M.Sc. Mathematics

Courses of study, Schemes of Examinations
& Syllabi

For the students admitted in the academic year 2021-2022
(Under Choice Based Credit System)

PG AND RESEARCH DEPARTMENT OF MATHEMATICS
(DST – FIST sponsored)
BISHOP HEBER COLLEGE (Autonomous)
(Reaccredited with 'A' Grade (CGPA – 3.58/4.0) by the NAAC &
Identified as College of Excellence by the UGC)
DST – FIST Sponsored &
DBT Sponsored
TIRUCHIRAPPALLI – 620 017
TAMIL NADU, INDIA
2021 – 2022

Vision and Mission of the Department.

Our Vision

- ✓ To develop globally competent mathematicians through industry-linked, research-focused, technology-enabled seamless higher education in Mathematics and mould the young minds to serve for the betterment of the society with love and justice.

Our Mission

- ✓ Offer Competent and comprehensive curriculum and conducive environment for holistic development.
- ✓ Inculcate passion for research and perform widely recognized outstanding research in the fields of Mathematics, Statistics and the interdisciplinary areas
- ✓ Collaborate globally, construct industry – academia link and contribute for nation building

Program Outcome and Program Specific Outcomes

Program Outcomes (POs)

After successful completion of the program, the students will be able to:

KNOWLEDGE

PO1: Analyze and apply the mathematical concepts in all fields leading to new research outcomes.

PO2: Solve the real-world problems that demand logical thinking and reasoning.

PO3: Demonstrate knowledge and understanding of mathematical concepts and establish proofs in terms of mathematical arguments

SKILLS

PO4: Identify, formulate and analyze the complex problems using the principles of Mathematics.

PO5: Represent mathematical information numerically, symbolically, graphically, verbally and visually using appropriate technology.

PO6: Exercise abstract reasoning and make ideas precise by formulating them mathematically.

ATTITUDES

PO7: Demonstrate critical thinking, leadership qualities through self-directed and life-long learning.

PO8: Collaborate with people across the world productively and contribute effectively to the scientific community.

ETHICAL & SOCIAL VALUES

PO9: Practice moral and ethical values with the responsibility of fulfilling the civic duty as per the societal expectations.

Programme Specific Outcomes (PSOs) – M.Sc.,

After successful completion of the program, the students will be able to:

INTELLECTUAL SKILLS

PSO1: Comprehend and write effective reports and design documentation related to Mathematical research and literature and make effective presentations.

PSO2: Investigate and solve Mathematical problems of statistics, optimization techniques required in science, technology, business and industry, and illustrate the solutions using symbolic, numeric, or graphical methods.

PRACTICAL SKILLS

PSO3: Integrate Mathematical knowledge and computational skills appropriate to professional activities.

TRANSFERABLE SKILLS

PSO4: Exhibit innovative skills to work effectively in the fields of Finance, Science and Technology and interdisciplinary domains.

PG AND RESEARCH DEPARTMENT OF MATHEMATICS

ARTICULATION MATRIX 2021 -2022

COURSE CODE	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
P21MA101	H	L	M	M	L	L	M	L	-	M	L	H	L
P21MA102	H	H	H	H	M	M	M	M	-	H	-	H	-
P21MA103	L	-	-	M	-	L	-	-	M	H	-	-	L
P21MA104	H	M	L	L	M	M	L	-	-	M	L	L	-
P21MA1:1	H	M	M	H	M	H	M	H	-	H	H	M	M
P21MA205	H	L	M	M	L	L	-	-	-	L	M	-	-
P21MA206	H	H	H	M	M	H	M	M	-	M	M	H	M
P21MA207	M	L	M	L	L	L	-	-	-	-	M	L	L
P21MA2:P	L	-	-	M	-	L	-	-	M	H	-	-	L
P21MA2:3	H	H	M	H	M	H	M	M	-	H	M	L	L
P21MA308	H	M	H	H	H	H	H	H	-	H	-	H	H
P21MA309	H	M	H	-	-	L	M	L	-	M	M	M	H
P21MA310	H	H	M	M	M	M	M	M	-	L	M	M	M
P21MA311	M	M	L	L	M	M	M	L	L	H	M	M	M
P21MA3:4	H	H	H	H	H	H	H	H	L	H	M	H	H
P21MA412	H	H	H	H	M	M	M	M	-	H	-	H	-
P21MA413	H	H	M	H	H	H	M	M	-	H	M	L	L
P21MA414	H	H	M	H	M	M	M	M	H	L	H	L	M
P21MA4:5	H	H	H	M	M	M	M	H	M	M	H	M	M

M. Sc Mathematics

Eligibility : An under graduate degree in Mathematics.

PD. REFERENCE : A high first class in Part III of the UG Curriculum.

Structure of the Curriculum

Parts of the Curriculum	**No. of courses**	**Credits**
Core	14	64
Elective	5	20
Project	1	4
VLOC	1	2
Total	**21**	**90**

List of Core Courses

1. Real Analysis
2. Linear Algebra
3. Ordinary Differential Equations
4. Calculus of Variations, Integral Equations & Transforms
5. Algebra
6. Partial Differential Equations
7. Fluid Dynamics
8. Topology
9. Measure and Integration
10. Complex Analysis
11. Probability and Statistics
12. Functional Analysis
13. Numerical Analysis
14. Operations Research

List of Elective Courses

1. Graph Theory
2. Finite Difference Methods
3. Object Oriented Programming in C++
4. Differential Geometry
5. Data Envelopment Analysis
6. Problem Solving in Advanced Mathematics
7. Stochastic Processes
8. Mathematical Modelling in Human Resource Management

List of Extra Credit Courses offered by the Department

1. Wavelet Theory
2. Theory of Linear Operators
3. Mathematical Physics
4. History of Modern Mathematics
5. Research Methodology

M.Sc., Mathematics

For the students admitted in the academic year 2021-2022

Sem.	Course	Course Code	Course Title	Hrs./ week	Credits	Marks		
						CIA	ESA	Total
I	Core I	P21MA101	Real Analysis	6	5	25	75	100
	Core II	P21MA102	Linear Algebra	6	5	25	75	100
	Core III	P21MA103	Ordinary Differential Equations	6	4	25	75	100
	Core IV	P21MA104	Calculus of Variations, Integral Equations and Transforms	6	4	25	75	100
	Elective I	P21MA1:1 / P21MA1:2	Graph Theory / Finite Difference Methods	6	4	25	75	100
II	Core V	P21MA205	Algebra	6	5	25	75	100
	Core VI	P21MA206	Partial Differential Equations	6	4	25	75	100
	Core VII	P21MA207	Fluid Dynamics	6	5	25	75	100
	Elective II	P21MA2:P	Object Oriented Programming in C++	6	4	40	60	100
	Elective III	P21MA2:3 / P21MA2:4	Differential Geometry / Data Envelopment Analysis	4	4	25	75	100
	VLOC	P17VL2:1 / P17VL2:2	Religious Instructions / Moral Instructions	2	2	25	75	100
III	Core VIII	P21MA308	Topology	6	5	25	75	100
	Core IX	P21MA309	Measure and Integration	6	5	25	75	100
	Core X	P21MA310	Complex Analysis	6	5	25	75	100
	Core XI	P21MA311	Probability and Statistics	6	4	25	75	100
	Elective IV	P21MA3:4	Problem Solving in Advanced Mathematics	6	4	25	75	100
IV	Core XII	P21MA412	Functional Analysis	6	5	25	75	100
	Core XIII	P21MA413	Numerical Analysis	6	4	25	75	100
	Core XIV	P21MA414	Operations Research	6	4	40	60	100
	Elective V	P21MA4:5 / P21MA4:6	Stochastic Processes / Mathematical Modelling in Human Resources Management	6	4	25	75	100
	Project	P21MA4PJ	Project	6	4	40	60	100
			Total		**90**			**2100**

CIA- Continuous Internal Assessment **ESA- End Semester Assessment**
VLOC- Value added Life Oriented Course

Core Course I: REAL ANALYSIS

Semester: I **Course Code: P21MA101**

Credits: 5 **Hours/Week: 6**

1. COURSE OUTCOMES

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

CO. No.	Course Outcomes	Level	Unit
CO1	Analyze the Metric space and functions defined on Metric Space	**K4**	**I**
CO2	Analyze the characteristics of compact set and perfect set.	**K4**	**I**
CO3	Explain how the continuity function preserve the compactness and connectedness of sets.	**K5**	**II**
CO4	Analyze the differentiability of various functions and characteristics of differentiable functions.	**K4**	**III**
CO5	Explain the existence of R-S Integral and its properties	**K5**	**IV**
CO6	Explain the uniform convergence of sequences and series of real functions and nature of the limit functions.	**K5**	**V**

2A. SYLLABUS

Unit I : Metric Space **(20 Hours)**

Metric spaces with examples – Neighbourhood – Open sets – Closed sets – Compact sets – Perfect sets – the Cantor set – Connected sets.

Unit II : Continuous Function **(20 Hours)**

Limit of functions – Continuous functions – Continuity and Compactness – Continuity and Connectedness – Discontinuities – Monotonic functions.

Unit III : Differentiable Function **(15 Hours)**

The derivative of a real function – Mean value theorems – The continuity of derivatives – L'Hospital's Rule – Derivative of higher order.

Unit IV: R-S Integral **(20 Hours)**

Definition and Existence of R-S Integral – Properties of the Integral – Integration and Differentiation.

Unit V: Uniform Convergence **(15 Hours)**

Discussion of main problem – Uniform Convergence – Uniform Convergence and Continuity – Uniform Convergence and Integration – Uniform Convergence and differentiation – The Stone Weierstrass theorem.

B. TOPICS FOR SELF STUDY

S.No.	Topics	Web Links
1	Construction of Everywhere Continuous Nowhere Differentiable Function	https://nptel.ac.in/courses/111/106/111106053/
2	Applications of Riemann Integrals	https://nptel.ac.in/courses/122/104/122104017/
3	Equicontinuous family of Functions: Arzela - Ascoli Theorem	https://www.youtube.com/watch?v=sslQQHAchMY
4	Introduction to the Implicit Function Theorem	https://www.youtube.com/watch?v=msIZz8ydzcM

C. TEXT BOOK(s)

Walter Rudin, Principles of Mathematical Analysis, McGraw – Hill Book Company, New York, 3rd Edition 2013.

Unit I - Chapter 2 § 2.15 - 2.47

Unit II - Chapter 4 § 4.1 - 4.30

Unit III - Chapter 5 § 5.1 - 5.15

Unit IV - Chapter 6 § 6.1 - 6.22

Unit V - Chapter 7 § 7.1 - 7.18 & 7.26

D. REFERENCES BOOKS

1. Tom Apostal, Mathematical Analysis, Addison – Wesley Publishing Company, London 1971.
2. Richard R.Goldberg, Methods of Real Analysis, Oxford & IBH Publishing Company(Last reprint), 2017.
3. H.L.Roydan, Real Analysis, Pearson Education (Singapore) Pvt. Ltd. Third Edition, (Reprint) 2004.

E. WEB LINKS

1. https://www.digimat.in/nptel/courses/video/111105043/L01.html

2. https://nptel.ac.in/courses/111/106/111106053/

3. SPECIAL LEARNING OUTCOMES (SLOs)

Unit/ Section	Course Content	Learning Outcomes	Highest Bloom's Taxonomic Level of Transaction
I	**Metric Space**		
1.1	Metric Spaces with examples	Identify the Metric Space	K3
1.2	Neighbourhood	Interpret the neighbourhood in different domain	K2
1.3	Open Sets	Examine the given set is open or not	K4
1.4	Closed Sets	Examine the given set is closed or not	K4
1.5	Compact Sets	Analyze the characteristics of a compact set.	K4
1.6	Perfect Sets	Explain the real number system as a perfect set.	K2
1.7	The Cantor Set	Recognize that there exist perfect sets in R which contain no segment.	K2
1.8	Connected Set	Analyze the property of the connected set.	K4
II	**Continuous Function**		
2.1	Limit of functions	Explain the limit point in terms of limits of sequences.	K5
2.2	Continuous functions	Explain the continuous function geometrically	K4
2.3	Continuity and Compactness	Analyze the characteristics of a compact set through continuity.	K4
2.4	Continuity and Connectedness	Analyse the characteristics of a connected set through continuity.	K4
2.5	Discontinuities	Classify the kinds of discontinuity.	K4
2.6	Monotonic functions	Identify the monotonically increasing and decreasing function	K3
III	**Differentiable Function**		
3.1	Mean Value Theorems	Apply the Mean Value Theorem	K3
3.2	The Continuity of derivatives	Explain the property of the derivative of a continuous function	K4
3.3	L'Hospital's Rule	Evaluate the limits using the L'Hospital's rule	K5

3.4	Derivative of higher order	Describe the existence of higher order derivative and prove the Taylor's theorem.	K5
IV	**Riemann Stieltjes Integral**		
4.1	Definition and Existence of R-S Integral	Explain the existence of the R-S integral	K2
4.2	Properties of the Integral	Analyze the properties of the R-S integral.	K4
4.3	Integration and Differentiation	Prove the fundamental theorem of Calculus & Integration by parts.	K5
V	**Uniform Convergence**		
5.1	Discussion of Main Problem	Determine whether important properties of functions are preserved under the limit operations.	K5
5.2	Uniform Convergence	Analyze the characteristics of uniform convergence.	K4
5.3	Uniform Convergence and Continuity	Analyze the characteristics of uniform convergence for the sequence of functions through continuity.	K4
5.4	Uniform Convergence and Integration	Analyze the uniform convergence of sequences of functions under integration.	K4
5.5	Uniform Convergence and Differentiation	Analyze the uniform convergence of sequences of functions under differentiation.	K4
5.6	The Stone-Weierstrass theorem	Analyze the uniform convergence for the sequence of polynomials.	K4

4. MAPPING SCHEME (POs, PSOs AND COs)

P21MA101	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	M	-	L	M	-	-	-	-	-	L	-	M	-
CO2	M	-	H	M	L	L	M	L	-	L	-	M	-
CO3	H	M	H	L	L	L	L	M	-	L	-	H	-
CO4	H	M	M	L	L	L	M	M	-	H	L	H	L
CO5	H	L	L	M	-	-	M	-	-	M	L	M	L
CO6	H	-	L	M	-	-	M	-	-	M	L	H	L

L – Low **M – Medium** **H-High**

5. COURSE ASSESSMENT METHODS

DIRECT:

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book
2. Open Book Test.
3. Cooperative Learning Report, Assignment, Group Presentation, Group Discussion, Project Report, Seminar, Quiz (written).
4. Pre-Semester & End Semester Theory Examination

INDIRECT:

1. Course end survey (Feedback)

NAME OF THE COURSE COORDINATOR: Dr. M. Evangeline Jebaseeli

Core Course II: LINEAR ALGEBRA

Semester : I **Course Code: P21MA102**

Credits : 5 **Hours/Week : 6**

1. COURSE OUTCOMES

After the successful completion of this course the students will be able to:

CO. No.	Course Outcomes	Level	Unit
CO1	Explain the concept of vector spaces and classify vector spaces based on their dimension.	**K5**	**I**
CO2	Determine the relationship between the matrices and linear transformations.	**K5**	**II**
CO3	Construct new ideals from the annihilating polynomials.	**K6**	**III**
CO4	Determine the eigenvalues and eigenvectors for the given matrix.	**K5**	**IV**
CO5	Build new invariant subspaces so that the given vector space can be written as a direct sum of its invariant subspaces.	**K6**	**V**
CO6	Examine the geometric perspectives of vectors.	**K4**	**V**

2A. SYLLABUS

Unit I : Vector Spaces **(20 Hours)**

Vector spaces – Subspaces – Bases and Dimension – Coordinates – Linear Transformation Algebra of Linear Transformation.

Unit II : Linear Transformations **(15 Hours)**

Isomorphism of Vector Spaces – Representation of Linear Transformations by Matrices – Linear Functional – The Double Dual – The Transpose of a Linear Transformation.

Unit III : Algebra of Polynomials **(15 Hours)**

Algebras - The Algebra of Polynomials – Polynomial Ideals – The Prime Factorization of a Polynomial - Commutative rings – Determinant Functions.

Unit IV : Eigenvalues and Eigenvectors, Direct Sum Decomposition **(20 Hours)**

Characteristic Values – Annihilating Polynomials - Invariant subspaces – Direct-sum Decompositions.

Unit V : Invariant Direct Sums, Inner Product Spaces, Operators **(20 Hours)**

Invariant Direct sums – The Primary Decomposition Theorem – Inner Products – Inner Product Spaces – Unitary Operators – Normal Operators

B. TOPICS FOR SELF STUDY

S.No.	Topics	Web Links
1	Quadratic Forms	http://www.rmi.ge/~kade/LecturesT.Kadeishvili/MathEconomics/Term3/Week3QuadraticLEC.pdf
2	Positive Forms	https://medium.com/sho-jp/linear-algebra-101-part-8-positive-definite-matrix-4b0b5acb7e9a
3	Spectral Theory	http://www.math.lsa.umich.edu/~speyer/417/SpectralTheorem.pdf
4	Bilinear Forms	https://kconrad.math.uconn.edu/blurbs/linmultialg/bilinearform.pdf

C. TEXT BOOK(s)

1. Kenneth Hoffman and Ray Kunze, Linear Algebra, Pearson India Education Services Pvt. Ltd, 2nd Edition 2015

D. REFERENCE BOOKS

1. I. N. Herstein, Topics in Algebra, Wiley Eastern Limited, New Delhi, 1975.
2. David C. Lay, Linear Algebra and its Applications, Pearson Education Pvt. Ltd. Third Edition (Fifth Indian Reprint) 2005.
3. I. S. Luther and I.B.S. Passi, Algebra, Vol. I – Groups, Vol. II – Rings, Narosa Publishing House (Vol. I – 1996, Vol. II - 1999).
4. N. Jacobson, Basic Algebra, Vols. I & II, Freeman, 1980 (also published by Hindustan Publishing Company).

E. WEB LINKS

1. https://nptel.ac.in/courses/111/106/111106051/
2. https://www.classcentral.com/course/swayam-linear-algebra-7928

3. 3. SPECIFIC LEARNING OUTCOMES (SLOs)

Unit/ Section	Course Content	Learning outcomes	Highest Bloom's Taxonomic Level of Transaction
I	**Vector Spaces**		
1.1	Vector spaces	Explain the basics of vector spaces	K5
1.2	Subspaces	Outline the idea of subspaces	K2
1.3	Bases and Dimension	Categorize vector spaces via basis	K4
1.4	Coordinates.	Infer the co – ordinates for the vectors	K2
1.5	Linear Transformation	Outline the basics of Linear Transformation	K2

1.6	The Algebra of Linear Transformations	Examine the properties of Linear Transformation	K4
II	**Linear Transformations**		
2.1	Isomorphism of Vector Spaces	Classify the vector spaces based on their dimensions	K4
2.2	Representation of Linear Transformations by Matrices	Determine the relationship between the matrices and linear transformations.	K5
2.3	Linear Functional	Explain the idea of functional	K5
2.4	The Double Dual	Construct double dual from the dual space	K3
2.5	The Transpose of a Linear Transformation.	Discover the relationship between the transformation and transpose of a transformation	K4
III	**Algebra of Polynomials**		
3.1	Algebras	Explain Algebra of Polynomials	K5
3.2	The Algebra of Polynomials	Examine the properties of Algebra of Polynomials	K4
3.3	Polynomial Ideals	Explain the concept of ideals generated by the polynomials	K5
3.4	The Prime Factorization of a Polynomial	Apply prime factorization to factorize the given polynomial into the product of irreducible polynomials	K3
3.5	Commutative rings	Explain Commutative Ring of polynomials.	K5
3.6	Determinant Functions	Recall the properties of determinant function	K1
IV	**Eigenvalues and Eigenvectors, Direct Sum Decomposition**		
4.1	Characteristic Values	Determine the eigenvalues and eigenvectors of the given matrix	K5
4.2	Annihilating Polynomials	Outline the idea of Annihilating Polynomials.	K2
4.3	Invariant subspaces	Construct invariant subspace from the given vector space.	K3
4.4	Direct-sum Decompositions.	Dissect the given vector space as a direct sum of its subspaces.	K4
V	**Invariant Direct Sums, Inner Product Spaces, Operators**		
5.1	Invariant Direct sums	Explain the concept of Invariant Direct sums.	K5
5.2	The Primary Decomposition Theorem	Dissect the given vector space as a direct sum of its invariant subspaces.	K4

5.3	Inner Products	Outline the idea of Inner Product	K2
5.4	Inner Product Spaces	Construct orthogonal set of vectors using the inner products	K6
5.5	Unitary Operators	Examine the eigenvectors of Unitary Operators.	K4
5.6	Normal Operators	Examine the eigenvectors of Normal Operators.	K4

4. MAPPING SCHEME FOR THE POs, PSOs AND COs

P21MA102	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	H	H	H	M	M	M	M	-	H	-	H	-
CO2	H	H	H	H	M	M	M	M	-	H	-	H	-
CO3	H	H	H	M	M	M	M	M	-	H	-	H	-
CO4	H	H	H	M	M	M	M	M	-	H	M	H	-
CO5	H	M	M	H	H	H	M	M	-	H	-	H	-
CO6	H	H	H	H	M	M	M	M	-	H	-	H	-

L-Low **M-Moderate** **H- High**

5. COURSE ASSESSMENT METHODS

DIRECT:

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book
2. Open Book Test.
3. Cooperative Learning Report, Assignment, Group Presentation, Group Discussion, Project Report, Seminar, Quiz (written).
4. Pre-Semester & End Semester Theory Examination

INDIRECT:

1. Course end survey (Feedback)

NAME OF THE COURSE COORDINATOR: Dr. M. Cruz

Core Course III - ORDINARY DIFFERENTIAL EQUATIONS

Semester : 1 **Course Code: P21MA103**

Credits: 4 **Hours/Week: 6**

1. COURSE OUTCOMES

After the successful completion of this course, the students will be able to

CO. No.	Course Outcomes	Level	Unit
CO1	solve ordinary differential equations using suitable methods.	**K3**	**I**
CO2	identify the existence of special functions and their properties.	**K3**	**II**
CO3	apply suitable methods to solve linear systems of first order equations	**K3**	**III**
CO4	deduct the analytical properties of a solution of a boundary value problem.	**K5**	**IV**
CO5	analyze the stability and critical points of system of nonlinear equations.	**K4**	**V**
CO6	construct models to solve problems in Physics.	**K6**	**V**

2A. SYLLABUS

Unit I : Second order linear equations **(18 Hours)**

The general solution of the homogeneous equation – The use of one known solution to find another – The method of variation of parameters – Power Series solutions. A review of power series – Series solutions of first order equations – Second order linear equations; Ordinary points.

