DEPARTMENT OF MATHEMATICS

VISION

- To evolve as a center of excellence in mathematics.
- To empower students with sound knowledge and investigate new methodologies and applications in research.
- To equip the learners for better service towards the society.

MISSION

- To encourage the students to take up student centered projects and develop their analytical and logical thinking.
- To provide quality education, enhance research and consultancy by providing highly skilled mathematical knowledge.
- To provide excellent knowledge of mathematical sciences for suitable career and groom them for national recognition.
- To enable the students as mathematical thinkers and become life- long learners in their chosen profession.

PROGRAMME OUTCOMES

PO1 Disciplinary Knowledge Capable of demonstrating comprehensive knowledge and understanding of one or more disciplines that form a part of an post graduate programme of study.

PO2 Critical Thinking Capability to apply analytic thought to a body of knowledge; analyse and evaluate evidence, arguments, claims, beliefs on the basis of empirical evidence; identify relevant assumptions or implications; formulate coherent arguments; critically evaluate practices, policies and theories by following scientific approach to knowledge development.

PO3 Research related skills Ability to analyze, interpret and draw conclusions from quantitative qualitative data; and critically evaluate ideas, evidence, and experiences from an open minded and reasoned research perspective; sense of inquiry and capability for asking relevant questions problem arising synthesizing articulating ability to recognize cause and effect relationships define problems. formulate hypothesis, test analyse interpret the results and derive conclusion, formulation and designing mathematical models.

PO4 Self-directed & Lifelong Learning Ability to work independently, identify and manage a project. ability to acquire knowledge and skills, including "learning how to learn", through self-placed and self-directed learning aimed at personal development, meeting economic, social and cultural objectives.

PO5 Analytical & Problem Solving Ability to evaluate the reliability and relevance of evidence; identify logical flaws and holes in the arguments of others; analyze and synthesize data from a variety of sources; Capacity to extrapolate from what one has learned and apply their competencies to solve different kinds of non-familiar problems.

PO6 Social Responsibilities

Understand the societal and ethical responsibilities of the professionals in their respective discipline.

PROGRAMME EDUCATIONAL OBJECTIVES

PEO1 To enable students to work as a mathematical professional or to employ as a scientific researcher.

PEO2 To develop the ability to utilize the mathematical problem solving methods such as analysis, modelling, programming and mathematical software applications in addressing the practical issues.

PEO3 To encourage the students to recognize the need for and to develop the ability to engage in life long learning.

PROGRAMME SPECIFIC OUTCOMES

PSO1 Acquire good knowledge and understanding, to solve specific theoretical & applied problems in different areas of mathematics & statistics.

PSO2 Understand, formulate, develop mathematical arguments logically and use quantitative models to address issues arising in social sciences, business and other context fields.

PSO3 Acquire knowledge in recent developments in various branches of mathematics and thus pursue research.

GRADUATE ATTRIBUTES

Knowledge
Students have disciplinary knowledge and the capacity of demonstrating comprehensive knowledge of mathematics and understanding one or more disciplines.

Employability
To impart qualitative inputs to the stake holders for CSIR/JRF, GATE and competitive examinations. ability to employ critical thinking in understanding every area of mathematics.

Quality Research
To acquire advanced knowledge for the higher studies and research. To gain specialized knowledge of particular field of study.

Independent and life-long learning
Students have the capacity to be a self directed learner, thinker and to study and work independently resulting in continuous learning, confidence, resilience.

Analytical and Problem Solving
Students will be able to collect, analyse and evaluate data and to solve problems by thinking clearly, critically.

Social Responsibilities
To build the good citizen responsibilities and life skills to the pupil. To function as a matured democratic citizen with participation in issues of equity and gender equality. To be academically honest and spiritually inspiring citizens.

