tata McGraw HillPublishing., 1987.
3. S. C. Mallik and S. Arora, *Mathematical Analysis*, 2nd Edition, New Age International Ltd.,New Delhi, 1992.

Book For References:

1. A. Kumar, S. Kumaresan, *A Basic Course in Real Analysis*, CRC Press,2014
2. K. A. Ross, *Elementary Analysis: The Theory of Calculus*, *Undergraduate Texts in Mathematics*, Springer (SIE), Indian Reprint, 2004A.Mattuck, Introduction to Analysis, Prentice Hall
3. Charles G. Denlinger, *Elements of Real Analysis*, Jones and Bartlett (Student Edition), 2011.

Course Outcome:

CO1.Students will have working knowledge on the concepts and theorems of the elementarycalculus of functions of one real variable

CO2. They will work out problems involving derivatives of function and their applications.

CO3.They can use derivatives to analyze and sketch the graph of a function of one variable; canalso obtain absolute value and relative extrema of functions.

CO4.This knowledge is basic and students can take all other analysis courses after learning thiscourse

CO-PO Mapping (CC-V)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	3	2	1	1	2	1	1	2
CO2	3	1	3	2	2	1	2	3
CO3	2	3	3	3	2	2	3	3
CO4	2	2	3	2	3	2	2	3

Programme articulation Matrix row for CC-V

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course CC-V	3	2	3	2	3	2	3	2

CO-PSO Mapping (CC-V)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	3	3	3	3	3
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	2	3	3	2	3

CORE PAPER-VI(CC-VI)
GROUP THEORY-I
(Credits-4) Full Marks-75 (Mid Term-15+End Term-60)

Course Objectives:

1.To introduce students to basic concepts of group theory and examples
2.To introduce the properties of groups
3.This course will lead to future basic courses in advanced mathematics
4.This course will lead to future basic courses in ring theory, module theory, algebraic topologyetc.

SYLLABUS:

UNIT-I: **(12 Hours)**

Symmetries of a square, Dihedral groups, definition and examples of groups including permutation groups and quaternion groups (illustration through matrices), elementary properties of groups, Subgroups and examples of subgroups, centralizer, normalizer, center of a group,

UNIT-II: **(12 Hours)**

Product of two subgroups, Properties of cyclic groups, classification of subgroups of cyclic groups, Cycle notation for permutations, properties of permutations, even and odd permutations, alternating group,

UNIT-III: **(12 Hours)**

Properties of cosets, Lagrange's theorem and consequences including Fermat's Little Theorem, external direct product of a finite number of groups, normal subgroups, factor groups.

UNIT-IV: **(12 Hours)**

Cauchy's theorem for finite abelian groups, group homomorphisms, properties of homomorphisms,Cayley's theorem, properties of isomorphisms, first, second and third isomorphism theorems.

Books Recommended:

1. Joseph A. Gallian, *Contemporary Abstract Algebra* (4thEdition), Narosa Publishing House,New Delhi, 2008.
2. John B. Fraleigh, *A First Course in Abstract Algebra,* 7th Edition., Pearson,2002.

Book For References:

1.M. Artin, *Abstract Algebra,* 2ndEdition. Pearson,2011.
2. Joseph 1. Rotman, *An Introduction to the Theory of Groups,* 4th Edition., Springer Verlag,1995.
3. I. N. Herstein, *Topics in Algebra,* Wiley Eastern Limited, India,1975.

Course Outcomes:

CO1. A student learning this course gets idea on concept and examples of groups and theirproperties
CO2. He understands cyclic groups, permutation groups, normal subgroups and related results
CO3 After this course he can opt for courses in ring theory, field theory, commutative algebras,linear classical groups etc
CO4. Students can be apply this knowledge to problems in physics, computer science,economics and engineerin

CO-PO Mapping (CC-VI)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	3	2	1	1	2	1	1	2
CO2	3	1	3	2	2	1	2	3
CO3	2	3	3	3	2	2	3	1
CO4	2	2	3	2	3	2	2	3

Programme articulation Matrix row for CC-VI

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course CC-V1	3	2	3	2	3	2	2	3

CO-PSO Mapping (CC-VI)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	3	3	3	3	3
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	2	3	3	2	3

CORE PAPER-VII (CC-VII)
PARTIAL DIFFERENTIAL EQUATIONS AND SYSTEM OF ODEs
(Credits-4) Full Marks-75 (Mid Term-15+End Term-60)

Course Objective:

1.To understand basic methods for solving Partial Differential Equations of first order andsecond order.
2. Students will be exposed to Charpit's Method, Jacobi Method and solve wave equation, heat equation, Laplace Equation etc
3.They will also learn classification of Partial Differential Equations and system of ordinary differential equations.
4.Students will be able to solve some applications of PDEs

SYLLABUS:

UNIT-I : (12 Hours)

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

UNIT-II: (12 Hours)

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

UNIT-III: (12 Hours)

The Cauchy problem, Cauchy problem of an infinite string. Initial Boundary Value Problems, Semi- Infinite String with a fixed end, Semi-Infinite String with a Free end. Equations with non- homogeneous boundary conditions, Non- Homogeneous Wave Equation. Method of separation of variables, Solving the Vibrating String Problem, Solving the Heat Conduction problem

UNIT-IV: (12 Hours)

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

LIST OF PRACTICALS (USING ANY SOFTWARE)

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

Solution of wave equation $\frac{\partial^2 u}{\partial t^2} - \frac{\partial^2 u}{\partial x^2} = 0$ for the following associated conditions c

(a) $u(x, 0) = ¢(x), u_t\{ (x, 0) = \psi(x), x \in R, t>0$

(b) $u(x,0)=¢(X), u_t\{ (x, 0) = \psi(x), u(0,t)=0, x\in(0,\infty), t>0$

(c) $u(x, 0)=¢(x), u_t \{ (x, 0) = \psi(x) , u_x (0,t) = 0, x \in(O,\infty), t>0$

(d) $u(x, 0) = ¢(x), ut (x, 0) = \psi(x), u(0,t) = 0, u(l,t) = 0, 0<x <l, t>0$

$\partial u - \kappa \partial^2 u =$

— ——
Solution of wave equation∂t ∂x^2 0
for the following associated conditions
(a) $u(x, 0) = \phi(x), u(0,t) = a, u(l, t) = b, 0 < x < l, t > 0$ (b) $u(x, 0) = \phi(x), x \in R, 0 < t < T(c)$ $u(x,0) = \phi(x), u(0,t) = a, x \in (0,\infty), t \geq 0$

Books Recommended:

1. Tyn Myint-U and Lokenath Debnath, *Linear Partial Differential Equations for Scientists andEngineers*, 4th Edition, Birkhauser, Indian Reprint,2014.
2. S.L. Ross, *Differential Equations*, 3rd Edition., John Wiley and Sons, India,

Book For References:

1. J. Sinha Roy and S Padhy, *A Course of Ordinary and Partial Differential Equation*, KalyaniPublishers, New Delhi,
2. Martha L Abell, James P Braselton, *Differential Equations with MATHEMATICA*, 3rd Edition., Elsevier Academic Press, 2004.
3. Robert C. McOwen: *Partial Differential Equations: Methods and Applications*, PearsonEducationInc.2nd Edition, 2002.
4. T Amarnath, *An Elementary Course in Partial Differential Equations*, Narosa Publications. 2010.

Course Outcomes:

CO1. After completing this course, a student will be able to take more courses on wave equation,heat equation, diffusion equation,
CO2. Students can solve different problems arising in gas dynamics, nonlinear evolutionequations etc
CO3. All these courses are important in engineering for solving boundary value problem.
CO4. All these courses are important in industrial applications for solving boundary valueproblem.