Unit II : Power series solutions and Special functions **(18 Hours)**

Regular Singular Points – Gauss's hypergeometric equation – The Point at infinity – Legendre Polynomials – Bessel functions – Properties of Legendre Polynomials and Bessel functions.

Unit III : Systems of first order equations **(18 Hours)**

Linear Systems of First Order Equations – Homogeneous equations with constant coefficients – The Existence and uniqueness of solutions of Initial Value Problems for First Order Ordinary Differential Equations – The method of solutions of successive approximations and Picard's theorem.

Unit IV : Qualitative properties of solutions **(18 Hours)**

Oscillation theory and Boundary Value Problems – Qualitative properties of solutions – Oscillations and the Sturm separation theorem, Sturm Comparison Theorems – Eigenvalues, Eigen functions and the Vibrating String.

Unit V : Nonlinear Equations **(18 Hours)**

Nonlinear equations: Autonomous Systems; the phase plane and its phenomena – Types of critical points; Stability – Critical points and stability for linear systems – Stability by Liapunov's direct method – Simple critical points of nonlinear systems.

B. TOPICS FOR SELF STUDY

S.No.	Topics	Web Links
1	Fourier series	https://www.mathsisfun.com/calculus/fourier-series.html
2	Laplace transform	https://mathworld.wolfram.com/LaplaceTransform.html
3	Legendre functions of the second kind (second solution), associated Legendre polynomials, bounds for Legendre polynomials and table of Legendre and associate Legendre functions	http://dsp-book.narod.ru/HFTSP/8579ch21.pdf
4	Integral representation of Bessel functions, Fourier-Bessel series, Bessel functions of the second kind and modified Bessel function	http://dsp-book.narod.ru/HFTSP/8579ch25.pdf

C. TEXT BOOKs

George F. Simmons, Differential Equations with Applications and Historical Notes, Tata McGraw Hill Publishing Company Limited, New Delhi, Second Edition 2003.

D. REFERENCE BOOKS

1. W.T. Reid, Ordinary Differential Equations, John Wiley & Sons, New York, 1971.

2. E. A. Coddington and N. Levinson, Theory of Ordinary Differential Equations, McGraw Hill Publishing Company, New York, 1955.

E. WEB LINKS

1. https://nptel.ac.in/courses/111/106/111106100/
2. https://onlinecourses.nptel.ac.in/noc21_ma09/preview

3. 3. SPECIFIC LEARNING OUTCOMES (SLOs)

Unit/Section	Course Content	Learning Outcomes	Cognitive process domain
I	**Second order linear equations**		
1.1	Second order linear differential equations.	find the general solution of second order linear differential equations.	K1

1.2	The general solution of the homogeneous equation.	construct the linearly independent solutions for homogeneous equation.	K3
1.3	The use of a known solution to find another.	utilize one independent solution to obtain another.	K3
1.4	The method of variation of parameters.	find the particular solution for non-homogeneous equation.	K1
1.5	A review of power series.	list the properties of power series.	K1
1.6	Series solutions of first order equations.	find the general solution of second order linear differential equations.	K1
1.7	Second order linear equations and ordinary points.	find the general solution of second order linear differential equations.	K1
II	**Power series solutions and Special functions**		
2.1	Regular singular points.	construct the solution near singular point.	K3
2.2	Guass's Hypergeometric equation.	find the solution for Guass's Hypergeometric equation.	K1
2.3	The point at infinity.	construct the solution near the point at infinity.	K3
2.4	Legendre polynomial.	find the solution for Legendre's equation.	K1
2.5	Properties of Legendre polynomials.	identify the properties of Legendre polynomials.	K3
2.6	Bessel Functions, the Gamma function, the general solution of Bessel's equation and the properties of Bessel functions.	construct the general solution for Bessel's Equation.	K3
III	**Systems of first order equations**		
3.1	Linear systems of first order equations.	solve linear systems of first order equations.	K3
3.2	Homogeneous linear systems with constant coefficients.	solve homogeneous linear systems of first order equations.	K3
3.3	The method of successive approximations.	compare the general solution of first order linear differential equations.	K2
3.4	Picard's Theorem.	demonstrate the Existence and uniqueness of solutions of Initial Value Problems for First Order Ordinary Differential Equations.	K2
IV	**Qualitative properties of solutions**		
4.1	Oscillations and the Sturm separation theorem, Sturm Comparison Theorem.	determine the behavior of the solutions.	K5

4.2	Eigenvalues, Eigen functions and the Vibrating String.	compare the general solution of second order linear differential equations	K5
V	**Nonlinear Equations**		
5.1	Nonlinear equations: Autonomous Systems; the phase plane and its phenomena.	define an autonomous system; the phase plane and its phenomena.	K1
5.2	Types of critical points; Stability.	list the types of critical points and stability for an autonomous system.	K1
5.3	Critical points and stability for linear systems.	determine the types of critical points and stability for linear systems.	K5
5.4	Stability by Liapunov's direct method.	construct the Liapunov's function for the system.	K6
5.5	Simple critical points of nonlinear systems.	classify the critical points of linear and non-linear systems of ordinary differential equations	K4

4. MAPPING SCHEME (POs, PSOs AND COs)

P21MA103	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	-	-	M	-	M	M	-	M	H	-	-	H
CO2	M	-	M	M	-	M	-	-	M	H	-	-	H
CO3	H	-	-	-	-	-	-	-	M	M	-	-	-
CO4	-	-	-	H	-	-	-	-	M	M	-	-	-
CO5	-	-	-	-	-	-	-	-	M	H	-	-	-
CO6	-	-	-	M	-	-	-	-	M	M	-	-	-

L-Low M-Moderate H- High

5. COURSE ASSESSMENT METHODS

DIRECT:

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book
2. Open Book Test.
3. Cooperative Learning Report, Assignment, Group Presentation, Group Discussion, Project Report, Seminar, Quiz (written).
4. Pre-Semester & End Semester Theory Examination

INDIRECT:

1. Course end survey (Feedback)

NAME OF THE COURSE COORDINATOR: Dr. S. Parthiban

Core Course IV - CALCULUS OF VARIATION, INTEGRAL EQUATIONS AND TRANSFORMS

Semester : I **Course Code: P21MA104**

Credits : 4 **Hours/Week: 6**

1. COURSE OUTCOMES

After the successful completion of this course the students will be able to:

CO. No.	Course Outcomes	Level	Unit
CO1	Identify extreme values of functional	**K3**	**I**
CO2	Evaluate Euler-Lagrange equation to find differential equations for stationary paths.	**K5**	**I**
CO3	Distinguish isoperimetric problems of standard types.	**K4**	**II**
CO4	Solve integral equations using Green's function in one and more unknown functions.	**K6**	**III**
CO5	Analyze the relationship between integral and differential equations and transform one type into another.	**K4**	**IV**
CO6	Analyze engineering problems by using Fourier Transform Techniques.	**K4**	**V**

2A. SYLLABUS

Unit I : Calculus of variations **(18 Hours)**

The Calculus of Variations - Functionals – Euler's equations – Geodesics – Variational problems involving several unknown functions – Functionals dependent on higher order derivatives – Variational problems involving several independent variables.

Unit II : Variational problem with moving boundaries **(18 Hours)**

Constraints and Lagrange multipliers – Isoperimetric problems – The general variation of a functional – Variational problems with moving boundaries – Hamilton's principle – Lagrange's equations.

Unit III : Integral equations **(18 Hours)**

Integral Equations – Introduction – Relation between differential and integral equations – Relationship between Linear differential equations and Volterra integral equations – The Green's function and its use in reducing boundary value problems to integral equations.

Unit IV : Fredholm equations **(18 Hours)**

Fredholm equations with separable kernels – Fredholm equations with symmetric kernels : Hilbert Schmidt theory – Iterative methods for the solution of integral equations.

Unit V : Fourier transform **(18 Hours)**

Fourier Transform and Its Inverse – Shifting Property of Fourier Transforms – Modulation Property of Fourier Transforms – Convolution Theorem – Fourier Sine and Cosine Transforms – Linearity of Transforms – Change of Scale Property of Transforms – Transforms of Derivatives – Parseval's Identities.

B. TOPICS FOR SELF STUDY

S.No.	Topics	Web Links
1.	Neumann Series and Resolvent Kernel I	https://nptel.ac.in/courses/111/107/111107103/
2.	Neumann Series and Resolvent Kernel II	https://nptel.ac.in/courses/111/107/111107103/
3.	Equations with Convolution type Kernel-I	https://nptel.ac.in/courses/111/107/111107103/
4.	Equations with Convolution type Kernel-II	https://nptel.ac.in/courses/111/107/111107103/
5.	Singular Integral Equations-I	https://nptel.ac.in/courses/111/107/111107103/
6.	Singular Integral Equations-I	https://nptel.ac.in/courses/111/107/111107103/

C. TEXT BOOK(s)

1. Dr. M.K. Venkataraman, Higher Mathematics for Engineering and Sciences, The National Publishing Company, 2001 (Unit I, II, III and IV).

2. P. Gupta, Topics in Laplace and Fourier Transforms, Fire Wall Media, Laxmi Publications Pvt. Ltd. 1st Edition (2019), (Unit V).

Unit I	Chapter 9 § 1 – 13
Unit II	Chapter 9 § 14 – 19
Unit III	Chapter 10 § 1 – 5
Unit IV	Chapter 10 § 6 – 9
Unit V	Chapter 5 § 5.3 – 5.11

D. REFERENCE BOOKS

1. Krasnov, Kiselu and Marenko, Problems and Exercises in Integral Equations, MIR Publishers, 1971.

2. Francis. B. Hildebrand, Methods of Applied Mathematics, Prentice-Hall of India Pvt. Ltd., New Delhi, Second Edition 1968.

3. Ram.P.Kanwal, Linear Integral Equations - Theory and Techniques, Academic press, New York, 1971.

E. WEB LINKS

1. https://www.swayam.gov.in/explorer?category=Mathematics
2. https://nptel.ac.in/courses/111/107/111107103/
3. https://nptel.ac.in/courses/111/104/111104025/

3. SPECIFIC LEARNING OUTCOMES (SLOs)

Unit/ Section	Course Content	Learning outcomes	Highest Bloom's Taxonomic Level of Transaction
I	**CALCULUS OF VARIATIONS**		
1.1	Functionals	Determine stationary paths of a functional to deduce the differential equations for stationary paths.	K5
1.2	Euler's equations	Illustrate extremals of the functionals using Euler equations.	K2
1.3	Geodesics	Determine geodesics on surfaces	K5
1.4	Variational problems involving several unknown functions	Identify Variational problems involving several unknown functions	K3
1.5	Functionals dependent on higher order derivatives	Identify extremals of functional with higher order derivatives	K3
1.6	Variational problems involving several independent variables.	Determine the Ostrogradsky equation by the extremals of functional with several independent variables.	K5
II	**VARIATIONAL PROBLEM WITH MOVING BOUNDARIES**		
2.1	Constraints and Lagrange multipliers	Determine Variational procedure for functional with constraints using Lagrange Multipliers.	K5
2.2	Isoperimetric problems	Find variational problems with constraints in both algebraic and isoperimetric.	K1
2.3	The general variation of a functional	Evaluate the General formula for the variation of the functional and Conditions.	K5
2.4	Variational problems with moving boundaries	Examine variational problems with moving boundries	K4
2.5	Hamilton's principle	Determine the Problems using Hamilton's principle.	K5

2.6	Lagrange's equations.	Determine the Problems using Lagrange's equations	K5
III	**INTEGRAL EQUATIONS**		
3.1	Integral Equations – Introduction	Develop the mathematical methods of applied mathematics and mathematical physics with an emphasis on calculus of variation and integral transforms.	K3
3.2	Relation between differential and integral equations	Distinguish the difference between differential equations and Integral equations.	K4
3.3	Relationship between Linear differential equations and Volterra integral equations	Dicuss the relationship between integral and differential equations and transform one type into another.	K6
		Determine linear Volterra and Fredholm integral equations using appropriate methods.	K2
3.4	The Green's function and its use in reducing boundary value problems to integral equations.	Evaluate boundary value problems to integral equations using Green's function.	K5
IV	**FREDHOLM EQUATIONS**		
4.1	Fredholm equations with separable kernels	Construct the general solution of Fredholm integral equation with separable kernel.	K3
4.2	Fredholm equations with symmetric kernels	Determine Fredholm equations with symmetric kernels	K5
4.3	Hilbert Schmidt theory	Find the integral equations by using Hilbert-Schmidt method.	K1
4.4	Iterative methods for the solution of integral equations	Determine integral equation of the second kind by Iterative methods	K5
V	**FOURIER TRANSFORM**		
5.1	Fourier Transform and its Inverse	Determine the solution of boundary value problems using Fourier transform techniques.	K5
5.2	Shifting Property of Fourier Transforms	Illustrate the problems by the concept of Shifting Property of Fourier Transforms	K2
5.3	Modulation Property of Fourier Transforms	Identify the concept of Modulation Property.	K3
5.4	Convolution Theorem	Identify that the convolution of signals in the time domain will be	K3

		transformed into the multiplication of their Fourier transforms in the frequency domain.	
5.5	Fourier Sine and Cosine Transforms	Explain Fourier transform is the input tool that is used to decompose an image into its sine and cosine components	K2
5.6	Linearity of Transforms	Explain Fourier Transform of a sum of functions and multiply function by a constant is the sum of Fourier and constant multiplication of the Fourier Transforms.	K2
5.7	Change of Scale Property of Transforms	Solve a periodic functions Using Change of Scale Property	K6
5.8	Transforms of Derivatives	Solve the problems by Transforms of derivatives.	K6
5.9	Parseval's Identities	Evaluate the problems by Parseval's Identities.	K5

4. MAPPING SCHEME (POs, PSOs AND COs)

P21MA104	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	H	H	M	-	-	H	M	H	L
CO2	H	H	M	-	M	M	M	-	-	M	M	-	-
CO3	H	M	-	M	M	M	-	-	-	-	-	-	-
CO4	M	M	-	-	M	-	-	-	-	-	M	-	-
CO5	M	-	-	-	M	-	-	-	-	M	-	-	-
CO6	H	M	-	-	-	H	-	-	-	H	M	-	-

L-Low M-Moderate H- High

5. COURSE ASSESSMENT METHODS

DIRECT:

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book
2. Open Book Test.
3. Cooperative Learning Report, Assignment, Group Presentation, Group Discussion, Project Report, Seminar, Quiz (written).
4. Pre-Semester & End Semester Theory Examination

INDIRECT:

1. Course end survey (Feedback)

NAME OF THE COURSE COORDINATOR: Dr. C. Priya

Elective I - GRAPH THEORY

Semester : I **Course Code : P21MA1:1**

Credits : 4 **Hours/Week: 6**

1. COURSE OUTCOMES

After the successful completion of this course the students will be able to:

CO. No.	Course Outcomes	Level	Unit
CO1	Determine a shortest route between two nodes in a network	**K5**	**I**
CO2	Explain the concept of connectivity in communication networks	**K5**	**II**
CO3	Explain the Euler tours and Hamiltonian cycles concept in finding shortest paths	**K5**	**II**
CO4	Determine the scheduling concept using edge colouring of graphs	**K5**	**III**
CO5	Explain the partitioning concept using the chromatic number of graphs	**K5**	**IV**
CO6	Design the different networks using directed graphs	**K6**	**V**

2A. SYLLABUS

Unit I : Graphs , Subgraphs and Trees **(18 Hours)**

Graphs and Simple Graphs – Graph Isomorphism – The Incidence and Adjacency Matrices – Subgraphs – Vertex, Degrees – Paths and Connections – Cycles. Trees – Cut edges and bonds, Cut vertices, Cayley's formula.

Unit II : Connectivity, Euler Tours and Hamilton Cycles **(18 Hours)**

Connectivity, Blocks, Euler Tours, Hamilton cycles.

Unit III : Edge Colourings , Independent Sets and Cliques **(18 Hours)**

Edge Chromatic number, Vizing's Theorem, Independent Sets, Ramsey's Theorem – Turan's Theorem.

Unit IV : Vertex colourings and Planar graphs **(18 Hours)**

Chromatic number, Brook's theorem, Hajos conjucture, Chromatic Polynomials, Girth and Chromatic number, Plane and Planar Graphs, Dual Graphs – Euler's formula.

Unit V : Directed Graphs **(18 Hours)**

The Five Colour Theorem and Four Colour Conjecture, Directed Graphs, Directed Paths – Directed Cycles.

B. TOPICS FOR SELF STUDY

S.No.	Topics	Web Links
1	Networks	https://www.youtube.com/watch?v=n4Tqd2jpRyM https://www.youtube.com/watch?v=u2QDNErdYLM
2	Flows in a network	https://www.youtube.com/watch?v=Tl90tNtKvxs
3	Cuts in a network	https://www.youtube.com/watch?v=u6FkNw16VJA
4	The Max-flow Min-cut theorem	https://www.youtube.com/watch?v=oHy3ddI9X3o

C. TEXT BOOKS

1. Bondy, J.A.& Murthy, U.S.R., Graph Theory with Applications, The Mac Millan Press Ltd., 1976.

D. REFERENCE BOOKS

1. Harary, Graph Theory, Narosha Publishing House, New Delhi, 1988.
2 . Arumugam, S & Ramachandran, S., Invitation to Graph Theory, New Gamma Publishing House, Palayamkottai, 1993.

E. WEB LINKS

1. https://swayam.gov.in/explorer?searchText=GRAPH+THEORY
2. https://nptel.ac.in/courses/111/106/111106102/

3. SPECIFIC LEARNING OUTCOMES (SLOs)

Unit/ Section	Course Content	Learning outcomes	Highest Bloom's Taxonomic Level of Transaction
I	**Graphs, subgraphs and trees**		
1.1	Graphs and Simple Graphs	Recall the types of graphs and the properties of graphs.	K1
1.2	Graph Isomorphism	Classify the isomorphic graphs and non-isomorphic graphs	K2
1.3	Incidence and Adjacency Matrices	Construct the graphs and matrices for the network.	K3
1.4	Subgraphs	Classify the types of subgraphs	K2
1.5	Degrees	Apply the concept of degree of vertices in networks.	K3
1.6	Paths and connections	Construct the shortest paths of graph	K3
1.7	Cycles	Apply the concept of cycles in network.	K3

1.8	Trees	Make use of spanning tree concept to find the shortest path.	K3
1.9	Cut edges and bonds	Apply the concept of the cut edge and bond in networks.	K3
1.10	Cut vertices	Apply the concept of the cut vertices in networks.	K3
1.11	Cayley's formula	Determine the number of spanning trees of a complete graph	K5
II	**Connectivity, Euler tours, and Hamilton cycles**		
2.1	Connectivity	Apply the connectivity concept in communication networks.	K3
2.2	Blocks	Relate 2-connected graph and internally - disjoint paths.	K3
2.3	Euler Tours	Determine the Euler tour	K5
2.4	Hamiltonian graphs	Determine the Hamiltonian cycle.	K5
III	**Edge colourings, independent sets and cliques**		
3.1	Edge Chromatic number	Apply the edge colouring concept in scheduling.	K3
3.2	Vizings Theorem	Determine the bounds of edge chromatic number	K5
3.3	Independent Sets	Apply the independent set concept in scheduling.	K3
3.4	Ramsey's Theorem	Identify the Ramsey number of graphs.	K3
3.5	Turans Theorem	Examine the condition for the graph to be isomorphic.	K4
1V	**Vertex Colourings and Planar Graphs**		
4.1	Chromatic number	Apply the vertex coloring concept in partitioning.	K3
4.2	Brook's theorem	Explain the relation between the chromatic number and the maximum degree of a graph.	K5
4.3	Hajos conjucture	Explain the necessary condition for graph to be 4-chromatic	K5
4.4	Chromatic Polynomials	Make use of the concept of chromatic polynomials in partitioning	K3
4.5	Girth and Chromatic Number	Utilize the concept of girth in other partitioning	K3
4.6	Plane and Planar Graphs	Identify the planar graphs	K3
4.7	Dual Graphs	Construct the dual of a graph.	K3
4.8	Euler's formula	Explain that Kuratwoski's graphs are non-planar graphs.	K5
V	**Directed graphs**		
5.1	The Five Colour Theorem and the Four Colour Conjecture	Explain the concept of the five colour theorem and the four colour conjecture in partitioning.	K5
5.2	Directed Graphs	Make use of the concept of the	K3

		Directed Graphs in networks.	
5.3	Directed Paths	Identify the relation between the tournament and Hamiltonian path.	K3
5.4	Directed Cycles	Explain the directed cycles concept in networks.	K5

4. MAPPING SCHEME (POs, PSOs AND COs)

P21MA1:1	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	H	H	H	H	H	H	M	H	-	H	H	M	M
CO2	H	M	M	H	H	H	M	H	-	H	H	M	M
CO3	H	M	M	H	M	H	M	H	-	H	H	M	M
CO4	H	M	M	H	M	H	M	H	-	H	H	M	M
CO5	H	M	M	H	M	H	M	H	-	H	H	M	M
CO6	H	M	M	H	M	H	M	H	-	H	H	M	M

L-Low **M-Moderate** **H- High**

5. COURSE ASSESSMENT METHODS

DIRECT:

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book
2. Open Book Test.
3. Cooperative Learning Report, Assignment, Group Presentation, Group Discussion, Project Report, Seminar, Quiz (written).
4. Pre-Semester & End Semester Theory Examination

INDIRECT:

1. Course end survey (Feedback)

NAME OF THE COURSE COORDINATOR: Dr. S. Sagaya Roesline

Elective I - Finite Difference Methods

Semester : I **Course Code : P21MA1:2**

Credits : 4 **Hours/Week: 6**

1. COURSE OUTCOMES

After the successful completion of this course, the students will be able to

CO. No.	Course Outcomes	Level	Unit
CO1	Classify Difference equation	K2	I
CO2	Solve Difference equation	K3	II
CO3	Analyze the stability of Linear and Non-linear system	K4	III
CO4	Solve Boundary Value Problems	K6	IV
CO5	Construct Difference equation for Partial Differential equation	K3	V
CO6	Solve Partial Differential equation using difference equation	K6	V

2A. SYLLABUS

Unit I : Difference Calculus **(18 Hours)**

Introduction, Difference Calculus – The Difference Operator, Summation, Generating functions and approximate summation.