PROGRAMME STRUCTURE FOR M.Sc MATHEMATICS
(For those admitted from the academic year 2023-2024 and onwards)

	Course Type	Course Code	Course Title	Contact Hours	Exam Hours	Marks			Credits
						CIA	ESE	Total Marks	
Semester-I									
	Core-1	P23MA101	Algebraic Structures	6	3	25	75	100	5
	Core-2	P23MA102	Real Analysis I	6	3	25	75	100	5
	Core-3	P23MA103	Ordinary Differential Equations	6	3	25	75	100	4
	Core Elective-1	P23MA1E1A P23MA1E1B P23MA1E1C	Algebraic Number Theory Graph Theory and its Applications Formal Languages and Automata Theory	6	3	25	75	100	3
	Core Elective-2	P23MA1E2A P23MA1E2B P23MA1E2C	Number Theory and Cryptography Discrete Mathematics Analytic Number Theory	6	3	25	75	100	3
	Comprehension-I (Self Study Course- Online Exam)	P23MA1C1	Comprehension in Mathematics - I	-	1	-	50	50	1
	Ability Enhancement	P23AE101	Cyber Security	-	2	-	50	50	2
	NPTEL(Self Study course – Online Exam – to be completed within fourth semester)			-	-	-	-	-	1
TOTAL				**30**				**600**	**24**
Semester-II									
	Core-4	P23MA204	Advanced Algebra	6	3	25	75	100	5
	Core-5	P23MA205	Real Analysis II	6	3	25	75	100	5
	Core-6	P23MA206	Partial Differential Equations	6	3	25	75	100	4
	Core Elective-3	P23MA2E3A P23MA2E3B P23MA2E3C	Fuzzy Sets & Their Applications Mathematical Statistics Tensor Analysis and Relativity	5	3	25	75	100	3

	Core Elective-4	P23MA2E4A P23MA2E4B P23MA2E4C	Wavelets Introduction to Python - Theory Neural Networks	4	3	25	75	100	3
	Skill Enhancement Course-(SEC 1)	P23MA2SEP	Mathematical documentation using LATEX	3	3	40	60	100	2
	Comprehension-II (Self Study Course- Online Exam)	P23MA2C2	Comprehension in Mathematics - II	-	1	-	50	50	1
	Ability Enhancement	P23AE202	Teaching and Learning Process and Core Teaching Skills	-	1	50	-	50	1
	Internship / Institutional Training / Minor Project	P23MA3IT	Internship /Institutional Training / Minor Project (Carried out during the summer vacation at the end of II semester)	-	-	-	-	-	-
TOTAL				**30**				**700**	**24**
Semester-III									
	Core-7	P23MA307	Complex Analysis	6	3	25	75	100	5
	Core-8	P23MA308	Differential Geometry	6	3	25	75	100	5
	Core-9	P23MA309	Topology	6	3	25	75	100	5
	Core-10 (Industry Module)	P23MA310	Operations Research	6	3	25	75	100	5
	Core Elective-5	P23MA3E5A P23MA3E5B P23MA3E5C	Research Methodology Numerical Analysis Stochastic Processes	3	3	25	75	100	3
	Comprehension-III (Self Study Course- Online Exam)	P23MA3C3	Comprehension in Mathematics - III	-	1	-	50	50	1
	Skill Enhancement Course (SEC2)	P23MA3SEP	Professional Communication Skill (Seminar Paper)	3	-	40	60	100	2

	Internship / Institutional Training / Minor Project	P23MA3IT	Internship / Institutional Training / Minor Project	-	3	40	60	100	2
TOTAL				**30**				**750**	**28**
Semester-IV									
	Core-11	P23MA411	Functional Analysis	6	3	25	75	100	6
	Core-12	P23MA412	Mechanics	6	3	25	75	100	5
	Core Elective-6	P23MA4E6A P23MA4E6B P23MA4E6C	Ring theory and lattices Algebraic Topology Calculus of variation and integral equation	5	3	25	75	100	3
	Major Project	P23MA4MP	Project with viva voce	9	3	50	150	200	7
	Professional Competency Skill Enhancement Course(SEC3)	P23MA4SE3	Training for Competitive Examinations • Mathematics for NET / UGC - CSIR/ SET / TRB Competitive Examinations (2 hours) • General Studies for UPSC / TNPSC / Other Competitive Examinations (2 hours)	4	-	100	-	100	2
	Extension Activity	P23EA401		-	-	-	-	-	1
	Research Publication (Minimum one)-Submission only			-	-	-	-	completion	1
TOTAL				**30**				**600**	**25**
OVERALL TOTAL								**2650**	**101**