CO-PO Mapping (CC-VII)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	3	2	1	1	2	1	1	1
CO2	3	1	3	2	2	1	2	2
CO3	2	3	3	3	2	2	3	3
CO4	2	2	3	2	3	2	2	3

Programme articulation Matrix row for CC-VII

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course CC-V1I	3	2	3	2	3	2	2	2

CO-PSO Mapping (CC-VII)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	3	3	3	3	3
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	2	3	3	2	3

SEMESTER-IV

CORE PAPER-VIII(CC-VIII)
NUMERICAL METHODS AND SCIENTIFIC COMPUTING
(Credits-4) Full Marks-75 (Mid Term-15+ End Term-60)

Use of Scientific Calculator is Allowed.

Course Objective:

1. To acquaint students with various numerical methods of finding solution of different type ofproblems, which arises in different branches of science such as locating roots of equations
2. To find solution of systems of linear equations
3. To solve differential equations, interpolation in numerical methods
4. To evaluate integration and other problems in numerical methods

.

SYLLABUS:

UNIT-I: **(12 Hours)**

Rate of convergence, Algorithms, Errors: Relative, Absolute, Round off, Truncation. Approximations in Scientific computing, Error propagation and amplification, conditioning, stability and accuracy, computer arithmetic mathematical software and libraries, visualization, Numerical solution of non-linear equations: Bisection method, Regula-Falsi method, Secant method, Newton-Raphson method, Fixed-point Iteration method.

UNIT-II: **(12 Hours)**

Rate of convergence of the above methods. System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis. Computing eigen-values and eigenvectors

UNIT-III: **(12 Hours)**

Polynomial interpolation: Existence uniqueness of interpolating polynomials. Lagrange and Newtons divided difference interpolation, Error in interpolation, Central difference & averaging operators, Gauss-forward and backward difference interpolation. Hermite and Spline interpolation, piecewise polynomial interpolation.

UNIT-IV: **(12 Hours)**

Numerical Integration: Some simple quadrature rules, Newton-Cotes rules, Trapezoidal rule, Simpsons rule, Simpsons *3/8th* rule, Numerical differentiation and integration, Chebyshev differentiation and FFT, Richard-son extrapolation.

PRACTICAL/LAB WORK TO BE PERFORMED ON A COMPUTER:

Use of computer aided software (CAS), for example *Matlab / Mathematica / Maple / Maxima* etc., for developing the following Numerical programs:

(i) Calculate the sum *1/1 + 1/2 + 1/3 +1/4 +* +1/*N*.
(ii) To find the absolute value of an integer.
(iii) Enter- 100 integers into an array and sort them in an ascending' order.
(iv) Any two of the following:
  (a) Bisection Method
  (b) Newton Raphson Method
  (c) Secant Method
  (d)Regular Falsi Method
(v) Gauss-Jacobi Method
(vi) SOR Method or Gauss-Siedel Method
(vii) Lagrange Interpolation or Newton Interpolation
(viii) Simpson's rule.

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

Books Recommended:

1. M. K. Jain, S. R. K. Iyengar and R. K. Jain, *Numerical Methods for Scientific and Engineering Computation*, New Age International Publisher, India, 2003.
2. Michael T. Heath: *Scientific Computing: An introductory Survey*. 2nd Edition, Mac GrawHill Higher Education, 2019.

Book Forreferences:

1. B. Bradie, *A Friendly Introduction to Numerical Analysis,* Pearson Education, India,2007.
   Kendall E. Atkinson: *An Introduction to Numerical Analysis*, Cambridge University Press(2003).
2. C. F. Gerald and P. O. Wheatley, *Applied Numerical Analysis*, Pearson Education, India,7th Edition, 2008
3. S. D. Conte & S. de Boor, *Elementary Numerical Analysis: An Algorithmic Approach*, McGraw Hill, 1980.

Course Outcomes:

CO1. Students can handle physical problems to find an approximated solution.
CO2. Student can opt for advance courses in Numerical analysis in higher mathematics.
CO3. Use of good mathematical software will help in getting the accuracy one need from thecomputer and can assess the reliability of the numerical results.
CO4. Students can determine the effect of round off error or loss of significance

CO-PO Mapping (CC-VIII)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	3	2	1	1	2	1	1	2
CO2	3	1	3	2	2	1	2	2
CO3	2	3	3	3	2	2	3	3
CO4	2	2	3	2	3	2	2	3

Programme articulation Matrix row for CC-VIII

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course CC-V1II	3	2	3	2	3	2	2	3

CO-PSO Mapping (CC-VIII)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	3	3	3	3	3
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	2	3	3	2	3

CORE PAPER-IX (CC-IX)
TOPOLOGY OF METRIC SPACES
(Credits-4) Full Marks-75 (Mid Term-15+ End Term-60)

Course Objectives:
1.To impart knowledge on open sets, closed sets,
2.To introduce continuous functions, uniform continuous in topological space
3.To introduce terms connectedness, separability etc in topological metric space
4.To introduce many properties such as compactness, density and many properties
.

SYLLABUS:

UNIT-I: **(12 Hours)**
Metric spaces, sequences in metric spaces, Cauchy sequences, complete metric spaces, open and closed balls, neighborhood, open set, interior of a set, limit point of a set, closed set, diameter ofa set, Cantor's theorem,

UNIT-II: **(10 Hours)**
Subspaces, Countability Axioms and Separability, Baire's Category theorem

UNIT-III: **(14 Hours)**
Continuity: Continuous mappings, Extension theorems, Real and Complex valued Continuous functions, Uniform continuity, Homeomorphism, Equivalent metrics and isometry, uniform convergence of sequences of functions.

UNIT-IV: **(12 Hours)**
Contraction mappings and applications, connectedness, Local connectedness, Bounded sets and compactness, other characterization of compactness, continuous functions on compact spaces,

Books Recommended:
Satish Shirali & Harikishan L. Vasudeva, *Metric Spaces*, Springer Verlag London (2006)(First Indian Reprint 2009)

Book For References:
S. Kumaresan, *Topology of Metric Spaces*, Narosa Publishing House, Second Edition 2011

Course Outcomes:
CO1. Students will learn to work with abstract topological spaces
CO2. Students will learn to work with abstract metric space spaces
CO3. Students will learn to relate abstract topological spaces and metric spaces
CO4. This is a foundation course for all analysis courses in future.

CO-PO Mapping (CC-IX)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	3	2	1	1	2	1	1	2
CO2	3	1	3	2	2	1	2	3
CO3	2	3	3	3	2	2	3	3
CO4	2	2	3	2	3	2	2	2

Programme articulation Matrix row for CC-IX

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course CC-1X	3	2	3	2	3	2	3	2

CO-PSO Mapping (CC-IX)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	3	3	3	3	3
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	2	3	3	2	3

CORE PAPER-X (CC-X)
RING THEORY
(Credits-4) Full Marks-75 (Mid Term-15+ End Term-60)

Course Objective:
1.To introduce new topic in algebra viz ring, integral domain, field etc
2.To introduce mapping between different rings, fields
3.To introduce different algebraic properties of rings, fields
4.To interpret application of ring, field structure.

SYLLABUS:

UNIT-I: **(12 Hours)**
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.

UNIT-II: **(12 Hours)**
Prime and maximal ideals. Ring homomorphisms, properties of ring homomorphisms,Isomorphism theorems I, II and III, field of quotients.

UNIT-III: **(12 Hours)**
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].

UNIT-IV: **(12 Hours)**
Divisibility in integral domains, irreducible, primes, unique factorization domains, Euclideandomains.

Books Recommended:

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

Book For References:

1.M. Artin, *Abstract Algebra*, 2ndEdition. Pearson,2011.
2.Joseph 1. Rotman, *An Introduction to the Theory of Groups*, 4th Edition, SpringerVerlag,1995.
3.I. N. Herstein, *Topics in Algebra*, Wiley Eastern Limited, India,1975.

Course Outcomes:
CO1. Students will enable to achieve new algebraic structures
CO2. Students can relate new algebraic structures via mapping.
CO3.Students can achieve concept on Galois theory and their applications
CO4. They can solve many applied concepts via different contents of the syllabus.