Unit II : Difference Equations **(18 Hours)**

Linear Difference Equations – First order equations. General results for linear equations. Equations with constant coefficients. Applications, Equations with variable coefficients. Nonlinear equations that can be linearized. The z-transform.

Unit III : Stability Theory **(18 Hours)**

Stability Theory – Initial value problems for linear system. Stability of linear system. Stability of nonlinear systems, chaotic behavior.

Unit IV : Boundary value problems **(18 Hours)**

Boundary value problems for Nonlinear equations – Introduction. The Lipschitz case. Existence of solutions. Boundary value problems for Differential equations.

Unit V : Partial Differential Equation **(18 Hours)**

Partial Differential Equation – Discretization of partial Differential Equations – Solution of Partial Differential Equations.

B. TOPICS FOR SELF STUDY

S. No.	Topics	Web Links
1	Polynomial fittingand one-sided approximation	https://nptel.ac.in/courses/111/107/111107107/
2	Solving Heat equation using Matlab	https://www.youtube.com/watch?v=skCHF5CJhoY
3	Finite differencemethod for waveequation	http://hplgit.github.io/num-methods-for-PDEs/doc/pub/wave/pdf/wave-4print-A4-2up.pdf

C. TEXT BOOKs

1. George F. Simmons, Differential Equations with Applications and Historical Notes, Tata McGraw Hill Publishing Company Limited, New Delhi, Second Edition 2003.

D. REFERENCE BOOKS

1. W.T. Reid, Ordinary Differential Equations, John Wiley & Sons, New York, 1971.
2. E. A. Coddington and N. Levinson, Theory of Ordinary Differential Equations, McGraw HillPublishing Company, New York, 1955.

E. WEB LINKS

1. https://nptel.ac.in/courses/111/107/111107107/
2. https://ocw.mit.edu/courses/mathematics/18-086-mathematical-methods-for-engineers-ii-spring-2006/index.htm

3. SPECIFIC LEARNING OUTCOMES (SLOs)

Unit	Course contents	Learning Outcomes	Cognitive process domain
I	**Difference Calculus**		
1.1	Introduction to Difference Calculus	Explain the concept of difference equation	K1
1.2	The Difference Operator, Summation	List the difference operator	K1
1.3	Generating functions and approximate summation.	Explain Generating function and approximate summation	K2
II	**Difference Equations**		
2.1	Linear Difference Equations	Recall Linear Difference Equations	K1

2.2	First order equations. Generalresults for linear equations.	Find the First order equations.	K1
2.3	The point at infinity Equationswith constant coefficients. Applications	Solve equations with constant coefficients.	K3
2.4	Equations with variablecoefficients.	Solve equations with variable coefficients.	K3
2.5	Nonlinear equations that can belinearized. The z-transform	Explain Linearization and Z transform	K2
III	**Stability Theory**		
3.1	Stability theory Initial valueproblems for linear system.	Explain Stability theory for Initial value problems for linear system.	K3
3.2	Stability of linear system.	Explain Stability theory for boundary value problems for linear system.	K3
3.3	Stability of nonlinear systems,chaotic behavior.	Analyze the stability of nonlinear system	K4
IV	**Boundary value problems**		
4.1	Boundary value problems forNonlinear equations	Demonstrate Boundary value problems for Nonlinear equations	K2
4.2	Introduction. The Lipschitz case.Existence of solutions.	Explain the Lipschitz case and Existence of solutions.	K2
4.3	Boundary value problems forDifferential equations.	Solve Boundary value problemsfor Differential equations	K6
V	**Partial Differential Equations**		
5.1	Partial Differential Equation –Discretization of partial Differential Equations	Construct Difference equation for partial Differential Equations	K3
5.2	Solution of Partial DifferentialEquations.	Solve Partial Differential Equations using Difference equation	K6

4. MAPPING SCHEME FOR THE POs, PSOs AND Cos

P20MA1:2	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	M	M	-	M	M	M	M	M	-	M	-	-	M
CO2	H	H	M	H	M	H	M	-	-	H	H	M	-
CO3	H	H	M	M	H	H	M	M	-	H	-	-	-
CO4	H	H	H	H	H	M	H	M	-	H	M	M	M
CO5	H	H	M	M	M	H	M	-	-	M	M	-	-
CO6	H	H	H	H	H	M	H	M	-	H	M	H	H

L-Low M-Moderate H- High

5. COURSE ASSESSMENT METHODS

DIRECT:

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book
2. Open Book Test.
3. Cooperative Learning Report, Assignment, Group Presentation, Group Discussion, Project Report, Seminar, Quiz (written).
4. Pre-Semester & End Semester Theory Examination

INDIRECT:

1. Course end survey (Feedback)

NAME OF THE COURSE COORDINATOR: Dr. N. Geetha

Core Course: V - ALGEBRA

Semester: II **Course Code: P21MA205**

Credits: 5 **Hours/Week: 6**

1. COURSE OUTCOMES:

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

CO. No.	Course Outcomes	Level	Unit
CO1	analyze structure and properties of finite abelian groups	**K4**	**I**
CO2	understand the properties of Internal and External direct products and modules	**K2**	**II**
CO3	construct finite extensions of fields	**K6**	**III**
CO4	construct Roots of polynomials and more about roots	**K6**	**III**
CO5	describe the concept of Automorphism and the elements of Galois theory	**K5**	**IV**
CO6	investigate solvability of polynomials through Galois theory	**K3**	**V**

2A. SYLLABUS

Unit I: **(18 Hours)**

Another counting principle – Conjugacy – Class equation and its applications – Cauchy's theorem – Partition of a positive integer 'n' – Relation between conjugate classes in Sn and number of partitions of 'n' - Sylow's theorem – Proof (First and Third proofs are omitted) and applications.

Unit II: **(18 Hours)**

Direct products – Internal direct products, external direct products and the relation between them – Finite abelian groups – Modules.

Unit III: **(18 Hours)**

Extension fields- Roots of polynomials – More about roots.

Unit IV: **(18 Hours)**

Galois theory – Fixed fields - Normal extensions - Galois group of a polynomial – Fundamental theorem of Galois theory.

Unit V: **(18 Hours)**

Solvability by radicals – Galois Groups over the rationals.

B. TOPICS FOR SELF-STUDY:

S.No.	Topics	Web Links
1	Another Counting principle Sylow's theorem	https://nptel.ac.in/courses/111/106/111106113/
2	Automorphism	https://nptel.ac.in/content/storage2/111/101/111101117/MP4/mod07lec32.mp4
3	The Elements of Galois Theory	https://nptel.ac.in/content/storage2/111/101/111101117/MP4/mod07lec33.mp4
4	Solvability by Radicals	https://nptel.ac.in/courses/111/101/111101001/

C. TEXT BOOK(s)

1. I. N. Herstein, Topics in Algebra, Willey – Eastern Ltd., New Delhi.

D. REFERENCE BOOKS

1. P. M. Cohn, Algebra (Vols. – I, II, III), John Wiley & Sons, 1982, 1989, 1991.
2. N. Jacobson, W. H. Freeman, Basic Algebra (Vols. – I & II), 1980 (also published by Hindustan Publishing Company)
3. D. S. Malik, J. N. Mordeson and M. K. Sen, Fundamentals of Abstract Algebra, McGraw Hill International Edition, 1997.

E. WEB LINKS

1. https://nptel.ac.in/courses/111/106/111106137/
2. https://swayam.gov.in/NPTEL

3. SPECIFIC LEARNING OUTCOMES (SLOs)

Unit/Section	Course Content	Learning Outcomes	Bloom's Taxonomy Level of Transaction
I	**Cauchy's and Sylow's theorem**		
1.1	**Another counting principle:** Conjugacy, Normalizer	Identify the given subset is conjugate, Normalizer or not. Give the example of conjugacy and Normalizer.	K4
1.2	Class equation and its applications	To know about applications	K4
1.3	Cauchy's theorem	Analyze the characteristics of Cauchy's theorem.	K3
1.4	Partition of a positive integer n	Define partition of n and S_n.	K3

1.5	Relation between conjugate classes in S_n and the number of partitions of n.	To describe the relation between Conjugate classes in S_n and the number of partitions of n.	K4
1.6	**Sylow's theorem:** First part of sylow's theorem, Equivalence class of an element in the Group, Second part of sylow's theorem, Third part of sylow's theorem, Applications of sylow's theorem.	Define Sylow's subgroup with an example. Find the number of Sylow's subgroup for the given group. Analyze the characteristics of Sylow's heorem.	K4
II	**Direct Products**		
2.1	**Direct Products:** Introduction to all aspects of Direct products, Internal direct product and External direct product, Relation between Internal direct product and External direct product.	Define direct product, Internal direct product and External direct product with an example.	K3
2.2	**Finite abelian Groups:** Isomorphism between two abelian Groups, Theorems continued on isomorphic abelian Groups,	Define Isomorphism between two abelian groups. Analyze the characteristics of two abelian groups.	K4
2.3	**Modules:** Introduction about Modules and Sub Modules, Introduction about R-Module, Left R-Module, Right R-Module and its Examples, Direct Sum, Cyclic and Finitely generated R-Module, Fundamental theorem on finitely generated module over Euclidean rings.	Define Modules, Sub modules and R- Module with an example. Analyze the characteristics of finitely generated module over Euclidean Rings.	K4
III	**Extension Fields**		
3.1	**Extension Fields:** Degree of a Vector space over a Field and Finite Extension, Theorems on Finite Extension, Algebraic and Algebraic	Describe the degree of a vector space over Field and finite extension with an example. Analyze the characteristics of Algebraic extension.	K4

	of degree n, Algebraic Extension.		
3.2	**Roots of Polynomials:** Remainder Theorem, A polynomial of degree n over a field can have atmost n roots in any extension field, Theorems continued on that, Splitting field, Theorems on Splitting field.	Define Splitting Field with an example. Determine the roots of polynomials in any extension Field.	K3
3.3	**More about Roots:** Derivative of a Polynomial, Characteristic of the field F, Theorems on Multiple root and non trivial common factor, Theorems continued on characteristic of the field F is 0 and $\neq 0$.	Find the derivative of a polynomial. Describe the characteristics of the Field F with an example.	K3
IV	**Automorphism**		
4.1	**Automorphism:** Intoduction about Automorphism, Fixed Field, Group of automorphisms of K relative to F, Examples for finding G(K,F), Symmetric rational functions and Elementary Symmetric functions, Theorems on field of rational functions in $x_1, x_2, \ldots, x_n$ over F.	Define Automorphism, Fixed Field and group of automorphism. Give an example for the above mentioned. Applications of symmetric rational functions, elementary symmetric functions.	K3
V	**Solvability by Radicals**		
5.1	**Solvability by Radicals:** Solvable, Commutator and Commutator Subgroup, Theorems continued on Solvable group, S_n is not solvable for $n \geq 5$, Galois group of $x^n - a$ over F is abelian, Galois group over F of p(x) is a solvable group.	Describe solvable and commutator of the group with an example. Find the given group is solvable or not.	K3
5.2	**Galois group over the rationals:** Problems to	Solve the particular polynomial over Q are irreducible or not.	

	prove the particular polynomial over Q are irreducible and have exactly two non real roots, Theorems on Galois group over the Rationals.	Illustrate Galois group over the rationals.	K4

4. MAPPING SCHEME (POs, PSOs AND COs)

P21MA205	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	L	M	M	L	L	-	-	-	-	M	-	-
CO2	H	L	M	M	L	L	-	-	-	L	M	-	-
CO3	H	L	M	M	L	L	-	-	-	L	M	-	-
CO4	H	L	M	M	L	L	-	-	-	L	M	-	-
CO5	H	L	M	M	-	L	-	-	-	L	M	-	-
CO6	H	L	M	M	L	L	-	-	-	L	M	-	-

L-Low **M-Moderate** **H- High**

5. COURSE ASSESSMENT METHODS

DIRECT:

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book
2. Open Book Test.
3. Cooperative Learning Report, Assignment, Group Presentation, Group Discussion, Project Report, Seminar, Quiz (written).
4. Pre-Semester & End Semester Theory Examination

INDIRECT:

1. Course end survey (Feedback)

NAME OF THE COURSE COORDINATOR: Dr. K. Rekha

Core Course – VI- PARTIAL DIFFERENTIAL EQUATIONS

Semester : II **Course Code : P21MA206**

Credits : 4 **Hours/Week: 6**

1. COURSE OUTCOMES

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

Co. No.	Course Outcomes	Level	Unit
CO1	solve the first order linear partial differential equations using Charpit's and Jacobi's method	**K3**	**I**
CO2	analyze the view of the Monge-cone	**K4**	**I**
CO3	explain the integral surface through a given curve for a quasi-linear partial differential equation	**K5**	**II**
CO4	solve the second and higher-order partial differential equations in Physics by using the method of separation of variables	**K3**	**III**
CO5	interpret the concept of boundary value problems under Laplace equation	**K5**	**IV**
CO6	justify the convergence of the solution to a heat conduction equation using Duhamel's principle	**K5**	**V**

2A. SYLLABUS

Unit I : First Order Partial differential equations **(15 hours)**

Curves and Surfaces – Genesis of first Order Partial differential equations – Classification of Integrals – Linear Equations of the First Order – Pfaffian Differential Equations – Compatible Systems – Charpit's Method – Jacobi's Method

Unit II : Integral Surfaces Through a Given Curve **(15 hours)**

Quasi-Linear Equations – Non-linear First Order Partial differential equations

Unit III : Second Order Partial differential equations **(20 hours)**

Genesis of Second Order Partial differential equations– Classification of Second Order Partial differential equations - One-Dimensional Wave Equation – Vibrations of an Infinite String –Vibrations of a Semi-infinite String –Vibrations of a String of Finite Length (Method of separation of variables)

Unit IV : Laplace's Equation **(20 hours)**

Boundary Value Problems – Maximum and Minimum Principles – The Cauchy Problem – The Dirichlet Problem for the Upper Half Plane – The Neumann Problem for the Upper Half Plane – The Dirichlet Problem for a Circle - The Dirichlet Exterior Problem for a Circle – The Neumann Problem for a Circle – The Dirichlet Problem for a Rectangle – Harnack's Theorem
.

Unit V : Heat Conduction Problem **(20 hours)**

Heat Conduction –Infinite Rod Case – Heat Conduction-Finite Rod Case – Duhamel's Principle – Wave Equation – Heat Conduction Equation

B. TOPICS FOR SELF STUDY

S.No.	Topics	Web Links
1	Families of Fourier Transform	https://www.dspguide.com/ch8/1.htm
2	Kelvin's Inversion Theorem	https://www.comsol.com/paper/application-of-kelvin-s-inversion-theorem-to-the-solution-of-laplace-s-equation--15090
3	Fourier Integral Theorem	https://www.sciencedirect.com/topics/mathematics/fourier-integral-theorem
4	Convolution Theorem	https://www.youtube.com/watch?v=W1EJH7a1oEQ&list=PLGCj8f6sgswntUil8yzohR_qazOfYZCg_&index=45

C. TEXT BOOK(s)

T. Amarnath, An Elementary Course in Partial Differential Equations, Narosa Publishing Company, 1997.

Unit I - Chapter 1 § 1.1 - 1.8

Unit I - Chapter 1 § 1.9 - 1.11

Unit III - Chapter 2 § 2.1 - 2.3.5

Unit IV - Chapter 2 § 2.4.1 - 2.4.10

Unit V - Chapter 2 § 2.5.1 - 2.6.2

D. REFERENCE BOOKS

1. Tyn Myint-U: Partial differential equations for scientists and engineers, 3rd ed. North Holland, 1989.
2. I.C. Evans, Partial Differential Equations, Graduate Studies in Mathematics, Vol. 19 AMS, 1998.
3. I.N. Snedden, Elements of Partial Differential Equations, McGraw Hill, 1985.
4. F. John, Partial Differential Equations, Springer Verlag, 1975.
5. Phoolan Prasad and Renuka Ravindran, Partial Differential Equations, Wiley-EasternLtd, 1985.
6. Lokenath Debnath and Dambaru Bhatta , Integral Transforms and Their Applications, Chapman & Hall/CRC; 2 edition, 2006.

E. WEB LINKS

1. https://nptel.ac.in/courses/111/103/111103021/

2. http://www.nptelvideos.com/lecture.php?id=1377

3. SPECIAL LEARNING OUTCOMES (SLOs)

Unit / Section	Course Content	Learning Outcome	Highest Bloom's Taxonomic Level of Transaction
I	**First Order Partial differential equations**		
1.1	Curves and Surfaces	illustrate Curves and Surfaces	K2
1.2	Genesis of first Order Partial differential equations	apply PDE in Surface of revolution	K3
1.3	Classification of Integrals	explain one-parameter and two-parameter family of planes	K5
1.4	Linear Equations of the First Order	explain a method of finding a general integral for a quasi-linear equation	K4
1.5	Partial Differential Equations	verify the Partial differential equation are exact/integrable	K4
1.6	Compatible Systems	analyze compatible system by the definition	K4
1.7	Charpit's Method	identify the complete integral of a PDE using Charpit's method	K3
1.8	Jacobi's Method	identify the complete integral of a PDE using Jacobi's method	K3
II	**Integral Surfaces Through a Given Curve**		
2.1	Integral Surfaces Through a Given Curve	discover the integral surface of the PDE through the given curve	K4
2.2	Quasi-Linear Equations	analyze quasi-linear PDE through the geometry of solutions	K3
2.3	Non-linear First Order Partial differential equations	analyze the view of the Monge-cone	K4
III	**Second Order Partial differential equations**		
3.1	Genesis of Second Order Partial differential equations	apply second order PDE which arise in Physics and Mathematics	K3
3.2	Classification of Second Order Partial differential equations	reduce the given PDE to its canonical form	K3
3.3	One-Dimensional Wave Equation	demonstrate d-Alembert's solution	K3

3.4	Vibrations of an Infinite String	analyze the properties of Characteristics of vibration of an infinite string	K4
3.5	Vibrations of a Semi-infinite String	explain vibrations of a semi-infinite String by the equation governing the motion of the string	K5
3.6	Vibrations of a String of Finite Length	deduct from d'Alembert's solution by converting the original problem into a problem of an infinite string	K5
3.7	Vibrations of a String of Finite Length (Method of separation of variables)	prove the uniqueness of the solution	K5
IV	**Laplace's Equation**		
4.1	Boundary Value Problems	explain the boundary value problems with examples	K5
4.2	Maximum and Minimum Principles	prove maximum principle and minimum principle	K6
4.3	The Cauchy Problem	explain the Cauchy problem in the case of Laplace's equation	K5
4.4	The Dirichlet Problem for the Upper Half Plane	apply the Fourier transform and the convolution theorem to get the solution for the Dirichlet Problem	K3
4.5	The Neumann Problem for the Upper Half Plane	construct a new variable to find the solution	K6
4.6	The Dirichlet Interior Problem for a Circle	prove the solution of the interior Dirichlet problem for a circle of radius 'a' is given by Poisson integral formula	K6
4.7	The Dirichlet Exterior Problem for a Circle	apply the Fourier transform to get the solution	K3
4.8	The Neumann Problem for a Circle	solve the exterior Neumann problem as in the case of the Dirichlet problem	K3
4.9	The Dirichlet Problem for a Rectangle	derive the solution with one of the boundary conditions being non-homogeneous	K5
4.10	Harnack's Theorem	explain Harnack's theorem	K5
V	**Heat Conduction Problem**		
5.1	Heat Conduction – Infinite Rod Case	analyze the heat conduction problem in an infinite rod case by using Fourier transform and Convolution theorem	K5

5.2	Heat Conduction-Finite Rod Case	prove the uniqueness of the solution of the problem of heat conduction in a finite rod	K6
5.3	Duhamel's Principle – Wave Equation –	construct the solutions of non-homogeneous PDE equations using Duhamel's principle	K6
5.4	Heat Conduction Equation	solve the heat conduction equation in an infinite rod with a heat source	K3

4. MAPPING SCHEME (POs, PSOs AND COs)

P21MA206	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	H	H	H	M	L	H	L	H	_	L	H	M	L
CO2	H	H	H	M	H	H	H	L	_	M	H	M	M
CO3	M	H	H	H	H	H	L	-	_	L	M	H	M
CO4	H	H	M	H	H	H	M	M	_	H	M	H	H
CO5	H	H	M	M	L	H	H	M	_	M	L	H	L
CO6	H	-	H	L	L	M	H	L	_	M	L	H	-

L – Low **M – Medium** **High – H**

5. COURSE ASSESSMENT METHODS

DIRECT:

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book
2. Open Book Test.
3. Cooperative Learning Report, Assignment, Group Presentation, Group Discussion, Project Report, Seminar, Quiz (written).
4. Pre-Semester & End Semester Theory Examination

INDIRECT:

1. Course end survey (Feedback)

NAME OF THE COURSE COORDINATOR: Dr. R. Janet

Core Course VII – FLUID DYNAMICS

Semester : II **Course Code: P21MA207**

Credits : 5 **Hours/Week : 6**

1. COURSE OUTCOMES

After the successful completion of this course the students will be able to:

CO. No.	Course Outcomes	Level	Unit
CO1	Estimate the kinematics of a fluid through equations of motion of the fluid.	**K5**	**I**
CO2	Derive Euler's Equation of motion and Bernoulli's equation	**K6**	**II**
CO3	Apply the special methods for treating problems in three dimensional flows and two-dimensional flows	**K3**	**III**
CO4	Explain complex velocity potentials	**K5**	**IV**
CO5	Analyze the applications of circle theorem	**K4**	**IV**
CO6	Prove the Navier-Stokes equations of motion of a viscous fluid	**K5**	**V**

2A. SYLLABUS

Unit I : Kinematics of Fluid in Motion **(18 Hours)**

Real fluids and Ideal Fluids – Velocity of a fluid at a point – Streamlines and Pathlines: Steady and Unsteady Flows – The Velocity potential – The Vorticity vector – Local and particle rates of change – The equation of Continuity – worked examples – Acceleration of a fluid.