CORE- 7: COMPLEX ANALYSIS (P23MA307)

Lecture Hours	**:85**	**Tutorial Hours**	**: 5**
Practical Hours	**:-**	**No. of Credits**	**:5**
Contact Hours per Semester	**:90**		
Contact hours per Week	**:6**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

Objectives of the Course

This Course focuses on

- complex functions and analytic functions as mappings.
- analyticity, conformality linear transformation and complex integration.

Course Learning Outcomes (for Mapping with POs and PSOs)

On completion of the Course, the students will be able to

CO1 remember and understand the concepts of analytic functions, polynomials, power series and rational functions.
CO2 demonstrate line integrals, their properties, Cauchy's theorem in a Rectangle and disc.
CO3 analyse Cauchy Integral formula, singularities, local mapping theorem, Maximum principle.
CO4 determine homology, Cauchy's general theorem, locally exact differentials, multiply connected regions.
CO5 develop further properties of analytic function using residues, evaluate poisson's formula.

CO-PO and PSO Mapping (Course Articulation Matrix)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	3	2	3	3	2	3	3
CO2	2	1	3	1	3	3	2	2	2
CO3	3	2	3	1	3	3	2	2	3
CO4	1	2	3	2	3	3	2	2	1
CO5	3	2	2	3	3	3	2	1	3
Total Contribution of COs to POs	**12**	**9**	**14**	**9**	**15**	**15**	**10**	**10**	**12**
Weighted Percentage of COs Contribution to POs	**80**	**60**	**93.33**	**60**	**100**	**100**	**66.67**	**66.67**	**80**

0- No Correlation **1-Weak** **2-Moderate** **3- Strong**

Course Content

Unit I Analytic function (L-17hrs; T-1hr)

Analytic functions – polynomials - power series - Abel's limit theorem, Rational functions.

Chapter2: Sections: 1.1 -1.4 & 2.4, 2.5

Unit II Complex Integration (L-17hrs; T-1hr)

Line Integrals – rectifiable arcs- line integrals as functions of arcs- Cauchy's theorem for rectangle– Cauchy's theorem in a Disc.

Chapter 4: Sections:1.1 - 1.5

Unit III Cauchy's Integral Formula (L-17hrs;T-1hr)

The Index of a point with respect to a closed curve – The Integral formula – Higher derivatives- Local Properties of analytic Functions - Removable Singularities-Taylor's Theorem – Zeros and poles – The local Mapping – The Maximum Principle.

Chapter 4: Section 2 : 2.1 to 2.3, Chapter 4 : Section 3 : 3.1 to 3.4

UNIT IV The general form of Cauchy's Theorem (L-17hrs;T-1hr)

Chains and cycles- Simple Continuity - Homology - The General statement of Cauchy's Theorem - Proof of Cauchy's theorem - Locally exact differentials- Multiply connected regions.

Chapter 4: Section 4 : 4.1 to 4.7

UNIT V Evaluation of Definite Integrals and Harmonic Functions (L-17hrs;T-1hr)

Residue theorem - The argument principle. Evaluation of definite integrals - Definition of Harmonic function and basic properties - Mean value property - Poisson formula.

Chapter 4: Section 5 : 5.1-5.3, Chapter 4 : Sections 6 : 6.1 to 6.3

Recommended Text

1. Lars Ahlfors V., *Complex Analysis*, (3rd edition) McGraw Hill Co., New York, 1979.

Reference Books

1. Presfly H.A., *Introduction to complex Analysis*, Clarendon Press, oxford, 1990.
2. Conway J.B., *Functions of one complex variables*, Springer - Verlag, International student Edition, Narosa Publishing Co.1978.
3. Hille E., *Analytic function Theory* Volume 2, Gon & Co, 1959.