CO-PO Mapping (CC-X)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	**3**	**2**	**1**	**1**	**2**	**1**	**1**	**2**
CO2	**3**	**1**	**3**	**2**	**2**	**1**	**2**	**2**
CO3	**2**	**3**	**3**	**3**	**2**	**2**	**3**	**3**
CO4	**2**	**2**	**3**	**2**	**3**	**2**	**2**	**3**

Programme articulation Matrix row for CC-X

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course CC-X	**3**	**2**	**3**	**2**	**3**	**2**	**3**	**3**

CO-PSO Mapping (CC-X)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	**3**	**3**	**3**	**3**	**3**
CO2	**3**	**2**	**3**	**2**	**2**
CO3	**3**	**3**	**3**	**3**	**2**
CO4	2	3	**3**	**2**	**3**

SEMESTER-V

CORE PAPER - XI (CC-XI)
MULTIVARIATE CALCULUS
(Credits-4) Full Marks-75 (Mid Term-15+ End Term-60)

Course Objectives:

1. To introduce functions of several variable to a student after he has taken a course in onevariable calculus.
2. To introduce partial derivatives and several of its consequences
3. To introduce double and triple integrals along with line integrals
4. To introduce all fundamental concepts for calculus.

SYLLABUS:

UNIT-I: **(12 Hours)**

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

UNIT-II: **(12 Hours)**

Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization problems, Definition of vector field, divergence and curl, Double integration over rectangular region, double integration over nonrectangular region. Double integrals in polar co- ordinates,

UNIT-III: **(12 Hours)**

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

UNIT-IV: **(12 Hours)**

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

Books Recommended:

1. M. J. Strauss, G. L. Bradley and K. J. Smith, Calculus (3rd Edition), Dorling Kindersley (India) Pvt.Ltd. (Pearson Education), Delhi,2007.
2. S C Mallik and S Arora: Mathematical Analysis, New Age International Publications, 2nd Edition,1992.

Book For References:

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Edition., Pearson Education, Delhi,2005.
2. E. Marsden, A.J. Tromba and A. Weinstein, *Basic Multivariable Calculus*, Springer (SIE). Indianreprint,2005.
3. James Stewart, *Multivariable Calculus, Concepts and Contexts*,2nd Edition., Brooks/*Cole*, ThomsonLearning, USA,2001.
4. S Ghorpade, B V Limaye, *A Course in Multivariable Calculus*, Springer international edition, 2010.

Course Outcomes:

CO1. After reading this course a student will be able to calculate partial derivatives, directionalderivatives, extremum values and can calculate double, triple and line integrals
CO2. He will have idea of basic vector calculus including Green's theorem, divergence theoremand Stoke's theorem
CO3. Students can take courses in calculus on manifolds, Differential geometry
CO4. This course helps in numerical computations involving several variables

CO-PO Mapping (CC-XI)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	3	2	1	1	2	1	1	2
CO2	3	1	3	2	2	1	2	2
CO3	2	3	3	3	2	2	3	3
CO4	2	2	3	2	3	2	2	3

Programme articulation Matrix row for CC-XI

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course CC-X1	3	2	3	2	3	2	3	2

CO-PSO Mapping (CC-XI)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	3	3	3	3	3
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	2	3	3	2	3

CORE PAPER –XII (CC-XII)

LINEAR ALGEBRA

(Credits-4)Full Marks-75 (Mid Term-15+ End Term-60)

Course Objective:

1. To introduce basic concept on linear algebra
2. To interpret various new concepts such as vector space, subspace etc.
3. To interrelate matrices, determinates in different vector spaces.
4. To introduce mapping between different vector spaces

SYLLABUS:

UNIT-I: **(12 Hours)**

Vector spaces, subspaces, examples, algebra of subs paces, quotient spaces, linear combination of vectors, linear span, linear independence, basis and dimension, dimension of subspaces. Linear transformations, null space, range, rank and nullity of a linear transformation.

UNIT-II: **(12 Hours)**

Matrix representation of a linear transformation, Algebra of linear transformations, Isomorphisms, Isomorphism theorems, invertibility and isomorphisms, change of coordinate matrix, Dual spaces, dual basis, double dual, transpose of a linear transformation and its matrixin the dual basis, annihilators, Basics of Fields.

UNIT-III: **(12 Hours)**

Eigenspaces of a linear operator, diagonalizability. Invariant subspaces and Cayley-Hamilton theorem, the minimal polynomial for a linear operator, Inner product spaces and norms, Gram- Schmidt orthogonalization process,

UNIT-IV: **(12 Hours)**

Orthogonal complements, Bessel's inequality, the adjoint of a linear operator, Least Squares Approximation, minimal solutions to systems of linear equations, Normal and self-adjoint operators, Orthogonal projections and Spectral theorem.

Books Recommended:

Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, *Linear Algebra* (4th Edition),Pearson, 2018.

Books For Reference:

1. Rao A R and Bhim Sankaram, *Linear Algebra*, Hindustan Publishing house.
2. Gilbert Strang, *Linear Algebra and its Applications*, Thomson,2007.

Course Outcomes:

CO1. Students will get knowledge on vector space, subspace, basis, dimension of vector spacesetc.
CO2. They can interpret matrices, differential equations in vector spaces.
CO3. This course also enables on eigenvalues, eigen vector and many elements.
CO4.This course helps students for special structure such as normed linear spaces, inner productspaces

CO-PO Mapping (CC-XII)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	**3**	**2**	**1**	**1**	**2**	**1**	**1**	**2**
CO2	**3**	**1**	**3**	**2**	**2**	**1**	**2**	**3**
CO3	**2**	**3**	**3**	**3**	**2**	**2**	**3**	**3**
CO4	**2**	**2**	**3**	**2**	**3**	**2**	**2**	**3**

Programme articulation Matrix row for CC-XII

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course CC-XII	**3**	**2**	**3**	**2**	**3**	**2**	**3**	**3**

CO-PSO Mapping (CC-XII)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	**3**	**3**	**3**	**3**	**3**
CO2	**3**	**2**	**3**	**2**	**2**
CO3	**3**	**3**	**3**	**3**	**2**
CO4	**2**	**3**	**3**	**2**	**3**

SEMESTER-VI

CORE PAPER-XIII (CC-XIII)
COMPLEX ANALYSIS
(Credits-4) Full Marks-75 (Mid Term-15+ End Term-60)

Course Objectives:

1. To aimed to provide an introduction to the theories for functions of a complex variable
2. To provide concepts of analyticity and complex integration are presented
3. To introduce integration of complex valued function and related remarkable results such as,The Cauchy's theorem, Cauchy's integral formula and many more and their applications.
4. To introduce calculus of residues and its applications are discussed in detail.

SYLLABUS:

UNIT-I **(12 Hours)**

Complex Numbers and Complex plane: Basic properties, convergence, Sets in the Complex plane, Functions on the Complex plane: Continuous functions, holomorphic functions, power series, Integration along curves.

UNIT-II **(12 Hours)**

Cauchy's Theorem and Its Applications: Goursat's theorem, Local existence of primitives and Cauchy's theorem in a disc, Evaluation of some integrals, Cauchy's integral formulas.

UNIT-III **(12 Hours)**

Morera's theorem, Sequences of holomorphic functions, Holomorphic functions defined in termsof integrals, Schwarz reflection principle, Zeros and poles.

UNIT-IV **(12 Hours)**

Meromorphic Functions and the Logarithm: The residue formula, Examples, Singularities and meromorphic functions, The argument principle and applications, The complex logarithm.

Books Recommended:

Elias M. Stein & Rami Shakarchi, *Complex Analysis*, Princeton University press,Princeton and Oxford, 2003.

Books For Reference:

1. James Ward Brown and Ruel V. Churchill, *Complex Variables and Applications* (8thEdition), McGraw - Hill International Edition,2009.
2. G. F. Simmons, *Introduction to Topology and Modern Analysis*, McGraw-Hill, Edition,2004.
3. Joseph Bak and Donald 1. Newman, *Complex Analysis* (2ndEdition), Undergraduate Textsin Mathematics, Springer-Verlag New York, Inc., New York,1997.