Unit II : Equations of Motion of a Fluid **(18 Hours)**

Pressure at a point in a fluid at rest – Pressure at a point in a moving fluid – Euler's equations of motion – Bernoulli‟s equation – Discussion of the case of Steady Motion under Conservative Body forces – Some potential theorems – Impulsive motion.

Unit III : Some Three-Dimensional Flows **(18 Hours)**

Sources, sinks and doublets – Images in a rigid infinite plane – Images in Solid spheres – Axisymmetric flows; Stoke‟s Stream function.

Unit IV : Some Two-Dimensional Flows **(18 Hours)**

The stream function – The complex potential for two dimensional, irrotational, incompressible flow – Complex velocity potentials for standard two dimensional flows – Some worked examples – Two dimensional image systems – The Milne Thomson circle theorem.

Unit V : Viscous Flow **(18 Hours)**

Stress Components in a Real Fluid – Relations between Cartesian components of stress - Translational Motion of Fluid element – The Coefficient of Viscosity and Laminar Flow – The Navier-Stokes equations of Motion of a Viscous Fluid, Some solvable problems in Viscous flow.

B. TOPICS FOR SELF STUDY

Sl. No.	Topics	Web Links
1.	Fluid Dynamics for Astrophysics	https://www.classcentral.com/course/swayam-fluid-dynamics-for-astrophysics-22979/course/swayam-fluid-dynamics-for-astrophysics-22979
2.	Fluid Mechanics	https://www.mooc-list.com/tags/fluid-mechanics

C. TEXT BOOK(S)

Chorlton F, Text Book of Fluid Dynamics, CBS Publishers & Distributors, Delhi, 2004.

Unit I Chapter 2 § 2.1 – 2.9

Unit II Chapter 3 § 3.1, 3.2, 3.4 – 3.8, 3.11

Unit III Chapter 4 § 4.2 – 4.5

Unit IV Chapter 5 § 5.3 – 5.8.1, 5.8.2

Unit V Chapter 8 § 8.1 – 8.3, 8.8 – 8.10

D. REFERENCE BOOKS

1. H. Schlichting, Boundary Layer Theory, McGraw Hill Company, New York, 1979.

2. Rathy R.K, An Introduction to Fluid Dynamics, Oxford and IBH Publishing

E. WEB LINKS:

1. https://www.classcentral.com/course/swayam-introduction-to-fluid-mechanics-7945/course/swayam-introduction-to-fluid-mechanics-7945.

2. https://onlinecourses.nptel.ac.in/noc20_me22/preview

3. SPECIFIC LEARNING OUTCOMES (SLOs)

Unit/ Section	Course Content	Learning outcomes	Highest Bloom's Taxonomic Level of Transaction
I	**Kinematics of Fluid in Motion**		
1.1	Real fluids and Ideal Fluids	Classify the types of fluids	K4
1.2	Velocity of a fluid at a point	Find the velocity of a fluid	K1
1.3	Streamlines and Path lines: Steady and Unsteady Flows	Discuss streamlines, path lines, types of flows and find the velocity of the streamlines	K6
1.4	The Velocity potential	Find the velocity potential	K1
1.5	The Vorticity vector	Explain the vorticity vector	K2
1.6	Local and particle rates of change	Evaluate the acceleration between the local and particle rates of change	K5
1.7	The equation of Continuity	Construct the equation of continuity	K6
1.8	Worked Examples	Classify the nature of the flow and motion of the fluid	K4
1.9	Acceleration of a fluid	Determine the acceleration of the fluid particle	K5
II	**Equations of Motion of a Fluid**		
2.1	Pressure at a point in a fluid at rest	Measure the pressure in a fluid at rest	K1
2.2	Pressure at a point in a moving fluid	Measure the pressure in a moving fluid	K1
2.3	Euler's equations of motion	Obtain the Euler's equations of motion	K5
2.4	Bernoulli's equation	Prove the Bernoulli's equation	K5
2.5	Worked Examples	Discuss the working principle of Pitot tube and Venturi tube.	K6
2.6	Discussion of the case of Steady Motion under Conservative Body forces	Test whether the motion is rotational or irrotational in the case of steady Motion under conservative body forces	K6
2.7	Some potential theorems	Prove the potential theorems	K5
2.8	Impulsive motion	Describe the impulsive motion of a particle	K2
III	**Some Three-Dimensional Flows**		
3.1	Sources, sinks and doublets	Apply the special methods for treating problems in three dimensional flows	K3
3.2	Images in a rigid infinite plane	Explain the images in a rigid infinite plane	K2

3.3	Images in Solid spheres	Prove the Weiss's sphere theorem	K5
3.4	Axisymmetric flows: Stoke's Stream function	Categorize some special forms of the stream function	K4
IV	**Some Two-Dimensional Flows**		
4.1	The stream function	Explain stream function in two dimensional flows	K2
4.2	The complex potential for two dimensional, irrotational, incompressible flow	Examine the complex potential for two dimensional, irrotational, incompressible flow	K4
4.3	Complex velocity potentials for standard two dimensional flows	Classify complex velocity potentials for standard two dimensional flows	K2
4.4	Some worked examples	Describe the motion of the incompressible liquid with complex potential	K2
4.5	Two dimensional image systems	Determine the image of a line source and line vortex	K5
4.6	The Milne Thomson circle theorem	Prove Milne Thomson circle theorem	K6
4.7	Some Applications of the Circle Theorem	Apply the circle Theorem to determine modified flows	K3
4.8	Extension of the Circle Theorem	Prove the Milne Thomson's circle theorem	K5
V	**Viscous Flow**		
5.1	Stress Components in a Real Fluid	List out the stress components in a real fluid	K1
5.2	Relations between Cartesian components of stress	Classify the Cartesian components of stress	K3
5.3	Translational Motion of Fluid element	Describe the translational motion of fluid element	K2
5.4	The Coefficient of Viscosity and Laminar Flow	Determine the coefficient of viscosity in laminar flow	K5
5.5	The Navier-Stokes equations of Motion of a Viscous Fluid	Prove the Navier-Stoke's equations	K5
5.6	Some solvable problems in Viscous flow	Solve some problems in Viscous flow	K6

4. MAPPING SCHEME (POs, PSOs AND COs)

P21MA207	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	M	-	H	-	M	-	-	-	-	-	L	-	-
CO2	H	-	M	H	-	-	-	-	-	M	-	L	M
CO3	-	H	-	-	M	-	-	-	-	-	M	-	-
CO4	-	-	M	L	-	M	-	-	-	-	M	-	M
CO5	H	M	-	M	-	L	-	-	-	-	M	-	L
CO6	M	H	M	M	-	M	-	-	-	-	M	M	-

L-Low **M-Moderate** **H- High**

5. COURSE ASSESSMENT METHODS

DIRECT:

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book
2. Open Book Test.
3. Cooperative Learning Report, Assignment, Group Presentation, Group Discussion, Project Report, Seminar, Quiz (written).
4. Pre-Semester & End Semester Theory Examination

INDIRECT:

1. Course end survey (Feedback)

NAME OF THE COURSE COORDINATOR: Dr. D. Jasmine

Elective Course II - OBJECT ORIENTED PROGRAMMING IN C ++

Semester: II **Course Code: P21MA2:P**

Credits : 4 **Hours/Week: 6**

1. COURSE OUTCOMES

After the successful completion of this course the students will be able to:

CO. No.	Course Outcomes	Level	Exercise
CO 1	Develop programming skills of students using object-oriented programming concepts in C++	**K3**	**1**
CO 2	Construct program for friend function and inline function.	**K6**	**2,3**
CO 3	Explain the concept of copy constructor and constructor overloading	**K5**	**4,5**
CO 4	Classify the types of Inheritance	**K4**	**6,7,8,9**
CO 5	Compare the function overloading, Unary and Binary operator overloading and virtual function.	**K5**	**10,11,12,13**
CO 6	Designing the programming for formulating, Manipulating and File Handling	**K6**	**14,15**

2A. SYLLABUS

Unit I **(18 Hours)**

An Overview of C++: What is Object Oriented Programming? – C++ Console I/O Commands – Classes– Some Difference Between C and C++ – Introduction Function Overloading – Introducing Classes : Constructor and Destructor Functions –Constructors that take Parameters – Introducing Inheritance –Object Pointers – In–Line Functions – Automatic In–Lining.

Unit II **(18 Hours)**

A Closer Look at Classes: Assigning Objects – Passing Object to Functions – Returning Object from Functions – An Introduction to Friend Functions. Arrays, Pointers and D. REFERENCEs: Arrays of Object – Using Pointers to Objects – The this Pointer – Using new & delete – More –about new & delete – D. REFERENCE – Passing D. REFERENCE to the Objects – Returning D. REFERENCE – Independent D. REFERENCEs and Restrictions.

Unit III **(18 Hours)**

Function Overloading: Overloading Constructor Functions – Creating and Using a Copy Constructor – Using Default Arguments – Overloading and Ambiguity – Finding the Address of an Overloaded Function. Introducing Operator Overloading: The Basics of Operator Overloading – Overloading Binary Operators –Overloading the Relational and Logical Operators – Overloading a Unary Operator – Using Friend Operator Functions – A closer look at the Assignment Operator Overloading– The Subscript - Operator Overloading.

Unit IV **(18 Hours)**

Inheritance: Base Class Access Control – Using Protected Members – Constructors, Destructors and Inheritance – Multiple Inheritance – Virtual Base Classes. Introducing the C++ I/O System: Some C++ I/O Basics – Formatted I/O using width ( ), precision( ), fill( ) – Using I/O Manipulators – Creating your own Inserters – Creating Extractors.

Unit V **(18 Hours)**

Advanced C++ I/O: Creating your own Manipulators –File I/O Basics –Unformatted, Binary I/O – More Unformatted I/O Functions – Random Access – Checking the I/O Status – Customized I/O and Files. Virtual Functions: Pointers and Derived Classes – Introduction to Virtual Functions – More about Virtual Functions – Applying Polymorphism – Templates and Exception Handling: Exception Handling – Handling Exceptions Thrown.

B. TOPICS FOR SELF STUDY

S. No.	Topics	Web Links
1	Exceptions (Error Handling in C): Part-I	https://nptel.ac.in/courses/106/105/106105151/
2	Exceptions (Error Handling in C): Part-II	https://nptel.ac.in/courses/106/105/106105151/
3	Template (Function Template): Part-I	https://nptel.ac.in/courses/106/105/106105151/
4	Template (Function Template): Part-II	https://nptel.ac.in/courses/106/105/106105151/
5	Closing Comments	https://nptel.ac.in/courses/106/105/106105151/

C. TEXT BOOKS

Herbert Schildt, Teach Yourself C++, McGraw Hill, Third Edition, 2000.

D. REFERENCE BOOKS

1. Robert Lafore, Object Oriented Programming in Turbo C++, Galgotia Publications, 2001.
2. E. Balaguruswamy, Object – Oriented Programming with C++, Tata McGraw Hill Publishing Company Limited, 1999.

E. WEB LINKS

1.https://www.classcentral.com/course/swayam-programming-in-c-6704

2. https://onlinecourses.nptel.ac.in/noc19_cs38/preview

3. https://nptel.ac.in/course.html

3. SPECIFIC LEARNING OUTCOMES (SLO)

S.No	Lab Exercises	Learning outcomes	Highest Bloom's Taxonomic Level of Transaction
1	Class and Objects	Distinguish classes from objects.	K4
2	Friend Functions	Identify the Friend Functions for efficiency and performance.	K3
3	Inline Functions	Construct Inline Functions for efficiency and performance.	K6
4	Copy Constructor	Create a C++ Program for Copy Constructor.	K6
5	Constructor Overloading	Develop C++ Program for constructor overloading.	K6
6	Single Inheritance	Create C++ program for single inheritance.	K6
7	Multiple Inheritance	Construct C++ program for multiple inheritance.	K6
8	Multilevel Inheritance	Create C++ program of multilevel inheritance.	K6
9	Hierarchical Inheritance	Construct the program for hierarchical inheritance.	K6
10	Function Overloading	Create overload functions in C++.	K6
11	Unary Operator Overloading	Classify overload unary operators in C++.	K4
12	Binary Operator Overloading	Classify overload binary operators in C++.	K4
13	Virtual Functions	Construct virtual function implement dynamic binding with polymorphism.	K6
14	I/O Formatting and I/O Manipulators	Classify I/O Formatting and I/O Manipulators in C++.	K4
15	File Handling	Construct files to read, write and update.	K6

4. MAPPING SCHEME FOR THE POs, PSOs AND COs

P21MA2:P	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	-	-	M	-	M	M	-	M	H	-	-	H
CO2	M	-	M	M	-	M	-	-	M	H	-	-	H
CO3	H	-	-	-	-	-	-	-	M	M	-	-	-
CO4	-	-	-	H	-	-	-	-	M	M	-	-	-
CO5	-	-	-	-	-	-	-	-	M	H	-	-	-

CO6	-	-	-	M	-	-	-	-	M	M	-	-	-

L-Low **M-Moderate** **H- High**

5. COURSE ASSESSMENT METHODS

DIRECT:

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book
2. Open Book Test.
3. Cooperative Learning Report, Assignment, Group Presentation, Group Discussion, Project Report, Seminar, Quiz (written).
4. Pre-Semester & End Semester Theory Examination

INDIRECT:

1. Course end survey (Feedback)

NAME OF THE COURSE COORDINATOR: Dr. C. Priya

Elective Course III: DIFFERENTIAL GEOMETRY

Semester: II **Course Code: P21MA2:3**

Credits: 4 **Hours/Week: 4**

1. COURSE OUTCOMES

After the successful completion of this course the students will be able to

CO. No	Course Outcomes	Level	Unit
CO1	Explain the basic concepts and definitions of space curves and planes.	K5	I
CO2	Explain the Existence and Uniqueness theorem under Intrinsic equations.	K5	II
CO3	Discuss the theory of surfaces and curves on surfaces.	K6	III
CO4	Explain the concept of metric on the surface	K5	III
CO5	Examine local non-intrinsic properties of a surface	K4	IV
CO6	Solve the techniques of differential calculus in the field of geometry.	K6	V

2A. SYLLABUS

Unit I : Curves in Space **(12 hours)**

Space curve, Tangent and Tangent line, Order of contact, Arc length Osculating plane, Normal plane, Rectifying plane, Fundamental planes, Curvature, Torsion, Frenet Serret formulae.

Unit II : Intrinsic Equations **(12 hours)**

Existence theorem and Uniqueness theorem, Helices, Osculating circle, Osculating sphere, Spherical indicatrices, Involutes and evolutes, Tangent surface.

Unit III : Curves and Surfaces **(12 hours)**

Definition of a surface, Regular point and singularities, Parametric transformations, Curves on a surface, Normal, General surface of revolution, Metric, First and second fundamental forms, Angle between the parametric curves.

Unit IV : Normal Curvature **(12 hours)**

Meusnier's theorem , Principal directions , Lines of curvature , Rodrigue's formula , Euler's formula , Envelope of surfaces , Edge of Regression, Developable surfaces.

Unit V : Surface Theory **(12 hours)**

Gauss equation, Weingarten equations, Gauss characteristic equation, Mainardi-Codazzi equations, Geodesics.

B. TOPICS FOR SELF STUDY

S.No.	Topics	Web Links
1	Regular surfaces locally on quadratic surfaces	https://nptel.ac.in/courses/111/104/111104095/
2	Pseudosphere	https://nptel.ac.in/courses/111/104/111104095/
3	Classification of quadratic surface	https://nptel.ac.in/courses/111/104/111104095/
4	Surface area and equiareal map	https://nptel.ac.in/courses/111/104/111104095/

C. TEXT BOOK(s)

1. Kailash Sinha, An Introduction to Differential Geometry, 4th Edition, Shalini Prakashan Publications, 1977.

D. REFERENCE BOOKS

1. Struik, D.J., Lectures on classical Differential Geometry, 2nd Edition,Addison-Wesley, 1988.

2. Willmore, T.J., An Introduction to Differential Geometry, Oxford Univ. Press, 1964.

3. Somasundaram D., Differential geometry: A first course, Narosa, 2008.

E. WEB LINKS

https://nptel.ac.in/courses/111/108/111108134/

https://www.classcentral.com/course/swayam-an-introduction-to-smooth-manifolds-17511

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit/ Section	Course Content	Learning outcomes	Highest Bloom's Taxonomic Level of Transactio
I	**Curves in Space**		
1.1	Space curve	Define the basic concepts of space curve	K1
1.2	Tangent	Discuss the equation of tangent line	K6
1.3	Order of contact	Solve problems using order of contact	K6
1.4	Arc length	Discuss the arc length of a curve in space	K5
1.5	Osculating plane	Explain the equation of osculating plane.	K5
1.6	Normal plane	Discuss the equation of normal planes.	K6
1.7	Rectifying plane	Define the rectifying plane on the curve	K2
1.8	Fundamental planes	Classify the fundamental planes.	K4
1.9	Curvature and Torsion	Explain the direction and magnitude of the curves.	K5

1.10	Frenet Serret formulae	Explain the Frenet Serret formula using fundamental planes.	K5
II	**Intrinsic equations**		
2.1	Existence and Uniqueness theorem	Discuss Existence and Uniqueness theorems on curves.	K6
2.2	Helices	Define the concepts of helices.	K1
2.3	Osculating circle and sphere	Explain the osculating circle and sphere to the curves.	K5
2.4	Spherical indicatrices	Discuss the spherical indicatrices of the tangent.	K6
2.5	Involutes and Evolutes	Explain the concept of involutes and evolutes of the given curve	K4
2.6	Tangent surface.	Discuss the tangent surface.	K6
III	**Curves and Surfaces**		
3.1	Curves on a surface	Justify curves on surface	K5
3.2	Normal	Explain the normal and also derive the equation of the normal.	K4
3.3	General surface of revolution.	Analyze the revolution on general surface.	K4
3.4	Metric	Explain the condition of metric.	K4
3.5	Angle between the parametric curves	Design the angle between the parametric curves.	K6
3.6	Elementary Area	Explain the elementary area of the surface.	K4
3.7	First and second fundamental forms	Explain the metric condition on first and second fundamental forms.	K5
IV	**Normal curvature**		
4.1	Normal curvature	Explain the normal curvature.	K4
4.2	Meusnier's theorem	Discuss Meusnier's theorem using first and second fundamental forms.	K6
4.3	Alternative form for normal curvature	Explain the alternative form of normal curvature	K4
4.4	Principal directions	Outline the concept of the principal directions.	K2
4.5	Lines of curvature	Construct the lines of curvature.	K6
4.6	Rodrigue's formula	Justify the necessary and sufficient condition to be a line of curvature.	K5
4.7	Euler's formula	Construct the equation of the normal curvature in terms of principal curvature.	K6
4.8	Envelope and characteristics of surfaces	Explain the definition of envelope and construct the equation of the envelope.	K4
4.9	Edge of Regression	Explain the edge of regression.	K4
4.10	Developable surfaces	Inspect the types of developable surfaces.	K4
V	**Surface Theory**		

5.1	Gauss equation	Define the Gauss equation on the surface.	K1
5.2	Weingarten equations	Explain the condition of Weingarten equations on surface	K6
5.3	Gauss characteristic equation	Discuss the Gauss coefficients.	K6
5.4	Mainardi-Codazzi equations	Explain the fundamental theorem of surfaces.	K2
5.5	Geodesics	Explain the special intrinsic curves on any surface.	K5
5.6	Geodesics differential Equation	Explain the differential equation of geodesics.	K2
5.7	Canonical Geodesic Equation	Relate the arc length as the parameter.	K1

4. MAPPING SCHEME (POs, PSOs AND COs)

P21MA2:3	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	M	-	-	M	-	M	M	H	-	M	-	-	M
CO2	H	H	M	H	M	H	M	-	-	H	H	M	H
CO3	H	H	M	M	H	H	M	M	-	H	-	-	-
CO4	H	H	H	H	H	M	M	H	-	H	H	M	M
CO5	H	H	M	M	M	H	M	-	-	M	M	-	-
CO6	H	H	H	H	H	M	H	M	-	H	H	H	-

L-Low **M-Moderate** **H- High**

5. COURSE ASSESSMENT METHODS

DIRECT:

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book
2. Open Book Test.
3. Cooperative Learning Report, Assignment, Group Presentation, Group Discussion, Project Report, Seminar, Quiz (written).
4. Pre-Semester & End Semester Theory Examination

INDIRECT:

1. Course end survey (Feedback)

NAME OF THE COURSE COORDINATOR: Dr. S. Jenita

Elective III: Introduction to Data Envelopment Analysis [DEA]

Semester: III **Course Code: P21MA2:4**

Credit: 4 **Hours/Week: 6**

1. COURSE OUTCOMES

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

Co. No.	Course Outcomes	Level	Unit
CO1	Analyze Decision Making Units, Linear Programming Problems,Fractional Programming Problems	**K4**	**I**
CO2	Describe Mathematical Modeling of DEA	**K5**	**II**
CO3	Formulate CRS DEA and VRS DEA	**K5**	**III**
CO4	Examine DEA Application in an Educational Institute	**K3**	**IV**
CO5	Demonstrate DEAP Software	**K4**	**V**
CO6	Evaluation of DEA Problems through DEAP Software	**K6**	**V**

2A. SYLLABUS

Unit I: Introduction **(20 hours)**

Introduction to Data Envelopment Analysis [DEA] – Decision Making Units [DMUs] – Fundamental Concepts of Effectively Evaluation – Operations Research – Models of Operations Research – Scope of Operations Research – Phase of Operations Research Methodology – General Model of the Linear Programming Problem – Assumptions of Linear Programming Problem – The Temporary Ordered Routing Algorithm (TORA) – Operations Research Software – Fractional Programming Problem – Performance Based on single input and single output – Performance Based on two input and a single output – Strongly and Weakly Efficient DMUs.

Unit II: Mathematical Modeling of DEA **(20 hours)**

Procedural Application of DEA – How to choose the DMUs for the study? – Selection of the Inputs and Outputs – Formulation of a Mathematical Structure of additive type – Dual concept in a Linear Programming – DEAP Version 2.1 – Economy of Scale.

Unit III: CRS DEA and VRS DEA Models **(15 hours)**

Constant Returns to Scale DEA Model [CRS DEA] – Variable Returns to Scale DEA Model [VRS DEA] – Technical and Scale Efficiencies.