Website and E-Learning Sources

1. http://mathforum.org
2. http://ocw.mit.edu/ocwweb/Mathematics

CORE-8: DIFFERENTIAL GEOMETRY(P23MA308)

Lecture Hours	**:85**	**Tutorial Hours**	**:5**
Practical Hours	**:-**	**No. of Credits**	**:5**
Contact Hours per Semester	**:90**		
Contact hours per Week	**:6**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

Objectives of the Course

This Course introduces

- space curves and their intrinsic properties of a surface and geodesics.
- non-intrinsic properties of surface and the differential geometry of surfaces.

Course Learning Outcomes (For mapping with POs and PSOs)

On successful completion of the Course, the students will be able to

CO1 remember and understand space curves, curves between surfaces, metrics on a surface, fundamental form of a surface and geodesics.
CO2 demonstrate involutes and evolutes.
CO3 analyse problems on helicoids.
CO4 study about Canonical geodesic equations, normal property of geodesics and Gauss-Bonnet Theorem.
CO5 construct and analyse the problems on curvature and minimal surfaces.

CO-PO and PSO Mapping (Course Articulation Matrix)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	3	2	3	3	2	2	3
CO2	2	1	3	1	3	3	2	2	2
CO3	3	2	3	1	3	3	2	3	3
CO4	1	2	3	2	3	3	2	2	1
CO5	3	1	2	3	3	3	2	1	3
Total Contribution of COs to POs	**12**	**9**	**14**	**9**	**15**	**15**	**10**	**10**	**12**
Weighted Percentage of COs Contribution to POs	**80**	**60**	**93.33**	**60**	**100**	**100**	**66.67**	**66.67**	**80**

0- No Correlation **1-Weak** **2-Moderate** **3- Strong**

Course Content

Unit I Space curves (L-17hrs; T-1hrs)

The theory of space curves – Definitions, Arc length – Tangent – Normal and Binormal – Curvature and Torsion.

Chapter 1 - Sections: 1.1 – 1.5

Unit II Curves and surfaces (L-17hrs; T-1hrs)

Contact between curves and surfaces – Tangent Surface – Involutes and evolutes – Helices - Definition of a surface – Curves on a surface.

Chapter 1 - Sections: 1.6 - 1.9, Chapter 2 – Sections: 2.1 – 2.3

Unit III Helicoids (L-17hrs; T-1hrs)

Helicoids – Metric – Direction Coefficients - Families of curves - Isometric correspondence- Intrinsic properties.

Chapter 2 - Sections: 2.4 - 2.9

Unit IV Geodesics (L-17hrs; T-1hrs)

Geodesics – Canonical geodesic equations – Normal property of geodesics- Existence Theorems – Geodesic parallels – Geodesics curvature - Gauss- Bonnet Theorem.

Chapter 2 - Sections: 2.10 – 2.16

Unit V Non Intrinsic properties of a surface (L-17hrs; T-1hrs)

The second fundamental form- Principal curvature – Lines of curvature – Developable - Developable associated with space curves and with curves on surface - Minimal surfaces.

Chapter 3 - Sections 3.1 – 3.7

Recommended Text

1. Willmore T. J., *An Introduction to Differential Geometry*, Oxford University Press, (17th Impresssion), New Delhi (Indian Print), 2002.

Reference Books

1. Mittal and Agarwal, *Differential Geometry*, Krishna Prakasam Publishers, Uttar Pradesh, 1998.
2. Somasundaram D, *Differential Geometry*, Narosa Publishing House, Chennai, 2014.
3. Dr H Kanwar, *Differential Geometry*, Mohindra capital publishers, 2023.

Website and E-Learning Sources

1. https://sistoput.files.wordpress.com/2014/10/classical-mechanics.pdf
2. https://overtueperba.wixsite.com/pelasnailod/post/differential-geometry-by-mittal-and-agarwal-pdf-download

CORE-9: TOPOLOGY (P23MA309)

Lecture Hours	**:85**	**Tutorial Hours:5**
Practical Hours	**:-**	**No. of Credits:5**
Contact Hours per Semester	**:90**	
Contact hours per Week	**:6**	
Internal Marks	**:25**	
External Marks	**:75**	
Total Marks	**:100**	

Objectives of the Course

The aim of the Course is

- to distinguish spaces by means of simple topological invariants.
- to provide the knowledge of constructing spaces, and to gain knowledge in normal and regular spaces.