Course Outcomes:

CO1. Students will be able to handle certain integrals not evaluated earlier
CO2. Will know a technique for counting the zeros of polynomials
CO3. Students will able to solve many applied contents
CO4. This course is prerequisite to many other advance analysis course

CO-PO Mapping (CC-XIII)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	**3**	**2**	**1**	**1**	**2**	**1**	**1**	**2**
CO2	**3**	**1**	**3**	**2**	**2**	**1**	**2**	**3**
CO3	**2**	**3**	**3**	**3**	**2**	**2**	**3**	**3**
CO4	**2**	**2**	**3**	**2**	**3**	**2**	**2**	**3**

Programme articulation Matrix row for CC-XIII

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course CC-XII1	**3**	**2**	**3**	**2**	**3**	**2**	**2**	**2**

CO-PSO Mapping (CC-XIII)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	**3**	**3**	**3**	**3**	**3**
CO2	**3**	**2**	**3**	**2**	**2**
CO3	**3**	**3**	**3**	**3**	**2**
CO4	**2**	**3**	**3**	**2**	**3**

CORE PAPER-XIV (CC-XIV)
GROUP-THEORY-II
(Credits-4)Full Marks-75 (Mid Term-15+ End Term-60)

Course Objectives:

1.To be exposed to more advanced results in group theory after completing a basic course.
2.To introduces results on automorphism, commutator
3.To introduce group action and related advanced topics of group theory
4.To introduce Sylow's theorems and their consequences and their applications**.**

SYLLABUS:

UNIT-I: (12 Hours)

Automorphism, inner automorphism, automorphism groups, automorphism groups of finite and infinite cyclic groups, applications of factor groups to automorphism groups. Characteristic subgroups.

UNIT-II: (12 Hours)

Commutator subgroup and its properties, Properties of external direct products, the group ofunits modulo n as an external direct product, internal direct products, Fundamental Theorem of finite abelian groups.

UNIT-III: (12 Hours)

Group actions, stabilizers and kernels, permutation representation associated with a given group action, Application of group actions: Generalized Cayley's theorem, Index theorem.

UNIT-IV: (12 Hours)

Groups acting on themselves by conjugation, class equation and consequences, conjugacy in S_n, p - groups, Sylow's theorems and consequences, Cauchy's theorem, Simplicity of A_n for $n \geq 5$, non-simplicity tests.

Books Recommended:

1. John B. Fraleigh, *A First Course in Abstract Algebra,2nd Edition,* Narosa Publishing House, New Delhi, 2020.
2. Joseph A. Gallian *Contemporary Abstract Algebra,* 4th Edition, Narosa Publishing House, New Delhi.2008.

Book For References:

1. M. Artin, *Abstract Algebra,* 2nd Edition., Pearson,2011.
2. David S. Dummit and Richard M. Foote, *Abstract Algebra,* 3rd Edition., John Wiley and Sons(Asia) Pvt. Ltd., Singapore, 2004.
3. J.R. Durbin, *Modern Algebra,* John Wiley & Sons, New York Inc.,2000.

Course Outcomes:

CO1. The knowledge of automorphism helps to study more on group theory
CO2. Students learn on direct products, group actions, class equations and their applications withproof of all results
CO3. This course helps to opt for more advanced courses in higher algebra.
CO4. Students able to enhance their concepts on modern algebra and linear classical group

CO-PO Mapping (CC-XIV)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	3	2	1	1	2	1	1	2
CO2	3	1	3	2	2	1	2	3
CO3	2	3	3	3	2	2	3	3
CO4	2	2	3	2	3	2	2	2

Programme articulation Matrix row for CC-XIV

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course CC-X1V	3	2	3	2	3	2	2	3

CO-PSO Mapping (CC-XIV)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	3	3	3	3	3
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	2	3	3	2	3

DISCIPLINE SPECIFIC ELECTIVE PAPER-1 (DSE-I)
LINEAR PROGRAMMING
(Credits-4) Full Marks-75 (Mid Term-15+ End Term-60)

Course Objective:

1.To familiarize industrial problems to students with various methods of solving LinearProgramming Problems
2. To introduce on Transportation Problems
3. To familiarize with Assignment Problems and their applications
4. To interpret the method in Game Theory.

SYLLABUS:

UNIT-I: **(12 Hours)**

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

UNIT-II: **(12 Hours)**

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

UNIT-III: **(12 Hours)**

Transportation problem and its mathematical formulation, northwest-corner method least cost method and Vogel approximation method for determination of starting basic solution, algorithm for solving transportation problem. Assignment problem and its mathematicalformulation, Hungarian method for solving assignment problem

UNIT-IV: **(12 Hours)**

Game theory: formulation of two-person zero sum games, solving two-person zero sum games, games with mixed strategies, graphical solution procedure, linear programming solution of games.

Books Recommended:

Kanti Swarup, P.K. Gupta, Man Mohan, *Operations Research*, Sultan Chand & Sons, NewDelhi. Books.

Books For Reference:

1. S. Hillier and G.J. Lieberman, *Introduction to Operations Research- Concepts and Cases* (9thEdition), Tata McGraw Hill,2010.
2. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, *Linear Programming and Network Flows* (2nd Edition), John Wiley and Sons, India,2004.
3. G. Hadley, *Linear Programming*, Narosa Publishing, New Delhi,2002.
4. Hamdy A. Taha, *Operations Research: An Introduction* (10^{th} Edition), Pearson,2017

Course Outcomes:

CO1. More knowledge on this topic in higher studies will help students to deal industrial models
CO2. This is also prerequisite for studying advanced courses in Nonlinear ProgrammingProblems
CO3. Students shall obtain basic concepts on Inventory Control Problem
CO4. This course also motivates students towards Queuing Theory, stochastic process andPoison process.

CO-PO Mapping (DSE-I)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	3	2	1	1	2	1	1	2
CO2	3	1	3	2	2	1	2	3
CO3	2	3	3	3	2	2	3	3
CO4	2	2	3	2	3	2	2	3

Programme articulation Matrix row for DSE-I

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course DSE-1	3	2	3	2	3	2	3	2

CO-PSO Mapping (DSE-I)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	3	3	3	3	3
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	2	3	3	2	3

DISCIPLINE SPECIFIC ELECTIVE PAPER-II (DSE-II)
PROBABILITY AND STATISTICS
(Credits-4)Full Marks-75 (Mid Term-15+ End Term-60)

Course Objective:

1.To expertise the student to the extensive role of statistics in everyday life and computation,
2.To make familiar the students' different parameters of statistics.
3.To interpret applications of different parameters of statistics
4.To provide basic course for all branches of mathematical and engineering sciences.

SYLLABUS:

UNIT-I: **(12 Hours)**

Probability: Introduction, Sample spaces, Events, probability of events, rules of probability, conditional probability, independent events, Bayes's theorem,

Probability distributions and probability densities: random variables, probability distributions, continuous random variables, probability density functions, Multivariate distributions, joint distribution function, joint probability density function, marginal distributions, conditional distributions, conditional density, The theory in practice, data analysis, frequency distribution, class limits, class frequencies, class boundary, class interval, class mark, skewed data, multimodality, graphical representation of the data, measures of location and variability. Population, sample, parameters

UNIT-II: **(12 Hours)**

Mathematical Expectation: Introduction, expected value of random variable, moments, Chebyshev's theorem, moment generating functions, product moments, moments of linear combinations of random variables, conditional expectations, the theory in practice, measures of location, dispersion

UNIT-III: **(12 Hours)**

Special probability distributions: Discrete Uniform distribution, binomial distribution, Negative binomial, geometric, hypergeometric, Poisson, multinomial distribution, multinomial. Special probability densities; Uniform distribution, gamma, exponential, gamma, chi-square, beta distribution, normal, normal approximation to binomial, bivariate normal, Functions of random variables, distribution function technique, transformation technique-one variable, several variables, moment generating function technique,

UNIT-IV: **(12 Hours)**

Sampling distributions: population distribution, random sample, sampling distribution of mean, Central Limit theorem, Sampling distribution of the mean: finite populations, chi-square, t, F distributions, regression and correlation: Bivariate regression, regression equation, Linear regression, method of least squares.