Unit IV: DEA Application in an Educational Institute **(15 hours)**

Introduction – Review of Literature – Research Methodology – Constant Return to Scale [CRS Model] – Empirical Result – Constant Return to Scale [CRS Model] – Variable Return to Scale [VRS Model] – Overall Efficiency – Summary and Research

Findings.

Unit V: DEA Software **(20 hours)**

DEA Software

B.TOPICS FOR SELF STUDY:

Sl. No.	Topics	Web Links
1	Introduction to Operations Research	https://www.britannica.com/topic/operations-research/History
2	An overview of DEA	http://people.brunel.ac.uk/~mastjjb/jeb/or/dea.html

C.TEXTBOOK(s)

1. Introduction to Data Envelopment Analysis [DEA] by Perumal Mariappan, LAPLAMBERT Academic Publishing, 2016. (Unit 1 – 4)

2. A Data Envelopment Analysis (Computer) Program by Tim Coelli. (Unit 5)

Unit	I	Chapter 1
Unit	II	Chapter 2
Unit	III	Chapter 3
Unit	IV	Chapter 4
Unit	V	Chapter 5

D. REFERENCE BOOKS

An Introduction to Data Envelopment Analysis: A tool for performance measurement, sagepublications.

E. WEB LINKS

1. https://encyclopedia.pub/entry/7783
2. https://economics.uq.edu.au/cepa/software
3. https://www.swmath.org/software/11887

3. SPECIFIC LEARNING OUTCOMES (SLOs)

Unit/ Section	Course Content	Learning Outcomes	Highest Bloom's Taxonomic Level of Transaction
I	**Introduction**		
1.1	Data Envelopment Analysis	Describe the basic Introduction of DataEnvelopment Analysis	K4
1.2	Decision Making Units	Identify the Decision-Making Units forModeling	K2

1.3	Models of Operations Research	Define the concepts of Operations Research Models	K1
1.4	Scope of Operations Research	State the Scope of Operations Research	K1
1.5	General Model of Linear Programming	Describe the General Model of LinearProgramming Problem	K2
1.6	Assumptions of Linear Programming	Define the basic assumptions related to LPP	K1
1.7	TORA	Compute the problems in optimizationsoftware	K4
1.8	Fractional Programming Problem	Illustrate the Fractional ProgrammingProblem	K4
1.9	Performance Based on Single Input and Output	Discover Single Input and Single outputmodel	K4
1.10	Performance Based on two Input and a single Output	Create a performance analysis based ontwo input and a single output model	K4
1.11	Strongly and weekly Efficient DMUs	Identify Strongly and weekly DMUs	K3
II	**Mathematical Modeling of DEA**		
2.1	Procedural Application of DEA	Employ the procedure of Application ofDEA	K3
2.2	How to choose the DMUs for the study?	Plan to choose the DMUs for the study	K3
2.3	Selection of the Inputs and Outputs	Identify the Inputs and Outputs	K5
2.4	Formulation of a Mathematical Structure of additive type	Formulate the Mathematical Model foradditive type	K4
2.5	Dual concept in a Linear Programming	Explain the dual concept in a Linear Programming	K5
2.6	DEAP Version 2.1	Compute DEAP	K5
2.7	Economy of Scale	Illustrate the Economy of Scale	K2
III	**CRS DEA and VRS DEA Models**		

3.1	Constant Returns to Scale DEA Model [CRS DEA]	Classify the CRS DEA Model	K5
3.2	Variable Returns to Scale DEA Model [VRS DEA]	Develop a VRS DEA Model	K5
3.3	Technical and Scale Efficiencies	Analyze the Technical and ScaleEfficiencies	K2
IV	**DEA Application in an Educational Institute**		
4.1	Introduction	Introduction about the DEA applicationin an Educational Institute	K3
4.2	Review of Literature	Define the reviews related to DEA application in an Educational Institute	K2
4.3	Research Methodology	Identify the methodology	K3
4.4	Constant Return to Scale [CRS Model]	Analyze the CRS DEA Model	K3
4.5	Variable Return to Scale [VRS Model]	Develop the VRS DEA Model	K3
4.6	Overall Efficiency	Examine the Overall Efficiency	K2
4.7	Summary and Research Findings	Illustrate the findings of model	K2
V	**DEA Software**		
5.1	DEA Software	Examine the DEA problems in DEAPsoftware	K6

4. MAPPING SCHEME (POs, PSOs and COs)

U20MA2:4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	-	M	M	M	-	H	H	M	M
CO2	M	M	M	-	H	L	M	M	-	H	H	M	M
CO3	H	M	L	-	M	M	M	M	-	H	M	H	M
CO4	H	H	H	M	L	M	L	M	-	H	H	M	M
CO5	H	M	M	-	H	M	M	M	-	H	M	M	M
CO6	H	M	M	-	H	H	M	H	-	H	H	M	M

L-Low **M-Moderate** **H- High**

5. COURSE ASSESSMENT METHODS

DIRECT:

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book
2. Open Book Test.
3. Cooperative Learning Report, Assignment, Group Presentation, Group Discussion,Project Report, Seminar, Quiz (written).L
4. Pre-Semester & End Semester Theory Examination

INDIRECT:

1. Course end survey (Feedback)

NAME OF THE COURSE COORDINATOR: Dr. M. Antony Raj

Core Course VIII: TOPOLOGY

Semester: III **Course Code: P21MA308**

Credits: 5 **Hours/Week: 6**

1. COURSE OUTCOMES

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

CO. No.	Course Outcomes	Level	Unit
CO1	Define topological spaces, continuous functions, metric topology, connected space, compact space, normal space, complete metric spaces and compactness in metric spaces.	K1	I – V
CO2	identify different topological spaces.	K3	I – V
CO3	construct continuous functions on topological spaces.	K5	I – V
CO4	prove the properties of topological spaces, continuous functions, metric topology, connected space, compact space, normal space, complete metric spaces and compactness in metric spaces.	K4	I – V
CO5	classify connected spaces and compact spaces.	K5	II&III
CO6	distinguish and relate Hausdorff, regular and normal spaces and the compactness of a metric space into a complete metric space	K6	IV&V

2A. SYLLABUS

Unit I: Topological spaces **(22 Hours)**

Topological spaces – Basis for a topology – The order topology – The product topology on X x Y – The subspace topology – Closed sets and limit points – Continuous functions – The product topology – The metric topology.

Unit II: Connected spaces **(17 Hours)**

The metric topology continued – Connected spaces – Connected subspaces of the real line – Components and local connectedness.

Unit III: Compact spaces **(17 Hours)**

Compact spaces – Compact subspaces of the real line – Limit point compactness – The countability axioms.

Unit IV: The separation axioms **(17 Hours)**

The separation axioms – Normal spaces –The Urysohn Lemma – Completely regular spaces.

Unit V: The Urysohn Metrization theorem **(17 Hours)**

The Urysohn Metrization theorem – Complete metric spaces – Compactness in metric spaces.

B. TOPICS FOR SELF STUDY

S. No.	Topics	Weblink
1	Problems in fundamental concepts of Topology	https://dbfin.com/topology/munkres/chapter-1/section-1-fundamental-concepts/problem-10-solution/
2	Problems in Connected spaces of the real line	https://dbfin.com/topology/munkres/chapter-3/section-24-connected-subspaces-of-the-real-line/
3	Problems in Compact Spaces of the real line	https://dbfin.com/topology/munkres/chapter-3/section-27-compact-subspaces-of-the-real-line/
4	Problems in Separation Axioms	https://dbfin.com/topology/munkres/chapter-4/section-31-the-separation-axioms/
5	Problems in Urysohn Metrization theorem	https://dbfin.com/topology/munkres/chapter-4/section-34-the-urysohn-metrization-theorem/

C. TEXT BOOK(s)

James. R. Munkres, Topology, Pearson Education Singapore Pvt. Ltd. Second Edition, (Ninth Indian Reprint), 2005.

D. REFERENCE BOOKS

1. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill Company, 1963.

2. James Dugundji, Topology, Prentice Hall of India Private Limited, 1975.

E. WEB LINKS

https://ocw.mit.edu/courses/mathematics/18-901-introduction-to-topology-fall-2004/

https://onlinecourses.nptel.ac.in/noc21_ma28/preview

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit/ Section	Course Content	Learning Outcomes	Highest Bloom's Taxonomic Level of Transaction
I	**Topological Spaces**		
1.1	Topological spaces	Define different topological spaces.	K1
		Illustrate examples of different topologies.	K2
		Prove the properties on topological spaces	K5
		Classify the different types of topological spaces	K4
1.2	Basis for a topology	Define basis for a topology	K1
		Illustrate examples of basis for topologies.	K2
		Prove related lemmas	K5
		Identify sub basis	K3

1.3	The order topology	Define the order topology	K1
		Illustrate examples of order topology.	K2
1.4	The product topology on X x Y	Define product topology and projection mappings	K1
		Illustrate examples of product topologies	K2
		Prove related theorems.	K5
1.5	The subspace topology	Define subspace topology	K1
		Illustrate examples of subspace topologies	K2
		Prove related theorems.	K5
1.6	Closed sets and limit points	Define closed set, open set, limit point and Hausdorff space	K1
		Prove the related theorems	K5
1.7	Continuous functions	Recall continuous Functions	K1
		Prove the various properties on continuous functions	K5
		Analyze the continuity on topological space	K4
1.8	The product topology	Define box topology	K1
		Compare box and product topologies	K2
1.9	The metric topology	Define metrizable space and different types of metrics	K1
		Prove metrization theorems	K5
II	**Connected spaces**		
2.1	The metric topology continued	Define continuous function on metric spaces	K1
		Prove sequence lemma and uniform limit theorem	K5
2.2	Connected spaces	Define connectedness	K1
		Prove the properties of connected spaces	K5
		Identify whether the spaces are connected or not.	K3
		Analyze the continuity on connected spaces	K4
2.3	Connected subspaces of the real line	Define linear continuum	K1
		Prove the connectedness on linear continuum and the Intermediate value theorem	K5
2.4	Components and local connectedness	Define Components, local connectedness and locally path connectedness	K1
		Prove the related properties	K5
		Classify connectedness and locally path connectedness	K2

III	Compact spaces		
3.1	Compact spaces	Define open covering and compact space	K1
		Illustrate examples	K2
		Construct new compact spaces and recognize the properties of compact spaces	K6
		analyze the continuity on compact spaces and list the properties of finite intersection condition	K4
		prove the product of compact spaces is compact using tube lemma.	K5
3.2	Compact subspaces of the real line	construct the compactness on real line	K6
		list all compact subspaces of the real line	K4
		prove extreme value theorem and uniform continuity theorem on compact spaces and the Lebesgue number lemma on compact metrizable space.	K5
3.3	Limit point compactness	define limit point compact and sequentially compact spaces	K1
		compare compact, limit point compact and sequentially compact spaces	K5
		use metrizable space to relate compact, limit point compact and sequentially compact spaces	K3
3.4	The countability axioms	define countability axioms, separable space and Lindelof space	K1
		illustrate examples of countability axioms, separable space and Lindelof space	K2
		combine countability axioms with separable and Lindelof spaces	K6
IV	**The separation axioms**		
4.1	The separation axioms	define Hausdorff, regular and normal spaces	K1
		illustrate examples of Hausdorff, regular and normal spaces	K2
		prove subspace and products theorem of Hausdorff and regular spaces.	K5
4.2	Normal spaces	develop the normal space from Hausdorff and regular spaces.	K6
		prove the properties of normal space.	K5
		Illustrate the examples of normal space	K2

4.3	The Urysohn Lemma	use normal space to state Urysohn Lemma	K3
		prove Urysohn Lemma	K5
		analyze the continuity on normal space	K4
4.4	Completely regular spaces	define completely regular spaces	K1
		illustrate examples of completely regular space.	K2
		prove subspace and product theorems of completely regular spaces	K5
		classify Hausdorff, regular and normal spaces and completely regular space.	K4
V	**Complete metric spaces**		
5.1	The Urysohn Metrization theorem	recall regular space, countable basis and metrizable space	K1
		use regular space, countable basis and metrizable space for Urysohn Metrization theorem	K3
		prove Urysohn Metrization theorem using the imbedding theorem	K5
5.2	Complete metric spaces	recall Cauchy sequence and define complete metric space	K1
		illustrate examples of Cauchy sequence and complete metric space	K2
		prove the properties of Cauchy sequence and complete metric space.	K5
5.3	Compactness in metric spaces	recall total boundedness and define compact metric space, completion of a metric space and equicontinuous family	K1
		illustrate examples of compact metric space and total boundedness	K2
		combine compact metric space with complete and totally bounded space.	K3
		classify complete metric space and compact metric space	K4
		use compact metric space, closed, bounded and equicontinuous for Ascoli's theorem	K6
		prove Ascoli's theorem and related theorems	K5

4. MAPPING SCHEME (POs, PSOs AND COs)

P21MA308	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	L	M	M	H	H	M	M	-	M	-	H	M
CO2	H	L	M	M	H	H	M	M	-	M	-	H	M
CO3	H	M	M	H	H	H	M	M	-	M	-	H	M
CO4	H	H	H	H	H	H	H	H	-	H	-	H	H
CO5	H	H	H	H	H	H	H	H	-	H	-	H	H
CO6	H	H	H	H	H	H	H	H	-	H	-	H	H

L-Low **M-Moderate** **H- High**

5. COURSE ASSESSMENT METHODS

DIRECT:

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book
2. Open Book Test.
3. Cooperative Learning Report, Assignment, Group Presentation, Group Discussion, Project Report, Seminar, Quiz (written).
4. Pre-Semester & End Semester Theory Examination

INDIRECT:

1. Course end survey (Feedback)

NAME OF THE COURSE COORDINATOR: Mr. A. Thilak Moses

Core Course IX: MEASURE AND INTEGRATION

Semester: III **Course Code: P21MA309**

Credits: 5 **Hours/Week: 6**

1. COURSE OUTCOMES

After the successful completion of this course the students will be able to

CO. No	Course Outcomes	Level	Unit
CO1	Analyze Borel and Lebesgue measurability of subsets of Real number system	K4	I
CO2	Evaluate the integration of non-negative functions by which integration of general functions is derived.	K5	II
CO3	Interpret Lebesgue and Riemann integration	K5	II
CO4	Conclude how a measure on a ring of sets can be extended to one on a generated sigma-ring.	K5	III
CO5	Analyze signed measure which decomposes the space into positive and negative parts.	K4	IV
CO6	Evaluate integration of functions defined on the Cartesian product space.	K5	V

2A. SYLLABUS

Unit I : Measure on Real line **(20 Hours)**

Measure on Real line – Lebesgue outer measure – Measurable sets – Regularity – Measurable function - Borel and Lebesgue measurability.

Unit II : The General integral **(20 Hours)**

Integration of non-negative functions – The General integral – Integration of series – Riemann and Lebesgue integrals.

Unit III : Abstract Measure spaces **(18 Hours)**

Abstract Measure spaces – Measures and outer measures – Completion of a measure – Measure spaces – Integration with respect to a measure.

Unit IV : Convergence & Signed Measures **(16 Hours)**

Convergence in Measure – Almost uniform convergence – Signed Measures and Halin Decomposition – The Jordan Decomposition.

Unit V : Measurability in Product space **(16 Hours)**

Measurability in a Product space – The Product Measure and Fubini's Theorem

B. TOPICS FOR SELF STUDY

S. No.	Topics	Web-link
1.	Lebesgue – Stieltjes Integration	http://www.math.utah.edu/~li/L-S%20integral.pdf
2.	Conversion between Lebesgue–Stieltjes integral and Lebesgue integral	http://www.math.utah.edu/~li/L-S%20integral.pdf
3.	Random variables &measurable functions.	http://www.math.ucsd.edu/~bdriver/280_06-07/Lecture_Notes/N9.pdf
4.	Probability measure	http://www.math.tifr.res.in/~publ/ln/tifr12.pdf

C. TEXT BOOK(s)

1. G. De Barra, Measure Theory & Integration, New Age International Pvt. Ltd.,2003.

D. REFERENCE BOOKS

1. M.E. Munroe, Measure and Integration, Addison – Wesley Publishing Company, Second Edition 1971.

2. P.K.Jain, V.P.Gupta, Lebesgue Measure and Integration, New Age International Pvt. Ltd. Publishers, New Delhi, 1986 (Reprint 2000).

3. Richard L. Wheeden and AntoniZygmund, Measure and Integral : An Introduction to Real Analysis, Marcel Dekker Inc. 1977.

4. Inder, K. Rana, An Introduction to Measure and Integration, Narosa Publishing House, New Delhi, 1997.

E. WEB LINKS

1. https://nptel.ac.in/courses/111/101/111101100/

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit/ Section	Course Content	Learning outcomes	Highest Bloom's Taxonomic Level of Transaction
I	**Measure on Real line**		
1.1	Introduction to Lebesgue Outer Measure	Define Lebesgue Outer Measure and list out the properties of Lebesgue Outer Measure	K1
1.2	Lebesgue outer measure of an interval	Prove that Lebesgue Outer Measure of an interval equals its length.	K5

1.3	Outer measure is countably sub-additive	Prove that Outer measure is countably sub-additive	K5
1.4	Measurable set	Identify a measurable set from a class power set of Real number system.	K2
1.5	Measurable sets and sigma algebra	Prove that the class of Measurable sets is sigma algebra	K5
1.6	Borel sets	Define Borel set	K1
1.7	Monotone sequence of measurable sets	Compare measure of limit of a monotone sequence of measurable sets and limit of measures of measurable sets of a monotone sequence	K4
1.8	Regularity	Estimate measurable sets in terms of outer measures of open, closed sets.	K5
1.9	Measurable and Borel function	Define Measurable and Borel function.	K1
1.10	Class of measurable functions	Identify if given function is a measurable function.	K2
1.11	Lebesgue measurability	Construct a non-measurable set	K5
	Borel measurability	Construct a measurable non-Borel set	K5
II	**The General Integral**		
2.1	Integration of simple functions	Define simple function	K1
2.2	Integration of non-negative functions	Evaluate integration of non-negative functions	K5
2.3	Lebesgue integral	Define Lebesgue integrability for non-negative functions	K1
2.4	Lebesgue's Monotone convergence theorem	Prove Monotone convergence theorem by proving Fatou's Lemma	K5
2.5	General integral	Define Lebesgue integration for general functions and evaluate integration for general functions	K1
2.6	Lebesgues dominated convergence theorem	Prove Lebesgues dominated convergence theorem	K5
2.7	Integration of series	Evaluate Integration of series	K5
2.8	Riemann integration	Prove that the class of Riemann integration is quite restricted	K5
2.9	Riemann and Lebesgue integration	Prove that all Riemann integrable functions are Lebesgue integrable but not all Lebesgue integrable functions are Riemann integrable	K5
III	**Abstract Measure Spaces**		

3.1	Ring and Sigma Ring	Define Ring and Sigma Ring	K1
3.2	Measure and outer measure	Define Measure (μ) and outer measure (μ) and list out the properties of the same	K1
3.3	Extension of a measure	Extend the concepts of Lebesgue outer measure and Lebesgue measure to ring and sigma ring	K2
3.4	μ measurability	Define measurability and class of μ measurable sets S	K1
3.5	Extension and complete measure	Prove that the class S is sigma ring and μ restricted to S is a complete measure.	K5
3.6	Uniqueness of extension	Prove that the extension of the original measure to complete measure is unique under some conditions.	K5
3.7	Extension of sigma finite measure	Prove that the sigma finite measure μ on a Ring has a unique extension to the sigma ring	K5
3.8	Completion of a measure	Prove how a measure which is not complete may be extended to one which is by adjoining to the original ring the subsets of the sets of measure zero	K5
3.9	Measurable space, measure space	Define and list out the properties of Measurable space and measure space	K1
3.10	Integration of simple functions and non-negative functions	Define simple function and evaluate integration of simple function and non-negative functions.	K1
3.11	Lebesgue's Monotone convergence theorem	Prove Monotone convergence theorem by proving Fatou's Lemma	K5
3.12	General integral	Define Lebesgue integration for general functions and evaluate integration for general functions	K1
3.13	Lebesgues dominated convergence theorem	Prove Lebesgue's dominated convergence theorem	K5
IV	**Convergence & Signed Measures**		
4.1	Convergence in measure	Investigate the forms of convergence of measurable functions.	K4
4.2	Completeness theorem for convergence in measure	Prove Completeness theorem for convergence in measure	K5

4.3	Almost uniform convergence	Identify similarities and differences of Almost uniform convergence, Uniform convergence a.e and convergence in measure.	K3
4.4	Ergov's Theorem	Prove Ergov's Theorem	K5
4.5	Signed measure, positive and negative sets	Define signed measure and list out its properties	K1
4.6	Positive and negative sets	Define positive, negative and null sets and list out their properties	K1
4.7	Hahn Decomposition	Decompose a space into positive and negative sets by Hahn decomposition.	K5
4.8	Jordon decomposition	Decompose a signed measure into different measures.	K5
V	**Measurability in Product space**		
5.1	Product of measurable space	Extend the concepts of measurability to two dimensions	K2
5.2	Measurable rectangles	Identify that class of measurable rectangles is algebra	K3
5.3	Monotone class	Analyze monotone class which provides the essential tool for integration theory in product space.	K4
5.4	x section, y section	Define measurable set has measurable sections.	K1
5.5	Product measure	Define product measure	K1
5.6	Fubinis theorem	Prove Fubin's theorem	K5

4. MAPPING SCHEME (POs, PSOs AND COs)

P21MA309	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	M	M	H	-	L	L	L	L	-	M	M	M	M
CO2	M	M	H	-	-	M	H	M	-	M	M	M	M
CO3	H	M	H	-	-	M	H	M	-	M	M	M	H
CO4	H	M	H	-	-	-	L	L	-	M	M	M	H
CO5	H	M	H	-	-	-	L	L	-	M	L	L	H
CO6	H	M	H	-	-	-	L	L	-	M	L	L	H

L-Low M-Moderate H- High

5. COURSE ASSESSMENT METHODS

DIRECT:

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book
2. Open Book Test.
3. Cooperative Learning Report, Assignment, Group Presentation, Group Discussion, Project Report, Seminar, Quiz (written).
4. Pre-Semester & End Semester Theory Examination

INDIRECT:

1. Course end survey (Feedback)

NAME OF THE COURSE COORDINATOR: Dr. V. Franklin

Course Code X: COMPLEX ANALYSIS

Semester: III **Course Code: P21MA310**

Credits : 5 **Hours/Week: 6**

1. COURSE OUTCOMES

After the successful completion of this course the students will be able to

CO. No	Course Outcomes	Level	Unit
CO1	Analyze power series, the number system of polynomial equation and Cauchy's theorem of geometrical form.	K4	I
CO2	Determine whether a given function is Differentiable.	K5	II
CO3	Examine the singularities.	K4	II
CO4	Analyze the connected sets and multiply connected regions and Conclusion of Cauchy's theorem and residue theorem.	K4	III
CO5	Justify whether a given function is harmonic function and derive its properties and understand reflection principle.	K5	IV
CO6	Evaluate integration of functions defined on Entire function and Prove the Formula for SinZ and Gamma Funtions and Jensen's Formula.	K5	V

2A. SYLLABUS

Unit I : Cauchy's Theorem **(16 Hours)**

Power series – Abel's limit theorem – Cauchy's theorem for a rectangle.