Course Learning Outcomes (For mapping with POs and PSOs)

On successful completion of the Course, the students will be able to

CO1 remember and understand the basic concepts of topology, the order topology, the product topology, the subspace topology, closed sets and limit points.
CO2 apply the concepts of continuous functions, metric topology.
CO3 analyse the concepts of connected spaces- connected subspaces of the real line – components and local connectedness.
CO4 evaluate the problems in compact spaces – compact subspaces of the real line – limit point compactness – local compactness.
CO5 develop the knowledge about Urysohn Metrization theorem and Tietze extension theorem.

CO-PO and PSO Mapping (Course Articulation Matrix)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	3	2	3	3	2	2	3
CO2	2	1	3	1	3	3	2	1	2
CO3	3	3	3	1	3	3	2	1	3
CO4	1	2	3	2	3	3	2	2	1
CO5	3	3	2	3	3	3	2	3	3
Total Contribution of COs to POs	**12**	**11**	**14**	**9**	**15**	**15**	**10**	**9**	**12**
Weighted Percentage of COs Contribution to POs	**80**	**73.33**	**93.33**	**60**	**100**	**100**	**66.67**	**60**	**80**

0- No Correlation **1-Weak** **2-Moderate** **3- Strong**

Course Content

Unit I Topological spaces (L-17hrs; T-1hr)

Topological spaces – Basis for a topology – The order topology – The product topology on $X \times Y$ – The subspace topology – Closed sets and limit points.

Chapter 2 : Sections 12 to 17

Unit II Continuous functions (L-17hrs; T-1hr)

Continuous functions – the product topology – The metric topology.

Chapter 2 : Sections 18 to 21 (Omit Section 22)

Unit III Connectedness (L-17hrs; T-1hr)

Connected spaces- connected subspaces of the Real line – Components and local connectedness.

Chapter 3 : Sections 23 to 25.

Unit IV Compactness (L-17hrs; T-1hr)

Compact spaces – compact subspaces of the Real line – Limit Point Compactness – Local Compactness.

Chapter 3 : Sections 26 to 29.

Unit V Countability and Separation Axiom (L-17hrs; T-1hr)

The Countability Axioms – The separation Axioms – Normal spaces – The Urysohn Lemma – The Urysohn Metrization Theorem – The Tietz extension theorem.

Chapter 4 : Sections 30 to 35.

Recommended Text

1. James Munkres R., *Topology*, Second Edition, Prentice Hall of India Pvt. Ltd, 2002.

Reference Books

1. Joshi K.D., *Introduction to General Topology*, Second Edition, New Age International Private Limited, 2017.
2. Chandrasekhara Rao K., *Topology*, Narosa Publishing House, 2009.
3. George Mc Carty, *Topology*, Dover Publicatiions inc., 2003.

Website and E-learning Sources

1. http://www.math.buffalo.edu/~badzioch/MTH427/_static/mth427_notes_12.pdf
2. https://www.youtube.com/watch?v=etyZDwcZWHs

CORE ELECTIVE – IV OPERATIONS RESEARCH (P23MA310)

Lecture Hours	**:85**	**Tutorial Hours**	**:5**
Practical Hours	**:-**	**No. of Credits**	**:5**
Contact Hours per Semester	**:90**		
Contact hours per Week	**:6**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

Objectives of the Course

The main aim of the Course is

- to learn different optimization techniques.
- to solve problems in Transportation model.

Course Learning Outcomes (for Mapping with POs and PSOs)

On successful completion of the Course, the students will be able to

CO1 remember and understand the concepts of transportation models and assignment models.

CO2 describe minimal spanning tree algorithm and PERT- CPM model.

CO3 analyse the construction of the LP model and graphical LP solutions

CO4 evaluate the problems in inventory model, probabilistic model, single period model, single item stock model.