Books Recommended:

Irwin Miller and Marylees Miller, *John E. Freund's Mathematical Statistics with Applications* (8^{th}Edition), Pearson, Asia, 2014.

Book For References:

l. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, *Introduction to Mathematical Statistics,* Pearson Education, Asia,2007.
2.Alexander M. Mood, Franklin A. Graybill and Duane C. Boes, *Introduction to the Theory of Statistics,* (3rd Edition), Tata McGraw- Hill, Reprint2007
3.Sheldon Ross, *Introduction to Probability Models* (9th Edition), Academic Press, Indian Reprint,2007

Course Outcome:

CO1. The students shall learn probability and statistics for various random variables
CO2. The students shall learn probability and statistics for distribution functions
CO3. Students are able to know expectation, variance, covariance and their application in dailylife
CO4. Students can apply various general aspects of random variables with their applications inpractical life.

CO-PO Mapping (DSE-II)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	3	2	1	1	2	1	1	2
CO2	3	1	3	2	2	1	2	3
CO3	2	3	3	3	2	2	3	3
CO4	2	2	3	2	3	2	2	2

Programme articulation Matrix row for DSE-II

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course DSE-I1	3	2	3	2	3	2	2	3

CO-PSO Mapping (DSE-II)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	3	3	3	3	3
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	2	3	3	2	3

DISCIPLINE SPECIFIC ELECTIVE PAPER-III (DSE-III)
DIFFERENTIAL GEOMETRY
(Credits-4)Full Marks-75 (Mid Term-15+ End Term-60)

Course Objective:
1. To introduce on learning on curve tracing
2 To interpret students on analytical geometry
3. To teach on differential geometry of curves and surfaces
4. To derive intrinsic properties of plain curves and space curves.

SYLLABUS:

UNIT-I: **(12 Hours)**
Theory of Space Curves: Space curves, Planer curves, Curvature, torsion and Serret-Frenet formulae. Osculating circles, Osculating circles and spheres. Existence of space curves.

UNIT-II: **(12 Hours)**
Evolutes and involutes of curves. Theory of Surfaces: Parametric curves on surfaces, surfaces of revolution, helicoids, Direction coefficients. First and second Fundamental forms.

UNIT-III: **(12 Hours)**
Principal and Gaussian curvatures. Lines of curvature, Euler's theorem. Rodrigue's formula, Conjugate and Asymptotic lines. Developable: Developable associated with space curves and curves on surfaces, Minimal surfaces.

UNIT-IV: **(12 Hours)**
Geodesics: Canonical geodesic equations. Nature of geodesics on a surface of revolution. Clairaut's theorem. Normal property of geodesics. Torsion of a geodesic. Geodesic curvature. Gauss-Bonnet theorem. Surfaces of constant curvature.

Books Recommended:
T.J. Willmore, *An Introduction to Differential Geometry*, Dover Publications,2012.

Book For References:
1.1 A. Pressley, *Elementary Differential Geometry*, Springer International Edition, 2014.
2. O'Neill, *Elementary Differential Geometry*, 2nd Edition., Academic Press,2006.
3.C.E. Weatherburn, *Differential Geometry of Three Dimensions*, Cambridge University Press2003.
4 D.J. Struik, *Lectures on Classical Differential Geometry*, Dover Publications,1988

Course Outcome:
CO1. Student will learn on different formulas and properties on plain and space elements.
CO2. They can relation between tangent, normal and binomials among different geometricalobjects
CO3 Students able to understand different form such as first and second fundamental forms andideas on various curvatures.
CO4. He has scope to take more advanced courses in surface theory and geometry.

CO-PO Mapping (DSE-III)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	3	2	1	1	2	1	1	3
CO2	3	1	3	2	2	1	2	3
CO3	2	3	3	3	2	2	3	3
CO4	2	2	3	2	3	2	2	2

Programme articulation Matrix row for DSE-III

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course DSE-III	3	2	3	2	3	2	3	2

CO-PSO Mapping (DSE-III)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	3	3	3	3	3
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	2	3	3	2	3

DISCIPLINE SPECIFIC ELECTIVE PAPER: IV (DSE-IV)
NUMBER THEORY
(Credits-4)Full Marks-75 (Mid Term-15+ End Term-60)

Course Objective:

1.To build up the basic theory of the integers, prime numbers and their primitive roots
2.To develop the theory of congruence in number theory
3.To incorporate students on different algebraic structures on number theory
4.To introduce application of number theoretic aspects

.

SYLLABUS:

UNIT- I: **(12 Hours)**

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

UNIT-II: **(12 Hours)**

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

UNIT-III: **(12 Hours)**

Order of an integer modulo *n*, primitive roots for primes, composite numbers having primitive roots, Euler's criterion, the Legendre symbol, Jacobi symbol and their properties, quadratic reciprocity, quadratic congruences with composite moduli.

UNIT-IV: **(12 Hours)**

Affine ciphers, Hillciphers, punlucky cryptography, RSA encryption and decryption, theequation$x^2 + y^2 = z^2$, Fermat's LastTheorem.

Books Recommended:

David M. Burton, *Elementary Number Theory*, (6thEdition), Tata McGraw-Hill Edition,Indian reprint,2007.

Book For References:

1.Thomas Koshy, *Elementary Number Theory with Applications* (2nd Edition), AcademicPress,2007.
2. Neville Robinns, *Beginning Number Theory* (2ndEdition), Narosa Publishing House Pvt. Limited, Delhi, 2007.

Course Outcomes:

CO1. Upon successful completion of this course students will able to know the basic definitionsand theorems in number theory.
CO2. They can identify order of an integer, primitive roots, Euler's criterion, the Legendresymbol, Jacobi symbol and their properties
CO3.Students can understand modular arithmetic number-theoretic functions
CO4 They can understand application of number theory elements in cryptography

CO-PO Mapping (DSE-IV)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	3	2	1	1	2	1	1	2
CO2	3	1	3	2	2	1	2	2
CO3	2	3	3	3	2	2	3	3
CO4	2	2	3	2	3	2	2	3

Programme articulation Matrix row for DSE-IV

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course DSE-IV	3	2	3	2	3	2	2	2

CO-PSO Mapping (DSE-IV)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	3	3	3	3	3
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	2	3	3	2	3

OR

DISCIPLINE SPECIFIC ELECTIVE PAPER-IV (DSE-IV)
PROJECT
(Credits-4)Full Marks-100

Course Objectives

1. To be equipped with a broad educational background in Mathematics needed to becomeleaders in industry and the public sector;
2. To correctly apply gained knowledge, work well with other people, effectively communicate technicalinformation and ideas with the public, their peers, customers, and employers;
3. To understand the need for life-long learning, the importance and professional involvement,are aware of cultural, societal, and professional issues;
4. To successfully pursue advanced

Guidelines for +3(CBCS) Under Graduate (B.A./B.Sc.) Mathematics (Honors) Project

(a) Any student registering for doing project is required to inform the HOD, Mathematics the name of his/her project supervisor(s) at the time of pre-registration.

(b) By the last date of add and drop, the student must submit the "Project Registration Form'', appended as Annexure-I to this document, to the HOD, Mathematics. This form requires a project title, the signature of the student, signature(s) of the supervisor(s) and the signature ofthe HOD, Mathematics of the college/university.

(c) The project supervisor(s) should normally be a faculty member(s) of the Department of Mathematics and the topic of the project should be relevant to Mathematical Sciences. If a student desires to have a Project Supervisor from another department of the institute, theprior approval for the same should be sought from the HOD, Mathematics.

(d) A student may have at the most two Project Supervisors. If a student desires to have two supervisors, at least one of these should be from the Department of Mathematics.