Unit II : Differential and Singularities **(19Hours)**

Higher derivatives – Morera's theorem – Liouville's theorem – Cauchy's estimates – Fundamental theorem of algebra – Local properties of analytical functions – Removable singularities – Taylor's theorem – Zeros and poles – Meromorphic functions – Essential singularities.

Unit III : Geometrical Representation of Complex Analysis **(19 Hours)**

The general form of Cauchy's theorem – Chains and cycles - Simply connected sets – Homology – The general statement of Cauchy's theorem and its proof – Locally exact differentials – Multiply connected regions – The residue theorem – The Argument principle – Evaluation of definite integrals.

Unit IV : Harmonic Functions in Complex Analysis **(18Hours)**

Harmonic functions – Basic properties – Polar form – Mean value property – Poisson's formula – Schwartz's theorem – Reflection principle.

Unit V : Entire Function **(18 Hours)**

Partial fractions – Infinite products – Canonical products – Entire functions – Representation of entire functions – Formula for sin z and gamma functions – Jensen's Formula

B. TOPICS FOR SELF STUDY

S.No.	Topics	Web-Links
1	Cauchy's theorem in Complex Analysis.	http://www.math.tifr.res.in/~publ/ln/tifr13.pdf
2	Differential and Singularities	https://www.atmschools.org/2016/tew/ca
3	Harmonic Functions	http://www.math.tifr.res.in/~publ/ln/tifr29.pdf
4	Evaluation of the integral.	https://people.reed.edu/~jerry/311/lec08.pdf

C. TEXT BOOK(s)

1.V. Ahlfors, Complex Analysis, McGraw Hill International, Third Edition, 1979.

D. REFERENCE BOOKS

1. S. Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House, 1997.
2. Churchill, R.V. Brown J. W., Complex Variables and Application, McGraw Hill Publishing Pvt.Ltd., 4th edition, 1984.
3. S. Lang, Complex Analysis, Addison Wesley, 1977

E. WEB LINKS

1.https://nptel.ac.in/courses/111/103/111103070/

2.https://nptel.ac.in/courses/111/106/111106141/

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit/ Section	Course Content	Learning outcomes	Highest Bloom's Taxonomic Level of Transaction
I	**Cauchy's Theorem**		
1.1	Introduction to Geometrical formation of Complex function	Define a power series and list out the properties of Complex variable.	K1
1.2	Abel's Limit Theorem in Complex Analysis	Prove the Abel's Limit theorem in geometrical formation.	K5

1.3	radius of convergence and circle of convergence	Analyze the radius of convergence and circle of convergence in complex region.	K5
1.4	Cauchy's Theorem	Prove the cauchy's theorem.	K5
1.5	Evaluation of the integral	Evaluate the cauchy's integral theorem.	K5
II	**Differential and Singularities**		
2.1	Derivation of simple functions	Define simple function	K1
2.2	Integration of non-negative Functions	Evaluate integration of non-negative functions	K5
2.3	Morera's theorem – Liouville's theorem – Cauchy's estimates	Prove Morera's theorem – Liouville's theorem – Cauchy's estimates	K5
2.4	Fundamental theorem of algebra	Prove Fundamental theorem of algebra	K5
2.5	Local properties of analytical functions	Define Local properties of analytical functions.	K1
2.6	Singularities	Classification of Singularities	K4
2.7	Taylor's theorem	ProveTaylor's theorem	K5
2.8	Zeros and poles Meromorphic functions.	Define Zeros and poles – Meromorphic functions.	K1
2.9	General integration	Evaluate the integration	K1
III	**Geometrical Representation of Complex Analysis**		
3.1	Chains and cycles - Simply connected sets – Homology.	Define a Chains and cycles, Simply connected sets and Homology.	K1
3.2	General statement of Cauchy's theorem and its proof.	Prove general statement of Cauchy's theorem and its proof	K5
3.3	Locally exact differentials and Multiply connected regions.	Define Locally exact differentials and Multiply connected regions.	K1
3.4	The residue theorem – The Argument principle.	Prove the residue theorem and Argument principle.	K5
3.5	Definite integrals.	Evaluate the definite integrals	K5
IV	**Harmonic Functions in Complex Analysis**		
4.1	Harmonic functions In Complex Analysis	Define Harmonic functions in Complex Analysis	K1
4.2	Basic properties of Harmonic Function.	Proved the Properties of Harmonic Function.	K5
4.3	Mean value property.	Prove the Mean value theorem.	K5
4.4	Poisson's formula	Prove Poisson Formula	K5
4.5	Schwartz's theorem – Reflection principle.	Prove Schwartz's theorem and Reflection principle.	K5
V	**Entire Function**		

5.1	Infinite products – Canonical products on Entire functions.	Define a Partial fractions, Infinite products and Canonical products on Entire functions.	K1
5.2	Representation of entire Functions	Explain the Representation of entire Functions	K2
5.3	Formula for sin z and gamma Functions	Apply the Formula for sin z and gamma Functions	K3
5.4	Jensen's Formula	Evaluate the integral using Jensen's Formula	K5
5.5	General integrals	Conclusion of the integrals	K5

4. MAPPING SCHEME (POs, PSOs AND COs)

P21MA310	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	M	H	M	H	M	H	M	-	L	L	M	H
CO2	H	M	M	M	H	M	H	M	-	L	M	M	M
CO3	H	M	M	M	H	M	M	H	-	M	M	M	M
CO4	H	H	M	M	M	M	M	M	-	L	H	H	M
CO5	H	H	H	M	M	H	M	M	-	L	M	M	M
CO6	H	H	M	L	L	L	L	L	-	M	M	L	H

L-Low **M-Moderate** **H- High**

5. COURSE ASSESSMENT METHODS

DIRECT:

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book
2. Open Book Test.
3. Cooperative Learning Report, Assignment, Group Presentation, Group Discussion, Project Report, Seminar, Quiz (written).
4. Pre-Semester & End Semester Theory Examination

INDIRECT:

1. Course end survey (Feedback)

NAME OF THE COURSE COORDINATOR: Mr. M. Suresh kumar

Core Course XI: PROBABILITY & STATISTICS

Semester : III **Course Code: P21MA311**

Credits : 4 **Hours/Week: 6**

1. COURSE OUTCOMES:

After the successful completion of this course the students will be able to

CO. No.	Course Outcomes	Level	Unit
CO1	Exhibit knowledge and understanding of probability as a continuous set function, the notion of discrete and continuous random variable and their probability functions, distribution functions and expectations.	K2	I, II & III
CO2	Measure the expectation of the joint distribution function of a random variable	K3	II
CO3	Find the probabilities of the events having partial or no information by applying Baye's formula and distinguish between independent and dependent events	K5	III
CO4	Determine the probability of different types of random variables like Binomial, Poisson and Normal random variables and evaluate the mean and variance of normal and exponential random variable	K5	III
CO5	Identify the distributions depending on the nature of the data and derive inferences	K4	IV
CO6	Analyse the construction of moment generating functions and to understand different results on random variables	K3	V

2A. SYLLABUS

Unit I: Probability **(20 hours)**

Basic concepts – Sample space and events – Axioms of probability – Some simple propositions – equally likely outcomes – Probability as a continuous set function - Probability as a measure of belief.

Unit II : Conditional Probability and Random Variables **(20 hours)**

Conditional probabilities – Baye's formula – Independent events – P(./F) is a probability – random variables – Expectation of a function of a random variable – Bernoulli, Binomial and Poisson random variables.

Unit III : Different types of Random Variables and Distributions **(20 hours)**

Discrete probability distributions – Geometric, Negative Binomial and Hypergeometric random variables – the zeta (z;pf) distribution – continuous random variables – the uniform and normal random variables – exponential random variables – other continuous distributions – the distribution of a function of a random variable.

Unit IV : Expectation and Conditional Expectation (15 hours)

Joint Distribution functions – Independent random variables – Their sums – conditional distribution – Joint probability distribution of functions – expectation – variance – covariance – conditional expectation and prediction.

Unit V : Moment Generating Functions (15 hours)

Moment generating function – general definition of expectation – limit theorems – Chebyshev's inequality – weak law of large numbers – central limit theorems – the strong law of large numbers – other inequalities

B. TOPICS FOR SELF STUDY

S. No.	Topics	Web Links
1	The Poisson Process	https://www.probabilitycourse.com/chapter11/11_1_2_basic_concepts_of_the_poisson_pr ocess.php
2	Markov Chains	https://brilliant.org/wiki/markov-chains/#:~:text=A%20Markov%20chain%20is%20a,possible%20future%20states%20are%20fixed.
3	Surprise, Uncertainty and Entropy	http://www2.hawaii.edu/~sstill/ICS636Lectures/ICS636Lecture2.pdf
4	Coding Theory and Entropy	https://www.stat.berkeley.edu/~aldous/205B/entropy_chapter.pdf

C. TEXT BOOK(s)

1. Sheldon Ross , A First Course in Probability, Maxwell MacMmillar International Edition, Maxmillar, New York, 6th Edition, 2008.

D. REFERENCE BOOKS

1.GeofferyGrimmell and Domenic Welsh , Probability – An Introduction, Oxford University Press, 1986.

E. WEB LINKS

https://nptel.ac.in/courses/111/105/111105041/

https://onlinecourses.swayam2.ac.in/cec20_ma01/preview

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit/ Section	Course Content	Learning Outcomes	Highest Bloom's Taxonomic Level of Transactio
I	**Probability**		
1.1	Sample space and events	Show the relationship between the three basic operations of the probability of an event.	K2
1.2	Axioms of probability	Apply the axioms of probability	K3
1.3	Some simple propositions	Utilizeaxioms to prove some simple prepositions regarding probability	K3
1.4	Sample space havingequally likely outcomes	Estimate probability for different problems	K5
1.5	Probability as a continuous set function	Prove the result for the sequence of events	K5
1.6	Probability as a measure of belief	Interpret probability as a measure of belief	K2
II	**Conditional Probability and Random Variables**		
2.1	Conditional Probabilities	Apply multiplication rule to compute the probability	K3
2.2	Baye's Formula	Apply Baye's formula	K3
2.3	Independent events	Evaluate the probability for independent events	K5
2.4	P(. / F) is a probability	Estimate the probability that a run of n consecutive successes before a run of m consecutive failures	K5
2.5	Random variables	Solve the problems on random variables	K3

2.6	Discrete Random Variables	Illustrate Discrete Random Variables and cumulative distribution function	K2
2.7	Expected Value	Measure the expectation of a random variable	K5
2.8	Expectation of a function of a random variable	Demonstrate how to maximize expected profit	K5
2.9	Variance	Define variance and standard deviation of a random variable	K1
2.10	The Bernoulli and Binomial Random variables	Apply the Bernoulli and Binomial random variable	K3
2.11	Properties of Binomial Random Variables	Prove some results on Binomial random variable	K5
2.12	Computing the Binomial Distribution function	Utilizethe recursion to compute the Binomial distribution function	K3
2.13	The Poisson Random Variable	Evaluate the problem on the Poisson random variable	K5
2.14	Computing the poisson Distribution function	Determine the probability of a Poisson random variable	K5
III	**Different types of Random Variables and Distributions**		
3.1	The Geometric random variable	Apply the concept of Geometric Random Variable	K3
3.2	The negative Binomial Distribution	Evaluate the expected value of the negative Binomial Random Variable	K5
3.3	The Hypergeometric random variables	Determine the expected value of hypergeometric random variable	K5
3.4	The zeta distribution	Define the zeta distribution	K1
3.5	Introduction	Evaluate the probability of a continuous Random Variable	K5

3.6	Expectation and variance of Continuous Random variables	Apply the concept of uniform distribution	K3
3.7	The Uniform Random Variables	Evaluate the mean and variance of uniform random variable	K5
3.8	Normal Random Variables	Evaluate the mean and variance of normal random variable	K5
3.9	Exponential Random variables	Evaluate the mean and variance of exponential random variable	K5
3.10	The Gamma Distribution	Evaluating the mean and variance of Gamma random variable	K5
3.11	The Weibull Distribution	Define Weibull distribution	K1
3.12	The Cauchy Distribution	Evaluating the problem of Cauchy Distribution	K3
3.13	The Beta distribution	Apply the concept of Beta distribution	K3
3.14	The distribution of a function of a Random variable	Solve the problem of the distribution function of a random variable	K5
IV	**Expectation and Conditional Expectation**		
4.1	Joint distribution functions	Evaluate marginal density functions and expectation	K5
4.2	Independent Random Variables	Prove the results on independent cases	K5
4.3	Sums of Independent Random Variables	Prove that the parameters are normally distributed	K5
4.4	Conditional distributions: Discrete case	Apply the conditional distribution	K3

4.5	Conditional distributions: Continuous Case	Measure probability for the continuous case.	K5
4.6	Introduction to property of expectation	Define the basic concepts of expectation	K1
4.7	Expectation of Sums of Random variables	Evaluate the expected square of the distance	K5
4.8	Obtaining bounds from expectation viva the probabilistic method	Estimate the maximum number of Hamiltonian paths in a tournament	K5
4.9	The maximum – minimums identity	Determine the expected number of cards that need to be turn over.	K5
4.10	Covariance, Variance of Sums and correlations	Estimate the variance the number of matches and the correlation of two random variables	K5
4.11	Conditional Expectation	Solve the problems to calculate the conditional expected value	K3
4.12	Computing expectation by conditioning	Determine the expected value for the conditional case	K5
4.13	Computing probabilities by conditioning	Evaluate probabilities by conditioning	K5
4.14	Conditional Variance	Derive the conditional variance formula	K2
4.15	Conditional Expectation and prediction	Analyze the conditional distribution	K4
V	**Moment Generating Functions**		
5.1	Moment Generating Functions	Evaluate M.G.F of Poisson and normal distribution	K5
5.2	Joint moment generating functions	Apply the concept of joint M.G.F	K3
5.3	Additional Properties of Normal Random Variables	Discuss the concept of the joint distribution of the	K5

		sample mean and sample variance	
5.4	General definition of Expectation	Define the general definition of Expectation	K1
5.5	Chebyshev's inequality and the weak law of large numbers	Evaluate the problem of chebyshev's inequality	K5
5.6	The central limit theorem	Prove the central limit theorem	K5
5.7	The strong law of large numbers	Prove the strong law of large numbers	K5
5.8	Other inequalities	Evaluate the mean and variance of one – sided Chebyshev's inequality	K5

4. MAPPING SCHEME (POs, PSOs AND COs)

P21MA311	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	M	M	L	L	M	H	M	-	L	M	L	M	M
CO2	M	H	-	L	M	H	M	L	-	H	M	H	H
CO3	H	H	M	-	L	M	L	-	L	M	M	M	M
CO4	M	H	M	M	M	H	M	L	L	H	L	H	H
CO5	H	M	-	L	H	L	H	M	M	H	L	M	M
CO6	L	L	L	-	L	M	M	-	M	M	M	M	M

L-Low **M-Moderate** **H- High**

5. COURSE ASSESSMENT METHODS

DIRECT:

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book
2. Open Book Test.
3. Cooperative Learning Report, Assignment, Group Presentation, Group Discussion, Project Report, Seminar, Quiz (written).
4. Pre-Semester & End Semester Theory Examination

INDIRECT:

1. Course end survey (Feedback)

NAME OF THE COURSE COORDINATOR: Mr. M. Suresh kumar

Elective IV: Problem Solving in Advanced Mathematics

Semester: III **Course Code: P21MA3:4**

Credits: 4 **Hours/Week: 6**

1. COURSE OUTCOMES:

After the successful completion of this course the students will be able to

CO. No.	Course Outcomes	Level	Unit
CO1	Analyse the concepts and Solve problems in Real Analysis	**K4**	**I, II**
CO2	Solve problems in Complex Analysis	**K4**	**II**
CO3	Construct various Algebric structures and solve problems	**K6**	**III**
CO4	Determine the relationships between Linear Algebraic structures and solve problems	**K5**	**IV**
CO5	Deduct various properties and apply suitable methods to solve Differential Equations	**K5**	**IV**
CO6	Construct Models to solve Physical and real life Problems	**K5**	**V**

2A. SYLLABUS

Unit I: Real Analysis **(20 hours)**

Sequences and series, Convergence, limsup, liminf, Bolzano Weierstrasss theorem, Hernie Borel theorem, Continuity, uniform continuity, differentiability, mean value theorem, Sequences and series of functions, uniform convergence, Riemann sums and Riemann integral, Improper Integrals, Monotonic functions, types of discontinuity, functions of bounded variation, Lebesgue measure, Lebesgue Integral.

Unit II: Complex Analysis **(15 hours)**

Analytic functions, Cauchy- Riemann equations, Contour Integral, Cauchy's theorem, Cauchy's Integral formula, Liouville's theorem, Maximum modulus principle, Schwarz lemma, Open mapping theorem, Taylor series, Laurent series, calculus of residues.

Unit III: Algebra **(20 hours)**

Groups, Subgroups, normal subgroups, quotient groups, homomorphisms, cyclic groups, permutation groups, Cayley's theorem, Class equations, Sylow theorems, Rings, Ideals, Prime and maximal ideals, quotient rings, unique factorization domain, principal ideal domain, Euclidean domain, Fields, Field extensions, Galois Theory.

Unit IV: Linear Algebra **(20 hours)**

Vector spaces, subspaces, linear dependence, basis, dimension, algebra of linear transformations, Algebra of matrices, rank and determinant of matrices, linear equations, Eigen values and eigen vectors, Cayley- Hamilton theorem, Matrix representation of linear transformations, Inner Product Spaces.

Unit V: Differential Equations (15 hours)

Existence and uniqueness of solutions of initial value problems for first order ordinary differential equations, singular solutions of first order ODE's, System of first order ODE's, Lagrange and Charpit methods for solving first order PDEs, Cauchy problem for first order PDEs, Classification of second order PDEs, General solution of higher order PDEs with constant coefficients.

B. TOPICS FOR SELF-STUDY

S. No.	Topics	E. WEB LINKS
1	A Problem Book in Real Analysis	http://websitem.karatekin.edu.tr/user_files/farukpolat/files/probookmathanal1.pdf
2	Complex Analysis: Problems with Solutions	https://fac.ksu.edu.sa/sites/default/files/2016_complex_analysis_problems_solutions.pdf

C. TEXT BOOKs

1. Info Study's Real Analysis by A.P.Singh Info study Publications
2. Info Study's Complex Analysis by A.P.Singh Info study Publications
3. Info Study's Modern Algebra by A.P.Singh Info study Publications
4. Info Study's Linear Algebra by A.P.Singh Info study Publications
5. Info study's Differential Equation by Dr. A. P. Singh Info study Publications

D. REFERENCE

1. Walter Rudin , Principles of Mathematical Analysis, Third Edition, McGraw-Hill Inter National Book Company, New York, 1976.
2. John B. Conway, Functions of one Complex Variable, Second Edition, Springer Graduate Text in Mathematics, New York, 1978.
3. Joseph. A. Gallian, Contemporary Abstract Algebra, 7th Edition Katherine Tegen Books.
4. Seymour Lipschutz and Marc Lipson, Schaum's Outlines Linear Algebra Third Edition.
5. Gilbert Strang, Introduction to Linear Algebra Fourth Edition, Wellesley Cambridge Press.
6. Earl A. Coddington, An Introduction to Ordinary Differential Equations, Prentice-Hall of India, New Delhi, 1992.
7. M.D Raisinghania, Advanced Differential Equations, S. Chand and Company ltd, New Delhi, 2001.