CO5 describe the basic elements of queuing model.

CO-PO and PSO Mapping (Course Articulation Matrix)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	3	3	2	2	2	2	3
CO2	3	3	2	2	3	1	2	2	3
CO3	3	3	2	3	2	1	3	2	3
CO4	2	2	3	3	3	2	2	3	2
CO5	3	3	2	2	3	3	3	2	3
Total Contribution of COs to POs	**14**	**13**	**12**	**13**	**13**	**9**	**12**	**11**	**14**
Weighted Percentage of COs Contribution to POs	**93.33**	**86.67**	**80**	**86.67**	**86.67**	**60**	**80**	**73.33**	**93.33**

0- No Correlation **1-Weak** **2-Moderate** **3- Strong**

Course Content

Unit I Transportation Models And Its Variants (L-17hrs; T-1hr)

Definition of the Transportation Model – Non-Traditional Transportation Model– Transportation Algorithm – The Assignment Model.

Chapter 5: Sections 5.1, 5.2, 5.3, 5.4. Exercise problems.

Unit II Network Analysis (L-17hrs; T-1hr)

Network Definitions – Minimal Spanning Tree Algorithm –Shortest Route Problem – Maximum Flow Model – CPM –PERT.

Chapter 6: Sections 6.2, 6.3, 6.4, 6.5, 6.7. Exercise problems.

Unit III Linear Programming (L-17hrs; T-1hr)

Introduction – Construction of the L.P model – Graphical LP Solution.

Chapter 2 – Sections: 2.1 - 2.3

Unit IV Inventory Theory (L-17hrs; T-1hr)

Basic Elements of an Inventory Model –Deterministic Models: Single Item Stock Model With And Without Price Breaks –Multiple Items Stock Model With Storage Limitations – Probabilistic Models: Continuous Review Model-Single Period Models.

Chapter 11 – Sections 11.1, 11.2, 11.3, Chapter 16 –Sections 16.1,16.2, 16.3, Exercise problems.

Unit V Queuing Theory (L-17hrs; T-1hr)

Basic Elements of Queuing Model – Role of Poisson and Exponential Distributions – Pure Birth and Death Models –Specialised Poisson Queues - (M/G/1): GD/∞/∞)-Pollaczek - Khintechine Formula.

Chapter 17: Sections 17.2, 17.3, 17.4, 17.6, 17.7. Exercise problems.

Recommended Text

1. Hamdy Taha A., *Operations Research*, Sixth Edition, Prentice Hall of India Private Limited, New Delhi, 2000.

Reference Books

1. Fredrick, Shiller, Genrald Literman J., *Introduction to Operations Research*, MC Graw Hill, 2017.
2. Kanti Swarup, Gupta P.K., Man Mohan, *Operations Research*, Sultan Chand and Sons, 2016.
3. Sharma J.N, *Operations Research*, Fifth Edition, MacMillian Publications, 2013.

Website and E-Learning Sources

1. http://public.tepper.cmu.edu/jnh/tutorialLSE.pdf
2. http://www.cs.toronto.edu/~stacho/public/IEOR4004-notes1.pdf

CORE ELECTIVE – V: RESEARCH METHODOLOGY (P23MA3E53)

Lecture Hours	**: 40**	**Tutorial Hours:5**	
Practical Hours	**:-**	**No. of Credits :3**	
Contact Hours per Semester	**:45**		
Contact hours per Week	**:3**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

Objectives of the Course

The aim of the Course is

- to know about research projects.
- to discuss different components of research projects.

Course Learning Outcomes (for Mapping with POs and PSOs)

On successful completion of the Course, the students will be able to

CO1 remember and understand the concept of research project.
CO2 describe the tips and strategies for writing style of research project.
CO3 discuss the different components of research project.
CO4 analyze the methodologies of research project.
CO5 learn about the publication and presentation of research articles and tool kits.