(e) The student(s) will be required to submit one progress report and a final report of the Project to the HOD, Mathematics. The progress report is to be submitted in the sixth week of the semester in which

the project is undertaken. The hard copy and an electronic version of the final report of the project should be submitted two weeks before the end semester examination of the sixth semester. In addition the student will be required to make an oral presentation in front of a committee **(**Under Graduate (B.A./B.Sc.) Mathematics (Honours) Project committee of the college in which supervisor is one of the members) constituted for this purpose by the Department of Mathematics of the college.

(f) The student is expected to devote about 100 hours. The project will be evaluated by a committee of faculty members at the end of the sixth semester. The committee will be constituted by the Under Graduate (B.A./B.Sc.) Mathematics (Honours) Project committee ofthe college keeping in mind the areas of project they will cover.

(g) In each semester the grade of a student will be awarded by the committee in consultation with his/her project supervisor(s). The project is evaluated on the basis of the following components: First Progress Reports: 20%; second/Final Report: 30%; Presentation: 30%; Viva:20%.

(h) Project progress reports should normally be no longer than 250 words and final report should not be longer than 40 A4 size pages in double spacing. Each final project report needs to contain the following: (i) Abstract (ii) Table of contents (iii)Review of literature (iv) Main text (v) List of references. It may be desirable to arrange the main text as an introduction, the main body and conclusions.

GUIDELINES FOR STRUCTURING CONTENTS

Sequence of Contents:
The following sequence for the thesis organization should be followed:

(i) Preliminaries

(ii) Title Page

(iii) Certificate

(iv) Abstract/Synopsis

(v) Acknowledgement and/ or Dedication

(vi) Table of Contents

(vii) List of Figures, Tables, Illustrations, Symbols, etc. (wherever applicable)

(viii) Text of Thesis Introduction

The body of the thesis, summary and conclusions

(ix) Reference Material List of References, Bibliography

(x) Appendices

NOTE:

1.Synopsis/Abstract should be self-complete and contain no citations for which the thesis has to be referred
2.The Text of the Thesis

(a) ***Introduction:***
Introduction may be the first chapter or its first major division. In either case, it should contain abrief statement of the problem investigated. It should outline the scope, aim, general character ofthe research and the reasons for the student's interest in the problem.

(b) **The body of Thesis**
This is the substance of the dissertation inclusive of all divisions, subdivisions, tables, figures,etc.

(c) Summary and conclusions
If required, these are given as the last major division (chapter) of the text. A further and finalsubdivision titled "*Scope* for Further Work" may follow.

(d) Reference material

The list of references should appear as a consolidated list with references listed eitheralphabetically or sequentially as they appear in the text of the thesis.

For referencing an article in a scientific journal, the suggested format should contain the following Information: authors, title, name of journal, volume number, page numbers and year. For referencing an article published in a book, the suggested format should contain, authors, the title of the book, editors, publisher, year, page number of the article in the book being referred to.For referencing a thesis, the suggested format should contain, author, the title of thesis, where thesis was submitted or awarded, year.

ANNEXURE-I

Department of Mathematics

Project Registration Form

Name of the college/university:

Name of the student:

Roll No. :

E-mail:

Name of the supervisor(s):

Department(s):

E-mail:

Title of the Project:

Signature of the Student:

Signature of Supervisor(s):

Signature of HOD, Mathematics:

Course Outcomes-:

CO 1-: Students can understand the basic concepts & broad principles of Mathematical projects

CC-2-: Get capable of self-education and clearly understand the value of achieving perfection in project implementation & completion.

CO-3-: Apply the theoretical concepts to solve mathematical problems with teamwork andmultidisciplinary approach

CO 4-: Demonstrate professionalism with ethics; present effective communication skills and relatemathematical Issues to broader societal context

CO-PO Mapping (DSE-IV)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	3	2	1	1	2	1	1	2
CO2	3	1	3	2	2	1	2	3
CO3	2	3	3	3	2	2	3	3
CO4	2	2	3	2	3	2	2	3

Programme articulation Matrix row for DSE-IV

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course DSE-IV	3	2	3	2	3	2	3	2

CO-PSO Mapping (DSE-IV)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	3	3	3	3	3
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	2	3	3	2	3

GENERIC ELECTIVES (TWO PAPER CHOICE)

GENERIC ELECTIVE PAPER I(GE-I)
CALCULUS AND DIFFERENTIAL EQUATIONS
(Credits-4)Full Marks-75 (Mid Term-15+ End Term-60)

Course Objective:

1.To equip the student with necessary analytic and technical skills to handle problems of amathematical nature
2. Practical problems using calculus and differential equation
3. To expose the students to basic ideas quickly without much theoretical emphasis withimportance on applications.
4.To solve mathematical problems which arise in all branches of science and engineering.

SYLLABUS:

UNIT-I: **(10 Hours)**

Curvature, Asymptotes, Tracing of Curves (Catenary, Cycloid, Folium of Descartes),Rectification, Quadrature, Elementary ideas about Sphere, Cones, Cylinders and Conicoids.

UNIT-II: **(12 Hours)**

Review of limits, continuity and differentiability of functions of one variable and their properties, Rolle's theorem, Mean value theorems, Taylor's theorem with Lagrange's theorem and Cauchy's form of remainder, Taylor's series, Maclaurin's series of sinx, cosx, e^S, log(1+x), $(1+x)^N$, L' Hospital's Rule, other Intermediate forms.

UNIT-III: **(13 Hours)**

Limit and Continuity of functions of several variables, Partial derivatives, Partial derivatives of higher orders, Homogeneous functions, Change of variables, Mean value theorem, Taylors theorem and Maclaurin's theorem for functions of two variables (statements &applications), Maxima and Minima of functions of two and three variables, Implicit functions, Lagrange's multipliers (Formulae & its applications), Concepts of Multiple integrals & its applications.

UNIT-IV: **(13 Hours)**

Ordinary Differential Equations of order one and degree one (variables separable, homogeneous, exactand linear). Equations of order one but higher degree. Second order linear equations with constant coefficients, homogeneous forms, Second order equations with variable coefficients, Variation of parameters.

Books Recommended:

1.Shanti Narayan, P. K. Mittal, *Differential Calculus*, S. Chand, 2014.
2.Shanti Narayan, P. K. Mittal, *Integral Calculus*, S. Chand, 2014.
3.S.C. Mallik and S. Arora, *Mathematical Analysis*, New Age International Publications.
4.J. Sinha Roy and S. Padhy: *A Course of Ordinary and Partial Differential Equations*,Kalyani Publishers.

Book For References:

1. H. Anton, I. Bivens and S. Davis, *Calculus, 10th*Edition., John Wiley and Sons (Asia) P. Ltd.,Singapore,2002.
2. Shanti Narayan and P.K. Mittal, *Analytical Solid Geometry*, S. Chand & Company Pvt. Ltd.,New Delhi.
3. Martin Braun, *Differential Equations and their Applications*, Martin Braun, SpringerInternational.
4. B. P. Acharya and D.C. Sahu, *Analytical Geometry of Quadratic Surfaces*, KalyaniPublishers.

Course Outcomes:

CO1. Students are expected to be able to apply knowledge of calculus
CO2. They can apply the concepts in differential equations
CP3. They can solve the many scientific problems arising in different branch
CO4 Students can employ the idea to their field and develop their project

CO-PO Mapping (GE-I)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	3	2	1	1	2	1	1	2
CO2	3	1	3	2	2	1	2	3
CO3	2	3	3	3	2	2	3	3
CO4	2	2	3	2	3	2	2	2

Programme articulation Matrix row for GE-1

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course GE-1	3	2	3	2	3	2	3	3

CO-PSO Mapping (GE-1)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	3	3	3	3	3
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	2	3	3	2	3

GENERIC ELECTIVE PAPER II (GE-II)
ALGEBRA
(Credits-4) Full Marks-75 (Mid Term-15+ End Term-60)

Course Objective:

1. To introduce basic course in mathematics like set, relation, functions
2. To motivate towards students towards abstract algebra and linear algebra
3. To acquaint students with the properties of natural numbers i.e. Euclidean algorithm,congruence relation, fundamental theorem of arithmetic, etc.
4. To introduce with vector spaces, matrices

SYLLABUS:

UNIT-I **(12 Hours)**

Sets, relations, Equivalence relations, partial ordering, well ordering, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set, statements, compound statements, proofs in Mathematics, Truth tables, Algebra of propositions, logical arguments

UNIT-II **(12 Hours)**

Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm, Congruence relation between integers, Principles of Mathematical Induction, statement of Fundamental Theorem of Arithmetic.