E. WEB LINKS

1. https://nptel.ac.in/courses/111/106/111106051/
2. https://nptel.ac.in/courses/111/106/111106137/
3. https://nptel.ac.in/courses/111/106/111106053/

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit/ Section	Course Content	Learning Outcomes	Highest Bloom's Taxonomic Level of Transaction
I	**Real Analysis**		
1.1	Sequences and series	Identify the concepts of sequences and series and use it in problem solving	K3
1.2	Convergence	Analyse the concepts of Convergence and use it in problem solving	K4
1.3	limsup, liminf	Outline the concepts of limsup and liminf and apply in problem solving	K3
1.4	Bolzano Weierstrass theorem	Demonstrate the use of Bolzano Weierstrass theorem in problem solving	K5
1.5	Hernie Borel theorem	Construction of the Theorem and solving problems related to the theorem	K3
1.6	Continuity, uniform continuity	Classify the concepts of Continuity and uniform continuity in problem solving	K4
1.7	differentiability	Apply the concepts of Differentiability in problem solving	K5
1.8	mean value theorem	Examine the Mean value theorem and apply in problem solving techniques	K4
1.9	Sequences and series of functions	Analyse the sequences and series of functions and use in problem solving	K4
1.1	Uniform convergence	Describe the Uniform convergence and use in problem solving	K5
1.11	Riemann sums and Riemann integral	Apply the concepts of Riemann sums and Riemann integrals	K5
1.12	Improper Integrals	Evaluate the different cases of Improper Integrals	K5
1.13	Monotonic functions	Analyse all the cases of Monotonic functions	K4
1.14	Types of discontinuity	Differentiate between the types of discontinuity in problem solving	K4
1.15	Functions of bounded variation	Examine the concepts of Functions of Bounded variation and use in problem solving	K4
1.16	Lebesgue measure	Construct Lebesgue measure and utilise in problem solving	K5

1.17	Lebesgue Integral	Evaluate Lebesgue Integrals	K6
II	**Complex Analysis**		
2.1	Analytic functions	Explain the concepts of Analytic functions and utilise in	K2
2.2	Cauchy- Riemann equations	Construct the C-R equations and solve problems related to C-R equations	K3
2.3	Contour Integral	Compute the Contour Integrals for various categories of problems	K4
2.4	Cauchy's theorem	Proving Cauchy's theorem and solving problems	K5
2.5	Cauchy's Integral formula	Interpret Cauchy's Integral formula and solve related problems	K2
2.6	Liouville's theorem	Establish Liouville's theorem and use the concept in problem solving	K3
2.7	Maximum modulus principle	Analyse the maximum modulus principle and solve related problems	K4
2.8	Schwarz lemma	Establish Schwarz lemma and utilise in problem solving	K3
2.9	Open mapping theorem	Explain Open mapping theorem and solve problems related to the theorem	K2
2.10	Taylor series	Recognize Taylor's series and solve problems based on Taylor's series	K2 & K3
2.11	Laurent series	Examine Laurent's series and solve problems using Laurent's series.	K4
2.12	Calculus of Residues	Identify the concept of Residues and solve various problems related to residues	K3
III	**Algebra**		
3.1	Groups	Interpret the concept of Groups and solve problems	K2 & K3
3.2	Subgroups	Formulate Subgroups and utilise in problem solving the Spectral Resolution	K5
3.3	Normal subgroups	Construct Normal subgroups and solve related problems	K5
3.4	Quotient Groups	Classify Quotient groups for problem solving	K4
3.5	Homomorphisms	Demonstrate the concept of Homomorphisms through problem solving	K3
3.6	Cyclic groups	Categorise the results for Cyclic groups and solve problems	K4

3.7	Permutation Groups	Construct Permutation groups and utilise the concepts in solving problems	K5
3.8	Cayley’s theorem	Recognize Cayley’s theorem and utilise the concepts in solving problems	K2 & K3
3.9	Class Equations	Identify Class Equations and solve related problems	K3
3.10	Sylow theorems	Explain Sylow’s theorems and use in problem solving	K5
3.11	Rings	Apply the concepts of Rings for problem solving	K5
3.12	Ideals	Differentiate between Ideals and use in problem solving	K4
3.13	Prime & Maximal Ideals	Categorize the concepts in Prime and Maximal Ideals and solve related problems	K5
3.14	Quotient Rings	Distinguish Quotient Rings and solve problems	K4
3.15	Unique Factorization Domain	Construct UFD and solve related problems	K5
3.16	Principal Ideal Domain	Construct PID and use in problem solving	K5
3.17	Euclidean Domains	Develop Euclidean Domains and solve problems	K5
3.18	Fields	Explain the various concepts of Fields and solve related problems	K5
3.19	Field Extensions	Develop Field Extensions and solve problems	K5
3.20	Galois Theory	Assess Galois Theory based on Field extensions and solve problems	K6
IV	**Linear Algebra**		
4.1	Vector Spaces	Explain the basics of vector spaces and utilise in problem solving	K5
4.2	Subspaces	Outline the idea of subspaces and solve various problems	K2 & K3
4.3	Linear Dependence	Contrast between Linear Dependence and Linear Independence for problem solving	K5
4.4	Basis	Identify the Basis of a Vector space and use in problem solving	K3
4.5	Dimension	Analyse the dimension of the vector space through the Basis of vector space	K3 & K4

4.6	Algebra of Linear Transformations	Determine the Algebra of Linear Transformations for problem solving	K5
4.7	Algebra of Matrices	Determine the Algebra of Matrices for problem solving	K5
4.8	Rank & Determinant of Matrices	Determine the Rank and Determinant of Matrices for problems	K5
4.9	Linear Equations	Evaluate Linear Equations for problem solving	K5
4.10	Eigen Values & Eigen Vectors	Contrast between Eigen values and Eigen vectors and solve problems	K6
4.11	Cayley-Hamilton theorem	Construct Cayley-Hamilton theorem and solve problems	K6
4.12	Matrix representation of linear transformations	Determine the matrix representation of Linear Transformations	K3
4.13	Inner Product Spaces	Construct Inner Product Spaces and solve related problems	K6
V	**Differential Equations**		
5.1	Existence and uniqueness of solutions of initial value problems for first order ordinary differential equations,	Analyse the solutions of the IVP for first order Differential equations	K4
5.2	Singular solutions of first order ODE’s	Evaluate Singular solutions of first order ODE’s	K5
5.3	System of first order ODE’s,	Classify the System of first order ODE’s and solve problems	K4
5.4	Lagrange and Charpit methods for solving first order PDEs,	Apply Lagrange and Charpit methods for solving first order ODE’s	K5
5.5	Classification of second order PDEs,	Classify different types of second order PDE’s and solve problems	K4
5.6	Cauchy problem for first order PDEs ,	Establish Cauchy problem for first order PDE’s and solve related problems	K4
5.7	General solution of higher order PDEs with constant coefficients.	Determine the General solution of higher order PDE’s and solve related problems of higher order	K5 & K6

4. MAPPING SCHEME (POs, PSO AND COs)

P21MA3:4	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSOs1	PSOs2	PSOs3	PSOs4
CO1	H	M	H	H	H	H	H	H	L	H	M	H	M
CO2	H	M	H	H	H	H	H	H	L	M	M	H	M
CO3	H	M	H	H	H	H	H	H	L	M	M	H	M
CO4	H	H	H	H	H	H	H	H	L	M	M	H	H
CO5	H	H	H	H	H	H	H	H	L	H	M	H	H
CO6	H	H	H	H	H	H	H	H	L	H	M	H	H

L-Low M-Moderate H- High

5. COURSE ASSESSMENT METHODS

DIRECT:

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book
2. Open Book Test.
3. Cooperative Learning Report, Assignment, Group Presentation, Group Discussion, Project Report, Seminar, Quiz (written).
4. Pre-Semester & End Semester Theory Examination

INDIRECT:

1. Course end survey (Feedback)

NAME OF THE COURSE COORDINATOR: Dr. P. John Robinson

Core Course XII: FUNCTIONAL ANALYSIS

Semester : IV **Course Code: P21MA412**

Credits : 5 **Hours/Week: 6**

1. COURSE OUTCOMES:

After the successful completion of this course the students will be able to

CO. No.	Course Outcomes	Level	Unit
CO1	Acquire Knowledge and Understand the concept of Normed Linear Space and to analyse the structure and properties of Banach Space & Hilbert Space	K2	I, II
CO2	Understand the properties of different Operators on Hilbert Space	K3	II
CO3	Analyse the importance of Conjugate Space in defining Operators	K4	III
CO4	Construct the Spectral Theory based on the developed Operators	K5	III
CO5	Combine the Algebra of Operators & Topological sets leading to Banach Algebra	K4	IV
CO6	Analyse the structure of Commutative Banach Algebra	K4	V

2A. SYLLABUS

Unit I : Banach Spaces **(20 hours)**

Banach Spaces : The definition and some examples – Continuous linear transformations – The Hahn-Banach theorem – The natural imbedding of N in N** - The open mapping theorem – The conjugate of an operator.

Unit II : Hilbert Spaces: **(20 hours)**

Hilbert Spaces : The definition and some simple properties – Orthogonal complements – Orthonormal sets – The conjugate space H* - The adjoint of an operator – Self-adjoint operators – Normal and unitary operators – Projections.

Unit III : Finite Dimensional Spectral Theory **(15 hours)**

Finite-Dimensional Spectral Theory: Matrices – Determinants and the spectrum of an operator – The spectral theorem – A survey of the situation.

Unit IV : Banach Algebra **(20 hours)**

General Preliminaries on Banach Algebras: The definition and some examples – Regular and singular elements – Topological divisors of zero – The spectrum – The formula for the spectral radius – The radical and semi-simplicity.

Unit V: The Structure of Commutative Banach Algebras **(15 hours)**

The Structure of Commutative Banach Algebras: The Gelfand mapping – Applications of the formula r(x) = x||lim n || 1/n – Involutions in Banach Algebras – The Gelfand-Neumark theorem.

B. TOPICS FOR SELF STUDY

S.No.	Topics	Web Links
1	Some concepts related to Functional Analysis	https://www.maths.usyd.edu.au/u/athomas/FunctionalAnalysis/daners-functional-analysis-2017.pdf
2	More on Banach space	https://ncatlab.org/nlab/show/Banach+space
3	Application of Hilbert space in Quantum Mechanics	https://www.whitman.edu/Documents/Academics/Mathematics/klipfel.pdf
4	Some fixed point theorems of Functional Analysis	http://www.math.tifr.res.in/~publ/ln/tifr26.pdf

C. TEXT BOOK(s)

1.G.F. Simmons, Introduction to Topology and Modern Analysis, Tata McGraw-Hill Publishing Company Ltd.,2006.

D. REFERENCE BOOKS

1. B.V. Limaye, Functional Analysis, Wiley Eastern Limited, Bombay, 2nd Print, 1985.

2.Walter Rudin, Functional Analysis, Tata McGraw Hill Publishing co., New Delhi, 1977.

3.K. Yosida, Functional Analysis, Springer-Verlag, 1974.

4.Laurent Schwarz, Functional Analysis, Courent Institute of Mathematical Sciences,

NewYork University, 1964.

E. WEB LINKS

1. https://nptel.ac.in/courses/111/105/111105037/#

2.https://ocw.mit.edu/courses/mathematics/18-102-introduction-to-functional-analysis-spring-2009/

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit/ Section	Course Content	Learning Outcomes	Highest Bloom's Taxonomic Level of Transaction
I	Banach Spaces		
1.1	Basic concepts of Banach space	Classify the concepts of Linear Space & Normed Linear space	K3
1.2	Continuous Linear Transformations	Analyse the characteristics of Banach space	K4
1.3	The Hahn-Banach Theorem	Outline the proof of the Hahn-Banach theorem	K3

1.4	Applications of Hahn-Banach Theorem	Demonstrate the use of continuous linear functionals in the Hahn-Banach theorem	K5
1.5	The concept of Conjugate space & the Natural Imbedding of N in N**	Construction of the Natural Imbedding	K3
1.6	The Open Mapping Theorem	Construct the Open map between Banach spaces when the linear transformations are surjective	K3
1.7	The Closed Graph Theorem	Justify that the linear transformation between Banach spaces is continuous iff its graph is closed	K6
1.8	The Uniform Boundedness Theorem	Conclude that for a family of continuous linear operators in a Banach space, pointwise boundedness is equivalent to uniform boundedness	K4
II	**Hilbert Spaces**		
2.1	Definition and simple properties	Define Hilbert Space	K2
2.2	Schwarz inequality, parallelogram law	Construct Schwarz inequality and parallelogram law for Hilbert space	K3
2.3	Polarization identity	Compute the Polarization identity for Hilbert space	K4
2.4	Orthogonal Complements Establishing $H = M \oplus M^{\perp}$	Showing that $H = M \oplus M^{\perp}$, where the subspaces are orthogonal complements	K5
2.5	Orthonormal sets	Define the concept Orthonormal set	K2
2.6	Bessel's inequality	Implement the concepts of orthonormal sets in proving the Bessel's inequality	K3
2.7	Theorems based on Orthonormal sets in Hilbert space	Implement the concepts of orthonormal sets in proving theorems in Hilbert space	K3
2.8	The concept of conjugate space and theorems,	Define a conjugate space of a Hilbert Space	K2
2.9	The Adjoint, Self-Adjoint, Normal, Unitary Operators	Outline the properties and results of different operators in Hilbert space Compare the operators defined on Hilbert space	K3
2.10	Basic concept of Projections	Implement the concept of Projections in Hilbert space	K3

2.11	Perpendicular Projections	Introducing the concept of perpendicular projections	K2
2.12	Some theorems on Projections	Translating the concept of perpendicular projections into relations between the operator and the projection on the closed linear subspace of H	K4
III	**Finite Dimensional Spectral Theory**		
3.1	Introduction to eigen value and eigen vector of operator T	Interpret the Eigen space corresponding to an Eigen value	K3
3.2	Spectral Resolution	Formulate the Spectral Resolution	K5
3.3	Matrices for spectral theory	Construct matrix representation of the operator involved in the spectral resolution relative to an ordered basis	K5
3.4	Determinants and the Spectrum of an Operator	Identify the determinant of the operator (matrix relative to any basis)	K1
3.5	Problem solving	Demonstrate the properties of the operator involved in the spectral theory through problem solving	K3
3.6	The Spectral Theorem: Preliminary theorems	Categorise the results for spectral theorem	K4
3.7	The Spectral Theorem	Construct the Spectral Theorem by establishing some equivalent conditions	K5
IV	**Banach Algebra**		
4.1	General Preliminaries on Banach Algebras	Define the concept of Banach Algebra	K2
4.2	The definition and some examples	Identify some examples for Banach Algebra	K3
4.3	Regular and singular elements	Contrast between Regular and Singular elements	K5
4.4	Inverse of a Regular Element	Calculate the inverse of a Regular element	K3
4.5	The set of all Regular elements is open	Justifying that the set of all regular elements in a Banach algebra is open	K4
4.6	Topological divisors of zero	Identify a Topological Divisor of Zero	K3
4.7	The spectrum: The Resolvent set and Resolvent equation	Define the concept of Resolvent set and equation	K2

4.8	The Spectrum is a non-empty set	Apply the Resolvent equation in proving the spectrum is non-empty	K3
4.9	Division Algebra	Identify the concept of Division Algebra	K2
4.10	The theorem to prove A=C	Justifying that any Division Algebra equals the set of all scalar multiples of the identity (i.e. A=C)	K6
4.11	The formula for the spectral radius	Construct the formula for the Spectral Radius	K3
4.12	Ideals	Identify the concept of Ideal (left and right Ideals)	K3
4.13	Regular & Singular Elements	Contrast between Regular & Singular elements	K4
4.14	The radical and semi-simplicity	Establishing that the Radical is a proper two sided Ideal	K5
4.15	A/I is a Banach Algebra	Checking the conditions for the quotient Algebra A/I to be a Banach Algebra	
4.16	A/R is semi-simple	Proving the Semi-simplicity of the quotient Algebra A/R	
V	**The Structure of Commutative Banach Algebras**		
5.1	The Gelfand mapping	Construct the Gelfand map on a commutative Banach Algebra Establish some properties of the Gelfand map	K5
5.2	Multiplicative Functionals	Define Multiplicative Functionals	K2
5.3	Maximal Ideals and multiplicative functionals	Construct the map from the set of Maximal ideals onto the set of all its multiplicative functional	K5
5.4	The Maximal ideal space is a compact Hausdorff space	Demonstrate that the Maximal ideal space is a compact Hausdorff space	K4
5.5	Gelfand Map is an Isometric Isomorphism	Establishing that the Gelfand map is an isometric isomorphism of A onto $\varsigma(\mathscr{M})$	K5
5.6	Applications of the formula of Spectral radius	Identify situations where spectral radius can be applied	K4
5.7	Involutions in Banach Algebras	Define the concept of Banach*-Algebra	K2

4. MAPPING SCHEME (POs, PSOs AND COs)

P21MA412	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	H	H	H	M	M	M	M	-	H	-	H	-
CO2	H	M	H	H	M	M	M	M	-	H	-	M	-
CO3	H	H	H	M	M	M	M	M	-	H	-	M	-
CO4	H	H	H	M	H	M	M	M	-	H	M	M	-
CO5	H	M	M	H	M	H	M	M	-	H	-	H	-
CO6	H	H	H	H	M	M	M	M	-	H	-	H	-

L-Low M-Moderate H- High

5. COURSE ASSESSMENT METHODS

DIRECT:

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book
2. Open Book Test.
3. Cooperative Learning Report, Assignment, Group Presentation, Group Discussion, Project Report, Seminar, Quiz (written).
4. Pre-Semester & End Semester Theory Examination

INDIRECT:

1. Course end survey (Feedback)

NAME OF THE COURSE COORDINATOR: Dr. P. John Robinson

Core Course XIII: NUMERICAL ANALYSIS

Semester: IV **Course Code: P21MA413**

Credits: 4 **Hours/Week: 6**

1. COURSE OUTCOMES

After the successful completion of this course the students will be able to

CO. No	Course Outcomes	Level	Unit
CO1	Recall the basic concepts and definitions of polynomial equations and Iterations.	K1	I
CO2	Demonstrate the iteration method to find basic solutions and also derive the related equations of iterative methods.	K2	II
CO3	Analyze and apply the interpolation and approximation methods and using interpolation methods to find solution.	K4	III
CO4	Survey the differentiation and integration methods based on finite difference operators.	K4	IV
CO5	Examine the aspects of ordinary differential equations	K4	V
CO6	Design the techniques of differential equations in stability analysis.	K6	V

2A. SYLLABUS

Unit I : Solution of Transcendental Equations **(18 hours)**

Transcendental and polynomial equations: Rate of convergence, Muller method and Chebyshev method. Polynomial equations: Descarte's rule of signs. Iterative methods: Birge-vieta method, Bairstow's method, Direct method : Graffe's root squaring method.

Unit II: Solution of Simultaneous Linear Algebraic Equations **(18 hours)**

Error Analysis of Direct methods- Operational count of Gauss Elimination, Vector Norm, Matrix Norm, Error Estimate. Iteration methods : Jacobi iteration method, Gauss seidel iteration method, Successive over Relaxation method- Convergence analysis of iterative methods, Optimal relaxation parameter for the SOR method. Finding eigen values and eigen vectors : Jacobi method for symmetric matrices and power methods only.

Unit III: Interpolation **(18 hours)**

Interpolation and Approximation : Hermite Interpolations, Piecewise and Spline Interpolation- Piecewise linear Interpolation, piecewise quadratic interpolation, piecewise cubic interpolation (excluding piecewise cubic interpolation using Hermite Type Data), spline interpolation- cubic spline interpolation. Bivariate Interpolation – Lagrange Bivariate interpolation. Least Square approximation.

Unit IV : Numerical Differentiation and Integration **(18 hours)**

Differentiation and Integration: Numerical Differentiation : Methods based on finite difference operators, Methods based on undetermined coefficients – Optimum choice of step length – Extrapolation methods – Partial Differentiation. Numerical Integration: Methods based on undetermined coefficients- Gauss Legendre Integration method and Lobatto Integration methods only.

Unit V: Numerical Solution of Ordinary Differential Equations (18 hours)

Ordinary differential equations – Single step methods: Local truncation error or Discretization Error, Order of a method, Taylor's series method, Runge-Kutta methods – Minimization of Local Truncation Error, system of equations, Implicit Runge-Kutta methods. Stability analysis of single step methods (RK methods only)

B. TOPICS FOR SELF STUDY

S. No.	Topics	Web Links
1	Stability of Numerical Solutions	https://youtu.be/WUiGiDKNKDQ
2	Stability Conditions	https://youtu.be/M4hNvz74oQI
3	Consistency, Stability and Convergence	https://youtu.be/cigFwhrQa3E
4	Stability for ODEs	https://youtu.be/_zHlRpgZ3-0
5	Stability analysis for Poisson's equation	https://youtu.be/acx5L4WK_Hw

C. TEXT BOOK(s)

M.K Jain, S.R.K Iyengar and R.K Jain, Numerical Methods for Scientific and Engineering Computation, New Age International (p) Limited Publishers, New Delhi, Sixth Edition 2012.

D. REFERENCE BOOKS

1. Kendall E.Atkinson, An introduction to Numerical Analysis, II Edn., John Wiley & Sons, 1998.
2. M.K Jain, Numerical Solution of Differential Equations, II Edn., New Age International Pvt Ltd., 1983.
3. Samuel. D. Conte, Carl.De Boor, Elementry Numerical Analysis, McGraw-Hill International Edn.,1983.

E. WEB LINKS

1. https://nptel.ac.in/courses/111/107/111107105/

2. https://onlinecourses.swayam2.ac.in/cec20_ma11/preview

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit/ Section	Course Content	Learning outcomes	Highest Bloom's Taxonomic Level of Transaction
I	**Transcendental and polynomial equations, Iterative and Direct method**		
1.1	Rate of convergence, Muller method and Chebyshev method	Explain the convergence and Muller method and Chebyshev method.	K2

1.2	Descarte's rule of signs ,	Analyze the Descarte's rule. Identify the solutions using iterative and direct method.	K4
1.3	Birge-vieta method, Bairstow's method	Design the solution using iterative method.	K6
1.4	Graffe's root squaring Method	Discuss the solution using direct method.	K6
II	**System of Linear Algebraic equations and Eigen Value Problems**		
2.1	Error Analysis of Direct methods-Operational count of Gauss Elimination, Vector Norm, Matrix Norm, Error Estimate.	Discuss the numerical methods to find the solutions of algebraic equations using different methods under different conditions.	K6
2.2	Jacobi iteration method, Gauss seidel iteration method, Successive over Relaxation method-Convergence analysis of iterative methods, Optimal relaxation parameter for the SOR method.	Find the solutions by using different types of iteration methods and also analyses convergence of iteration methods.	K4
2.3	Jacobi method for symmetric matrices and power methods only.	Determine the eigen values and eigen vectors to the given matrices by using Jacobi and Power methods.	K5
III	**Interpolation and Approximation**		
3.1	Hermite Interpolations	Using varies interpolation models to determined the solution for given problems.	K5
3.2	Piecewise linear Interpolation, piecewise quadratic interpolation, piecewise cubic interpolation (excluding piecewise cubic interpolation using Hermite Type Data), spline interpolation- cubic spline interpolation	Identify the solutions by using piecewise interpolation method .	K3
3.3	Lagrange Bivariate interpolation	Solve the given problem under Lagrange Bivariate interpolation.	K3
3.4	Least Square approximation.	Using least square approximation to determined the solution.	K5
IV	**Differentiation and Integration and Numerical Differentiation**		

4.1	Numerical Differentiation: Methods based on finite difference operators, Methods based on undetermined coefficients	Analyze numerical differentiation on different methods.	K4
4.2	Optimum choice of step length	Identify the solution under step length method.	K3
4.3	Extrapolation methods	Explain the extrapolation methods.	K2
4.4	Partial Differentiation	Design the partial differentiation concepts with examples.	K6
4.5	Numerical Integration	Solve the problem by using numerical Integration.	K3
4.6	Methods based on undetermined coefficients- Gauss Legendre Integration method and Lobatto Integration methods only.	Explain numerical integration on different methods whenever routine methods are not applicable.	K5
V	**Ordinary differential equations – Single step methods**		
5.1	Local truncation error or Discretization Error, Order of a method, Taylor's series method, Runge-Kutta methods – Minimization of Local Truncation Error, system of equations, Implicit Runge-Kutta methods	Explain the problem by numerically on ordinary differential equations using different methods through single step methods.	K5
5.2	Stability analysis of single step methods (RK methods only)	Determine the truncation error.	K5

4. MAPPING SCHEME FOR THE POs, PSOs AND COs

P21MA413	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	M	M	-	M	M	M	M	H	-	M	-	-	M
CO2	H	H	M	H	M	H	M	-	-	H	H	M	-
CO3	H	H	M	M	H	H	M	M	-	H	-	-	-
CO4	H	H	H	H	H	M	H	H	-	H	M	M	M
CO5	H	H	M	M	M	H	M	-	-	M	M	-	-
CO6	H	H	H	H	H	M	H	M	-	H	M	H	H

L-Low **M-Moderate** **H- High**

5. COURSE ASSESSMENT METHODS

DIRECT:

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book
2. Open Book Test.
3. Cooperative Learning Report, Assignment, Group Presentation, Group Discussion, Project Report, Seminar, Quiz (written).
4. Pre-Semester & End Semester Theory Examination

INDIRECT:

1. Course end survey (Feedback)

NAME OF THE COURSE COORDINATOR: Dr. S. Jenita

CORE COURSE XIV – OPERATIONS RESEARCH

Semester-IV **Course Code: P21MA414**

Credits: 4 **Hours/Week: 6**

1. COURSE OUTCOMES

After the successful completion of this course the students will be able to

CO. No	Course Outcomes	Level	Unit
CO1	Solve Integer Programming problems	K3	I
CO2	Apply dynamic programming approach to solve Linear Programming Problem.	K3	II
CO3	Understand decision making concepts.	K3	III
CO4	Solve Game theory problems.	K3	III
CO5	Solve inventory problems for various models .	K4	IV
CO6	Solve unconstrained and constrained nonlinear programming problem	K4	V

2A. SYLLABUSS

Unit I **(18 Hours)**

Integer Programming.