CO-PO and PSO Mapping (Course Articulation Matrix)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	2	3	2	3	3
CO2	2	2	2	1	3	3	3	1	2	2
CO3	3	2	1	3	2	3	3	1	2	3
CO4	2	3	1	2	3	2	2	2	3	2
CO5	3	2	2	3	2	3	3	3	2	3
Total Contribution of Cos to Pos	**13**	**11**	**9**	**11**	**13**	**13**	**14**	**9**	**12**	**13**
Weighted Percentage of Cos Contribution to Pos	**86.67**	**73.33**	**60**	**73.33**	**86.67**	**86.67**	**93.33**	**60**	**80**	**86.67**

0- No Correlation **1-Weak** **2-Moderate** **3- Strong**

Course Content

Unit I Research Project (L-8hrs; T-1hr)

Research Project – Difference between a dissertation and a thesis – Basic requirements of research degree -Deciding on a Research Topic- Choosing a Supervisor

Chapter 5 ; Sec 5.1- 5.5

Unit II Writing a proposal (L-8hrs; T-1hr)

Writing a proposal –Adopting Correct Mindset-Studying Independently- Understanding Disciplinary Differences-Ethical considerations

Chapter-5 Sec:5.6-5.8,5.10, 5.13

Unit III Different components of a Research Project (L-8hrs; T-1hr)

Different components of a Research Project – Title page – Abstract- Acknowledgement- List of Contents- Introduction- Literature Review.

Chapter 6: Section 6.1 – 6.7

Unit IV Methodology (L-8hrs; T-1hr)

Methodology -Result\ Data- Analysis and Discussion–Style of Presentation – Conclusions– Bibliography–Appendices.

Chapter 6: 6.8– 6.13

Unit V Publishing and presenting Research article (L-8hrs; T-1hr)

Publishing and presenting your research and Tool kit- Journal Articles – A book – conference presentation- A final note – All punctuations.

Chapters 7 & 8

Recommended Text

1. *Writing up your University Assignments and Research Projects – A Practical Handbook*, Neil Murray and Geraldine Hughes, McGraw Hill Open University Press, 2008.

Reference Books

1. Kothari C. R., Gaurav Garg, *Research Methodology : Methods And Techniques* (Multi Colour Edition) 4th Edition, New Age International Publications, New Delhi, 2019.
2. Cauvery R., Sudha Nayak U. K., Girija M., Meenakshi R., *Research Methodology,* S. Chand Publication, 2016.
3. Morgan Shields, *Research Methodology and Statistical Methods,* First Edition, ED Tech Press, 2021.

Website and E-Learning Sources

1. https://www.euacademic.org
2. https://www.research.com

CORE ELECTIVE – V : NUMERICAL ANALYSIS (P23MA3E5B)

Lecture Hours	**:40**	**Tutorial Hours : 5**
Practical Hours	**:-**	**No. of Credits :3**
Contact Hours per Semester	**:45**	
Contact hours per Week	**:3**	
Internal Marks	**:25**	
External Marks	**:75**	
Total Marks	**:100**	

Objectives of the Course

The Course deals with

- the methods of solving linear algebraic equations.
- numerical differentiation and integration.

Course Learning Outcomes (for mapping with POs and PSOs)

On successful completion of the Course, the students will be able to

CO1 remember and understand the concepts of interpolation.

CO2 demonstrate numerical differentiation, Newton's forward and backward, central difference formula

CO3 analyze numerical integration, Gaussian quadrature formula.

CO4 evaluate solutions of ODE by Euler's method, Picard's method and Runge-Kutta method.

CO5 find the solutions using Predictor-Corrector method.

CO-PO and PSO Mapping (Course Articulation Matrix)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	2	2	2	2	3	2	2
CO2	3	3	2	2	2	2	3	3	2
CO3	3	3	2	3	2	2	3	3	2
CO4	3	2	2	2	2	2	3	2	2
CO5	2	2	2	2	2	2	2	2	2
Total Contribution of COs to POs	**14**	**12**	**10**	**11**	**10**	**10**	**14**	**12**	**10**
Weighted Percentage of COs Contribution to POs	**93.33**	**80**	**66.67**	**73.33**	**66.67**	**66.67**	**93.33**	**80**	**66.67**

0- No Correlation **1-Weak** **2-Moderate** **3- Strong**

Course Content

Unit I Interpolation (L-8hrs; T-1hr)

Newton's Interpolation Formula – Central difference Interpolation - Lagrange's Interpolation formula – Divided differences - Newton's Divided differences formula – Inverse Interpolation – Hermit's Interpolating Polynomial.