UNIT-III **(12 Hours)**

Matrices, algebra of matrices, determinants, fundamental properties, minors and cofactors, product of determinant, adjoint and inverse of a matrix, Rank and nullity of a matrix, Systemsof linear equations, row reduction and echelon forms, solution sets of linear systems, applications of linear systems.

UNIT-IV **(12 Hours)**

Vector spaces and subspaces, examples, linear independence, linear dependence, basis, dimension, examples, Introduction to linear transformations, matrix representation of a linear transformation, Eigen values, Eigen vectors of a matrix.

Books Recommended:

1. Edgar G. Goodaire and Michael M. Parmenter, *Discrete Mathematics with Graph Theory*,3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.
2. V Krishna Murthy, V P Mainra, J L Arora, *An Introduction to Linear Algebra*, Affiliated East-West Press Pvt. Ltd

Books For Reference:

1.David C. Lay, *Linear Algebra and its Applications*, 3rdEd., Pearson Education Asia,Indian Reprint, 2007.
2.B S Vatsa and Suchi Vatsa, *Theory of Matrices*, New Age International, 3rd Edition, 2010.
3.Ward Cheney, David Kincaid, *Linear Algebra Theory and Applications*, Jones and Bartlett, 2010.

Course Outcomes:

CO1. The acquired knowledge will help students to study further courses in mathematics
CO2. Students can achieve fundamental concepts on group theory, ring theory and field theory and linear algebra.
CO3. Students can apply the concepts on higher mathematics
CO4.They can also interrelate all the concepts to different branches of science subjects likecomputer science statistics, physics, chemistry etc.

CO-PO Mapping (GE-II)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	3	2	1	1	2	1	1	2
CO2	3	1	3	2	2	1	2	3
CO3	2	3	3	3	2	2	3	3
CO4	2	2	3	2	3	2	2	2

Programme articulation Matrix row for GE-II

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course GE-II	3	2	3	2	3	2	3	3

CO-PSO Mapping (GE-II)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	3	3	3	3	3
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	2	3	3	2	3

GENERIC ELECTIVE PAPER III ((GE-III))
REAL ANALYSIS
(Credits-4)Full Marks-75 (Mid Term-15+ End Term-60)

Course Objective:

1. To have the knowledge on basic properties of the field of real numbers and their importantapplications
2. To study about sequence of real numbers with different properties such as convergence.
3. To know on convergence test of real sequences
4. To know about series of real sequences and test of series

SYLLABUS:

UNIT-I **(12 Hours)**

Review of Algebraic and Order Properties of *R*, s-neighborhood of a point in *R*, Idea of countable sets, uncountable sets and uncountability of *R*, bounded above sets, bounded below sets, Bounded Sets, Unbounded sets, Suprema and Infima, The Completeness Property of *R*, The Archimedean Property, Density of Rational (and Irrational) numbers in *R*.

UNIT-II **(12 Hours)**

Intervals, Interior point, Open Sets, Closed sets, Limit points of a set, Illustrations of Bolzano- Weierstrass theorem for sets, closure, interior and boundary of a set. Sequences, Bounded sequence, Convergent sequence, Limit of a sequence. Limit Theorems, Monotone Sequences, Monotone Convergence Theorem. Subsequences, Divergence Criteria, Monotone Subsequence Theorem (statement only). Bolzano Weierstrass Theorem for Sequences, Cauchy sequence,Cauchy's Convergence Criterion.

UNIT-III **(12 Hours)**

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

UNIT-IV **(12 Hours)**

Sequence and Series of functions, point-wise and uniform convergences, $M_n$test, M test, statement of results about uniform convergence, differentiability and integrability of function, power series and radius of convergence**.**

Books Recommended:

1. S.C. Mallik and S. Arora, *Mathematical Analysis*, 2nd Edition, New Age International Publications, 1992
2. G. Das and S. Pattanayak, *Fundamentals of Mathematical Analysis*, TMH Publishing Co.

Books For Reference:

1. R.G. Bartle and D. R. Sherbert, *Introduction to Real Analysis* (3rd Edition), John Wiley andSons (Asia) Pvt. Ltd., Singapore, 2002.
2. A. Kumar, S. Kumaresan, *A Basic Course In Real Analysis*, CRC Press, 2014.
3. Brian S.Thomson, Andrew. M. Bruckner, and Judith B. Bruckner, *Elementary Real Analysis*, Prentice Hall, 2001.
4. Gerald G. Bilodeau, Paul R. Thie, G.E. Keough, *An Introduction to Analysis*, Jones &Bartlett, 2nd Edition,2010.

Course Outcomes:

CO1. Students will be able to handle fundamental properties of the real numbers that lead to the formal development of real analysis

CO2. Students understand limits and their use in sequences, series, differentiation andintegration.

CO3. Students will appreciate how abstract ideas and rigorous methods in mathematical analysiscan be applied to important practical problems

CO4. Students can apply many mathematical tools such as convergence test in differentfield.

CO-PO Mapping (GE-III)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	3	2	1	1	2	1	1	2
CO2	3	1	3	2	2	1	2	2
CO3	2	3	3	3	2	2	3	2
CO4	2	2	3	2	3	2	2	3

Programme articulation Matrix row for GE-III

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course GE-III	3	2	3	2	3	2	3	2

CO-PSO Mapping (GE-III)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	3	3	3	3	3
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	2	3	3	2	3

GENERIC ELECTIVE PAPER IV(GE-IV)
NUMERICAL METHODS
(Credits-4) Full Marks-75 (Mid Term-15+ End Term-60)

Course Objective:

1. To interpret calculation of error and approximation is a necessity in all real life, industrial andscientific computing
2. To acquaint students with various numerical methods of finding solution of different type ofproblems, which arises in different branches of science such as locating roots of equations,
3. To find solution of nonlinear equations, systems of linear equations, differential equations
4. To know about interpolation, differentiation, evaluating integration

SYLLABUS:

UNIT-I **(12 Hours)**

Algorithms, Convergence, Bisection method, False position method, Fixed Point iteration method, Newton's method, Secant method. Gauss Elimination and Gauss Jordan methods, LU decomposition, Gauss-Jacobi, Gauss- Siedel.

UNIT-II **(12 Hours)**

Lagrange and Newton interpolation: linear and higher order, finite difference operators.

UNIT-III **(12 Hours)**

Numerical differentiation: forward difference, backward difference and central Difference.

UNIT-IV **(12 Hours)**

Integration: trapezoidal rule, Simpson's rule, Euler's method, Runge-Kutta methods of orders twoand four.

Books Recommended:

M.K. Jain, S.R.K. Iyengar and R.K. Jain, *Numerical Methods for Scientific and Engineering Computation*, 5th Edition., New Age International Publisher, India,2007.

Books For Reference:

1. S. S. Sastry, *Introductory Method for Numerical Analysis*, PHI New Delhi, 2012.
2. S. D. Conte and Carl De Boor, *Elementary Numerical Analysis*, Mc Graw Hill, 1980.