Unit II **(18 Hours)**

Dynamic (Multistage) programming.

Unit III **(18 Hours)**

Decision Theory and Games.

Unit IV **(18 Hours)**

Inventory Models.

Unit V **(18 Hours)**

Non-linear Programming algorithms.

B. TOPICS FOR SELF STUDY

S.No.	Topics	Web Links
1	Decision making	https://www.youtube.com/watch?v=pMm5TnupegI
2	Inventory Models.	https://www.youtube.com/watch?v=M7eJr2dZoeM&list=PLbRMhDVUMngeoZAXW4scdUTky7-By9L4d
3	Non-linear Programming	https://www.youtube.com/watch?v=liFWi2zR0MA&list=PLUWAmF1HRAbE2Br6xX3GurNxEAqzitnnC

C. TEXT BOOK

Hamdy A. Taha, Operations Research, Macmillan Publishing Company, 4th Edition, 1987.

- Unit I Chapter 8 § 8.1 – 8.5
- Unit II Chapter 9 § 9.1 – 9.5
- Unit III Chapter 11 § 11.1 – 11.4
- Unit IV Chapter 13 § 13.1 – 13.4
- Unit V Chapter 19 § 19.1, 19.2

D. REFERENCE BOOKS

1. L. Mangasarian, Non-Linear Programming, Mc Graw Hill, New York, 1969.
2. Mokther S. Bazaraa and C.M. Shetty, Non-Linear Programming, Theory and Algorithms, Willy, New York, 1979.
3. Prem Kumar Gupta and D.S. Hira, Operations Research - An Introduction, S. Chand and Co., Ltd., New Delhi, 2012.
4. S.S. Rao, Optimization Theory and Applications, Wiley Eastern Limited, New Delhi,1979.

E. WEB LINKS

1. https://www.youtube.com/watch?v=Lt7OZP_F3jY

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit/ Section	Course Content	Learning outcomes	Highest Bloom's Taxonomic Level of Transaction
I	**Integer Programing**		
1.1	Integer Programming	To solve Integer Programming Problem using Fractional- cut method & Branch and Bounded method	K3
II	**Dynamic Programming**		
2.1	Dynamic(Multistage) programming.	To apply dynamic programming approach to solve linear programming problem	K3
III	**Decision Theory and Games**		
3.1	Decision Theory.	To understand decision making concepts.	K3
3.2	Game Theory	To solve Game theory problem using Graphical method	K3
IV	**Inventory Models**		
4.1	Inventory Models	To apply multiple item static model to solve inventory problems.	K4
V	**Non-linear programming**		
5.1	Non-linear Programming algorithms.	To solve unconstrained nonlinear programming problem using direct search method, Gradient method,	K4

		Separable programming and quadratic programming methods	

4. MAPPING SCHEME (POs, PSOs AND COs)

P21MA414	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	M	L	L	L	L	L	M	H	L	L	H	L	H
CO2	H	H	M	H	M	H	M	L	H	L	H	L	H
CO3	H	H	M	H	H	H	H	M	H	L	H	L	H
CO4	H	H	H	H	H	M	M	H	H	L	H	L	M
CO5	H	H	M	H	M	H	M	L	H	L	H	L	M
CO6	H	H	H	H	H	M	H	M	M	L	H	L	L

L-Low M-Moderate H- High

5. COURSE ASSESSMENT METHODS

DIRECT:

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book
2. Open Book Test.
3. Cooperative Learning Report, Assignment, Group Presentation, Group Discussion, Project Report, Seminar, Quiz (written).
4. Pre-Semester & End Semester Theory Examination

INDIRECT:

1. Course end survey (Feedback)

NAME OF THE COURSE COORDINATOR: Dr. B. Venkatesh

Elective course V – STOCHASTIC PROCESSES

Semester : IV **Course Code : P21MA4:5**

Credits : 4 **Hours/Week : 6**

1. COURSE OUTCOMES

After the successful completion of this course the students will be able to

CO. No	Course Outcomes	Level	Unit
CO1	Understand the concepts of Stochastic processes, Markov chain and its real-life applications	K2	I
CO2	Existence of Absorption probabilities, have been investigated.	K4	II
CO3	Analyse and discuss the implications and significance of Birth and Death processes	K4	III
CO4	Able to understand the concepts of Renewal equations and their applications	K3	IV
CO5	To know the concepts of Queueing process	K3	V
CO6	Apply theoretical knowledge acquired to solve realistic problems in real life	K3	V

2A. SYLLABUS

Unit I **(18 hours)**

Elements of Stochastic Processes - Two simple examples of stochastic processes - Classification of general stochastic processes - Defining a discrete time Markov chain - Classification of states of a Markov chain - Recurrence- (Abel's Lemma-Statement only) Examples of recurrent Markov chains-More on recurrence.

Unit II **(18 hours)**

Basic limit theorem of Markov chains and applications-Discrete renewal equation-Absorption probabilities-Criteria for recurrence.

Unit III **(18 hours)**

Classical examples of continuous time Markov Chains-General pure birth processes and Poisson processes-Birth and Death Processes-Differential equations of birth and death processes- Linear growth process with immigration-Birth and death processes with absorbing states- Finite state continuous time Markov chain.

Unit IV **(18 hours)**

Definition of a renewal processes and related concepts- Some examples of renewal processes- More on some special renewal processes - Renewal equations and the Elementary renewal theorem- Basic renewal theorem-Applications of the renewal theorem.

Unit V **(18 hours)**

Queueing processes-General description – The simple queuing processes (M/M/1) – Embedded Markov chain method applied to the Queueing model (M/GI/1) – Exponential service times (GI/M/1) – The virtual Waiting time and the busy period.

B. TOPICS FOR SELF STUDY

S.No.	Topics	Web Links
1	Markov chain	https://brilliant.org/wiki/markov-chains/
2	Markov processes	https://www.randomservices.org/random/markov/index.html
3	Queueing theory	https://queue-it.com/blog/queuing-theory/

C. TEXT BOOK(s)

1. Samuel Karlin& Howard M.Taylor, A First Course in Stochastic Processes, Academic press, 1975. (For units I to IV)

2. Samuel Karlin& Howard M.Taylor, A Second Course in Stochastic Processes, Academic press, 1981 (For unit V)

D. REFERENCE BOOKS

1. J.Medhi, Stochastic Processes, Wiley Eastern Limited 3rd Edition, 2009.

2. U.Narayanan Bhat, Elements of Applied Stochastic Processes, John Wiley & Sons, 1984.

3. S.K. Srinivasan& K.M. Mehata, Probability and Random Process, Tata McGraw Hill, New Delhi 2nd Edition, 1988.

4. Sheldon M. Ross, Stochastic Processes. 2nd Edition John Wiley and Sons, Inc.2004.

E. WEB LINKS

1. https://swayam.gov.in/

2. https://nptel.ac.in/

3. http://home.iitk.ac.in/~skb/qbook/solution.html

3. SPECIFIC LEARNING OUTCOMES (SLO)

Unit/ Section	Course Content	Learning outcomes	Highest Bloom's Taxonomic Level of Transaction
I	**Elements of Stochastic Process and Markov Chain**		
1.1	Two simple example of stochastic processes	Understand the concepts of stochastic processes	K2

1.2	Classification of general Stochastic processes	Classify the types of stochastic processes	K3
1.3	Markov chains	Understand the concepts of Markov chains	K2
1.4	Examples of Markov Chains	Apply the concepts of Markov chains in real life situation.	K3
1.5	Transition Probability Matrices of a Markov Chain	Discuss transition Probability Matrices of a Markov chain	K2
1.6	Classification of States of a Markov chains	Classify the states of a Markov chains	K3
1.7	Recurrence	Discuss the concept of Recurrence	K2
1.8	Examples of Recurrent Markov chains	Analyze the examplesof Recurrent Markov chains	K3
1.9	More on Recurrence	Discuss the concepts of Recurrence and its applications	K2
II	**Basic limit theorem of Markov chain and Applications**		
2.1	Basic limit theorem of Markov chain and Applications	Analyze and discuss the implications and significance of Basic limit theorem of Markov chain	K3
2.2	Absorption Probabilities	Discuss the concepts of Absorption Probabilities	K2
2.3	Criteria for Recurrence	Understand the basic ideas of Criteria for Recurrence	K2
III	**Example of Continuous time Markov Chains**		
3.1	Classical example of Continuous time Markov Chains	Apply to solve the real life problems	K3
3.2	More about Poisson processes	Apply and analyze Poisson processes	K3
3.4	Birth and death process	Discuss the concepts of Birth and death process and also its postulates	K6
3.5	Differential Equations of Birth and Death process	Examine the Differential Equations of Birth and Death process	K4
3.6	Examples of Birth and Death process	Able to read, interpret, and critically analyse examples of Birth and Death process	K3
IV	**Renewal processes**		
4.1	Renewal processes	Apply the concepts of Renewal processes	K3
4.2	Some example of Renewal processes	Applicable in the real life problem	K3

4.3	More on some special Renewal processes	Applicable in scientific area	K3
4.4	Application of Renewal theorem	Discuss the concepts of Application of Renewal theorem	K3
V	**Queueing Theory**		
5.1	Queueing processes- General description – The simple queuing processes (M/M/1)	Apply and analyse the concepts of simple queuing processes (M/M/1)	K3
5.2	Embedded Markov chain method applied to the Queueing model (M/GI/1)	Explain the concept of Embedded Markov chain method applied to the Queueing model (M/GI/1)	K2
5.3	Exponential service times (GI/M/1) – The virtual Waiting time and the busy period.	Apply and analyse Exponential service times (GI/M/1) in real life situation	K3

4. MAPPING SCHEME FOR THE POs, PSOs AND COs

P21MA4:5	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PSO1	PSO2	PSO3	PSO4
CO1	H	M	H	M	M	H	M	H	M	M	H	M	H
CO2	M	M	H	M	-	M	M	H	M	M	M	M	H
CO3	H	H	M	M	H	H	M	M	-	M	H	M	M
CO4	M	H	H	H	H	L	M	M	M	M	M	H	H
CO5	H	M	M	M	-	M	H	H	M	H	M	H	-
CO6	M	H	M	H	M	H	M	M	M	M	H	M	M

L-Low M-Moderate H- High

5. COURSE ASSESSMENT METHODS

DIRECT:

1. Continuous Assessment Test: T1, T2 (Theory & Practical Components): Closed Book
2. Open Book Test.
3. Cooperative Learning Report, Assignment, Group Presentation, Group Discussion, Project Report, Seminar, Quiz (written).
4. Pre-Semester & End Semester Theory Examination

INDIRECT:

1. Course end survey (Feedback)

NAME OF THE COURSE COORDINATOR: Dr. A. Devi

Elective Course V: Mathematical Modelling in Human Resource Management

Semester : IV **Course Code : P21MA4:6**
Credits : 5 **Hours / week : 6**

Unit I: Introduction and Two Characteristic Manpower flow model including demotion

Introduction – Concepts of Manpower Planning – Review of Literature – Organization of the Text – Two Characteristic Manpower flow under different recruitment policies including demotions – Optimum recruitment policy for constant grade size including demotion – Attainability of a two characteristic Manpower structure including demotion – Conclusion

Unit II: Three characteristic Markov Type Manpower Flow model including demotion and Expected time for recruitment with correlated inter-arrival time of Departure – A shock model approach

Notations and fractional flow matrices – Matrices of t-step transition probabilities – Equations of Stocks and flows – Transient properties of the stocks – Conclusion – Assumptions and notations of the model – Results – Numerical illustration – Conclusion

Unit III: Mean Time to recruitment in a single graded manpower system with exponentiated exponential threshold and Stochastic models on the time to recruitment in a single graded manpower system with two thresholds using different recruitment policies

Introduction – Main Results – Numerical illustration and Conclusions – Model description and main results for model-I – Model description and main result for model-II – Numerical illustrations and Conclusions

Unit IV: Mean and Variance of the time to recruitment in a two graded manpower system with two thresholds for the organization and A Stochastic Model on time to Recruitment in a three Grade Manpower System with Extended Exponential Thresholds

Introduction – Model description and main results for model-I – Model description and main result for model-II – Numerical illustrations and Conclusions - Introduction –Model description – Main Results – Numerical illustration and Conclusions

Unit V: A Stochastic Model on time to Recruitment in a three Grade Manpower System with a Univariate Policy of Recruitment and Stochastic Model for Mean time to Recruitment in a three Graded Organization with Inter-Decision Times as a Geometric Process using a Univariate Policy of Recruitment

Introduction –Model description – Main Results – Numerical illustration and Conclusions – Findings – Model Description and Analysis for Model-I – Model Description - Model Description and Analysis for Model-II – Conclusion

TEXT BOOK(s)

Mathematical Modeling In Human Resource Management, Perumal Mariappan, Lap Lambert Academic Publishing (2013), Germany, Isbn 9783659451133

CHAPTERS

Unit I – Chapter 1 & 2: 1.1 – 1.4 & 2.1 – 2.4
Unit II – Chapter 3 & 4: 3.1 – 3.5 & 4.1 – 4.4
Unit III – Chapter 5 & 6: 5.1 – 5.3 & 6.1 – 6.4
Unit IV – Chapter 7 & 8: 7.1 – 7.4 & 8.1 – 8.4
Unit V – Chapter 9 & 10: 9.1 – 9.5 & 10.1 – 10.5

Core Project – PROJECT

Semester : IV **Course Code : P14MA4PJ**

Credits : 4 **Hours/Week : 6**

Post Graduate - Extra Credit Courses

(For the candidates admitted from the academic year 2021 onwards)

Course	Code	Title	Credits	Marks	
				ESA	TOTAL
I	P21MAX:3	Wavelet Theory	2	100	100
II	P21MAX:4	Theory of Linear Operators	2	100	100
III	P21MAX:5	Mathematical Physics	2	100	100
IV	P21MAX:6	History of Modern Mathematics	2	100	100
V	P21MAX:7	Research Methodology	2	100	100

Extra Credit Course I - Wavelet Theory

Code : P21MAX:1 **Credits : 2**

General objectives & Learning outcomes:

On completion of this course, the learner will

1. know the basic concepts of wavelet theory.
2. be able to understand construction of wavelets.
3. be able to comprehend wavelets on the real line.

Unit I

Different ways of constructing wavelets-Orthonormal bases generated by a single function: the Balian –Low theorem. Smooth projections on L2 (R). Local sine and cosine bases and the construction of some wavelets. The unitary folding operators and the smooth projections.

Unit II

Multire solution analysis and construction of wavelets. Construction of compactly supported wavelets and estimates for its smoothness. Band limited wavelets.

Unit III

Orthonormality. Completeness. Characterization of Lemarie-Meyer wavelets and some other characterization. Franklin wavelets and Spline wavelets on the real line. Orthonormal bases of piecewise linear continuous functions and Spline wavelets on the real line.

Unit IV

Orthonormal bases of piecewise linear continuous functions for L2(T) Orthonormal bases of periodic splines., Periodizations of wavelets defined on the real line.

Unit V

Characterizations in the theory of wavelets – The basic equations and some of its applications. Characterizations of MRA wavelets, low-pass filters and scaling functions.

REFERENCEs

1. Eugenio Hernandez and Guido Weiss, A First Course on Wavelets, CRC Press, New York, 1996.
2. C.K. Chui, An Introduction to Wavelets, Academic Press, 1992
3. I. Daubechies, Ten Lectures on Wavelets, CBS-NSF Regional Conferences. In Applied Mathematics,61, SIAM, 1992.

4. Y.Meyer, Wavelets, Algorithms and Applications (translated by R.D.Rayan, SIAM) 1993.

5. M.V.Wickerhauser, Adapted Wavelet Analysis from Theory to Software, Wellesley, MA,A.K.Peters, 1994.

6. Mark A.Pinsky, Introduction to Fourier Analysis and Wavelets, Thomson, 2002.

Extra Credit Course II - Theory of linear Operators

Code : P21MAX:2 **Credits : 2**

General objectives & Learning outcomes:

On completion of this course, the learner will

1. know the theory of linear operators and their properties in normed spaces
2. be able to understand the characteristics of linear operators.

Unit I

Spectral theory of linear operators in normed spaces – Spectral theory on finite dimensional normed spaces – basic concepts – Spectral properties of bounded linear operators – properties of resolvent and spectrum – Banach Algebra.

Unit II

Compact linear operators on normed spaces – properties – Spectral properties of compact linear operators on normed spaces.

Unit III

Operator equations involving compact linear operators – theorems of Fredholm Type – Fredholm alternative.

Unit IV

Spectral properties of bounded self-adjoint linear operator – positive operators – square roots of a positive operators.

Unit V

Projection operators – their properties – spectral family of bounded self-adjoint linear operators.

REFERENCEs

1. Erwin Kreyszig, Introductory Functional Analysis with its Applications, John Wiley & Sons; Reprint edition (5 April 1989).
2. K.Yosida, Functional Analysis, Springer-Verlag, 1974.
3. P.R.Halmos, Introduction to Hilbert Space and the Theory of Spectral Multiplicity, second edition, Chelsea Publishing Co., New York, 1957.

Extra Credit Course III - Mathematical Physics

Code : P21MAX: 3 **Credits : 2**

General objectives & Learning outcomes:

On completion of this course, the learner will

1. be able to comprehend some special mathematical functions and their relevance in other fields.

2. be able to analyse boundary value problems and their applications in other fields.

Unit I

Boundary value problems and series solution – examples of boundary value problems – Eigenvalues, Eigen functions and the Sturm-Liouville problem – Hermitian Operator, their Eigenvalues and Eigen functions.

Unit II

Bessel functions – Bessel functions of the second kind, Hankel functions, Spherical Bessel functions – Legendre polynomials – associated Legendre polynomials and spherical harmonics.

Unit III

Hermit polynomials – Laguerre polynomials – the Gamma function – the Dirac delta function.

Unit IV

Non homogeneous boundary value problems and Green's function – Green's function for one dimensional problems – Eigen function expansion of Green's function.

Unit V

Green's function in higher dimensions – Green's function for Poisson's equation and a formal solution of electrostatic boundary value problems – wave equation with source – the quantum mechanical scattering problem.

REFERENCEs

1. B. D. Gupta, Mathematical Physics, Vikas Publishing House Pvt. Ltd., New Delhi, 1993.

2. Goyal AK Ghatak, Mathematical Physics – Differential Equations and Transform Theory, McMillan India Ltd., 1995.

3. Kreyszig, Advanced Engineering Mathematics, Wiley; Ninth edition (2011).

Extra Credit Course IV - History of Modern Mathematics

Code : P21MAX:4 **Credits : 2**

General objectives:

On completion of this course, the learner will

1. know the prominent movements in modern mathematics.
2. know the mathematicians' work and their valuable contributions.

Learning outcomes:

On completion of this course, the learner will

1. be motivated to continue the line of innovative thinking
2. have a better understanding over the concepts and the interlinks

Unit I

Theory of Numbers – Irrational and transcendent numbers - Complex numbers.

Unit II

Quaternions and Ausdehnungslehre – Theory of equations – Substitutions and groups.

Unit III

Determinants – Quantics – Calculus – Differential Equations.

Unit IV

Infinite series – Theory of functions – Probabilities and least squares.

Unit V

Analytic geometry – Modern geometry – Elementary geometry – non-Euclidean geometry.

REFERENCE

1. David Eugene Smith, History of Modern Mathematics, MJP Publishers, 2008.

Extra Credit Course V - Research Methodology

Code : P21MAX:5 **Credits : 2**

General objectives:

On completion of this course, the learner will

1. know the process of academic writing.
2. know to write a thesis.

Learning outcome:

On completion of this course, the learner will be able to prepare a research article to report his/her research findings

Unit I

The research thesis –The intellectual content of the thesis –Typing, organizing and developing the thesis.

Unit II

Grammar, punctuation and conventions of academic writing – Layout of the thesis – The preliminary pages and the introduction.

Unit III

Literature review –Methodology.

Unit IV

The data analysis –The conclusion.

Unit V

Completing the thesis – Publishing findings during preparation of the thesis.

REFERENCE

1. Paul Oliver, Writing Your Thesis, Sage Publication, 2nd edition 2008.