Course Outcome:

CO1. Students can handle physical problems to find an approximated solution
CO2. Students can opt for advance courses in Numerical analysis in higher mathematics.
CO3. Students can use of good mathematical software will help in getting the accuracy one needfrom the computer
CO4. They can assess the reliability of the numerical results, and determine the effect of roundoff error or loss of significance

CO-PO Mapping (GE-IV)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	**3**	**2**	**1**	**1**	**2**	**1**	**1**	**2**
CO2	**3**	**1**	**3**	**2**	**2**	**1**	**2**	**3**
CO3	**2**	**3**	**3**	**3**	**2**	**2**	**3**	**3**
CO4	**2**	**2**	**3**	**2**	**3**	**2**	**2**	**3**

Programme articulation Matrix row for GE-IV

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course GE-IV	**3**	**2**	**3**	**2**	**3**	**2**	**2**	**2**

CO-PSO Mapping (GE-IV)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	**3**	**3**	**3**	**3**	**3**
CO2	**3**	**2**	**3**	**2**	**2**
CO3	**3**	**3**	**3**	**3**	**2**
CO4	**2**	**3**	**3**	**2**	**3**

SKILL ENHANCEMENT COMPULSORY COURSES (SECC)

Optional for SECC II paper (SECC-II)

Skill Enhancement Compulsory Courses (Option1)

COMPUTER GRAPHICS

(Credits-4) Full Marks-100

Course Objective

1.To introduce to the students the concepts of computer graphics viz software, hardware andapplications
2. To introduce students with fundamental concepts and theory of computer graphics.
3. It presents the important drawing algorithm, polygon fitting, clipping and 2D transformationcurves and an introduction to 3D transformation.
4. It provides the basics of OpenGL application programming interface which allows students todevelop programming skills in CG.

SYLLABUS:

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

Books Recommended:

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

Course Outcome

CO1. Explain the applications, areas, and graphic pipeline, display and hardcopy technologies.
CO2. Apply and compare the algorithms for drawing 2D images also explain aliasing, antialiasing and half toning techniques.
CO3. Discuss OpenGL application programming Interface and apply it for 2D & 3D computergraphics.
CO4. Analyze and apply clipping algorithms and transformation on 2D images.
CO5. Solve the problems on viewing transformations and explain the projection and hiddensurface removal algorithms
CO 6. Explain basic ray tracing algorithm, shading, shadows, curves and surfaces and alsosolve the problems of curves.

CO-PO Mapping SECC-II (Computer Graphics)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	3	2	1	1	2	1	1	2
CO2	3	1	3	2	2	1	2	2
CO3	2	3	3	3	2	2	3	2
CO4	2	2	3	2	3	2	2	3
CO5	2	3	2	3	3	2	3	3
CO6	3	2	2	3	2	3	3	3

Programme articulation Matrix row for SECC-II (Computer Graphics)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course SECC-II	3	2	3	2	3	2	2	2

CO-PSO Mapping SECC-II (Computer Graphics)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	3	3	3	3	3
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	2	3	3	2	3
CO5	2	2	3	2	3
CO6	3	3	3	3	2

SKILL ENHANCEMENT COURSES (Option 2)

INFORMATION SECURITY

(Credits-4) Full Marks-100

Course Objective

1. Know that information security is concerned with securing all of the information resources, not just hardware and data
2. Know the three main objectives of information security.
3. Know that management of information security consists of two areas-information security management (ISM) and business continuity management (BCM).
4. See the logical relationship among threats, risks, and controls.

SYLLABUS:

Overview of Security: Protection versus security; aspects of security data integrity, data availability, privacy; security problems, user authentication, Orange Book. Security Threats: Program threats, worms, viruses, Trojan horse, trap door, stack and buffer over flow; system threats- intruders; communication threats- tapping and piracy. Security Mechanisms: Intrusion detection, auditing and logging, tripwire, system-call monitoring.

Books Recommended:

1. C. Pfleeger and S. L. *Pfleeger-Security in Computing*, 3rd Edition. Prentice-Hall of India,2007.
2. D. Gollmann, *Computer Security*, John Wiley and Sons, NY, 2002.
3. J. Piwprzyk, T. Hardjono and J. Seberry, *Fundamentals of Computer Security*, Springer-Verlag Berlin, 2003.335
4. J.M. Kizza, *Computer Network Security*, Springer, 2007.
5. M. Merkow and J. Breithaupt, *Information Security: Principles and Practices*,PearsonEducation, 2006.

Course Outcomes

After studying this course, you should be able to:

CO1. define what information is
CO2. appreciate the value of information to the modern organization
CO3. understand the CIA triad of Confidentiality, Integrity and Availability
CO4 appreciate the difficulties that arise when valuable information needs to be shared
CO5. identify the five leading-edge resources that have up-to-date information on informationsecurity.

SKILL ENHANCEMENT COURSES-II (Option3)
INTRODUCTION TO MATLAB
(Credits-4)Full Marks-100

Course Objective

1. To Impart the Knowledge to the students with MATLAB software.
2. This enhances programming knowledge in Research and Development.
3. To provide a working introduction to the MATLAB technical computing environment.
4. To allow a programmer to interactively design a Graphical User Interface (GUI) for hisprogram.

SYLLABUS:

UNIT-I **(12 Hours)**

Starting with MATLAB, MATLAB Windows, Arithmetic Operations, Elementary Math built-in functions, Defining scalar variables, Creating arrays: one dimensional, two-dimensional.

UNIT-II **(12 Hours)**

Variables in MATLAB, Transpose, Array addressing, Adding and deleting elements, Addition and Subtraction with arrays, Array multiplication, Array division, Element-by-element operations, using arrays in MATLAB built-in Math functions, Built-in functions for analyzing arrays.

UNIT-III **(12 Hours)**

Two-dimensional plots: The plot command, f plot command, plotting multiple graphs, formatting a plot, Plots with special graphics, Histograms, Polar plots.

UNIT-IV **(12 Hours)**

Three dimensional plots: Line plots, Mesh and surface plots, plots with special graphics.

Books Recommended:

1. A. Gilat, *MATLAB: An Introduction with Applications*, Wiley, 2004
2. Rudra Pratap, *Getting started with MATLAB*., 2nd Edition, Oxford University Press,1999

1. Training Programmes to be Imparted

1. There should be training programs in MATLAB/ PYTHON/R/ MATHEMATICA software forall college teachers to acquaint the teachers on state of the art. Experts from Indian Statistical Institute Kolkata and nearby IIT's should be invited for the programs to ensure quality.
2. The faculty members in colleges/universities should be trained in the following courses at University

or

any Institute of Higher Learning.

(a) Advanced Group Theory
(b) Advanced RingTheory
(c) Differential Equations & Mathematical Modeling
(d) Mathematical Finance
(e) Object Oriented Programming in C++
(g) Computer Graphics
(h) Information Security

3. Emphasis may be given for implementation of the programs as listed in the courses with Practical.
4. College/ Universities should be provided with the recommended set of books in adequate numbers.
5. There should be frequent visits to colleges/ Universities offering crash courses to initiate some ofthe new courses.

Required Equipment/Technical Experts

The following equipment /software are to be provided to colleges / universities for smooth running ofpractical/ project:

There should be funding to Computer Lab with minimum of 15 computer systems for 30 studentswith licensed MATLAB/ PYTHON/R/MATHEMATICA software.
At least one computer programmer must be assigned in computer labs during practical sessions.

Course Outcomes.

CO1. Use MATLAB effectively to analyze and visualize data.
CO2. They are fully familiar to all the features of MATLAB software and easily handle thesoftware.
CO3. Apply numeric techniques and computer simulations to solve engineering-relatedproblems.
CO4. Can design refined data-analysis programs that can be operated by relativelyinexperienced users.

CO-PO Mapping SECC-II (Information Security)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO1	3	2	1	1	2	1	1	2
CO2	3	1	3	2	2	1	2	2
CO3	2	3	3	3	2	2	3	2
CO4	2	2	3	2	3	2	2	3
CO5	3	3	2	3	2	3	2	3

Programme articulation Matrix row for SECC-II (Information Security)

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
Course SECC-II	3	2	3	2	3	2	2	2

CO-PSO Mapping SECC-II (Information Security)

	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5
CO1	3	3	3	3	3
CO2	3	2	3	2	2
CO3	3	3	3	3	2
CO4	2	3	3	2	3
CO5	3	2	3	2	3