Chapter 7- Sections: 7.1 to 7.7

Unit II Numerical Differentiation (L-8hrs; T-1hr)

Numerical differentiation – Derivatives using Newton's forward, backward, central difference formulae.

Chapter 8 – Sections: 8.1 to 8.3

Unit III Numerical Integration (L-8hrs; T-1hr)

Numerical Integration –Gaussian Quadrature formula –Numerical evaluation of double integrals.

Chapter 8 – Sections: 8.5 to 8.7

Unit IV Numerical Solutions of ODE (L-8hrs; T-1hr)

Numerical solutions of ordinary differential equations – Taylor's series Method – Picard's Method – Euler's Method – Runge Kutta Method.

Chapter 10 – Sections: 10.1 to 10.4

Unit V Predictor Corrector Method (L-8hrs; T-1hr)

Predictor corrector Method – Milnes Method – Adams-Bashforth Method.

Chapter 10 – Sections: 10.5 to 10.7

Recommended Text

1. Arumugam S. and Issac, *Numerical Methods*, Second Edition, Tata Mc Graw-Hill Publishing Company Limited, New Delhi.

Reference Books

1. Jain M.K., Iyengar S.R. K., Jain R.K., *Numerical Methods for Scientific and Engineering Computation*, Sixth Edition, New Age International Publishers, New Delhi, 2012.
2. Devi Prasad, *An Introduction to Numerical Analysis*, Third Edition, Narosa Publishing House, New Delhi, 2009.
3. Sastry S. S, *Introductory Methods of Numerical Analysis*, Fifth Edition, Prentice Hall of India, 2012.

Website and E-Learning Sources

1. https://www.youtube.com/watch?v=tcqsLqIyjmk
2. https://www.youtube.com/watch?v=zr12pnzNoXI

CORE ELECTIVE – V : STOCHASTIC PROCESS (P23MA3E5C)

Lecture Hours	**:40**	**Tutorial Hours**	**:5**
Practical Hours	**:-**	**No. of Credits**	**: 3**
Contact Hours per Semester	**:45**		
Contact hours per Week	**:3**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

Objectives of the Course

The Course focuses on

- classification of general stochastic process, Markov chain.
- joint probabilities for Brownian Motion.

Course Learning Outcomes (for mapping with POs and PSOs)

On successful completion of the Course, the students will be able to

CO1 remember and understand the concepts of general stochastic process and Markov chain.

CO2 demonstrate the concepts of queuing models and limit theorems on Markov chains.

CO3 explain about the pure birth , death processes and Poisson process.

CO4 acquire the knowledge of some special Renewal process.

CO5 find the joint probabilities for Brownian motion.

CO-PO and PSO Mapping (Course Articulation Matrix)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	2	3	2	3	3
CO2	2	3	2	1	3	2	3	2	2	2
CO3	3	3	1	3	2	3	3	2	1	3
CO4	2	3	1	2	3	2	3	2	1	2
CO5	3	2	2	3	2	2	3	2	2	3
Total Contribution of COs to POs	**13**	**14**	**9**	**11**	**13**	**11**	**15**	**10**	**9**	**13**
Weighted Percentage of COs Contribution to POs	**86.67**	**93.33**	**60**	**73.33**	**86.67**	**73.33**	**100**	**66.67**	**60**	**86.67**

0- No Correlation **1-Weak** **2-Moderate** **3- Strong**

Course Content

Unit I Markov Chains (L-8hrs; T-1hr)

Classification of general stochastic processes – markov chain – Examples – Transition probability matrix – Classification of states - Recurrence

Chapter 1 : Section 3 only and Chapter 2 : sections 1 to 5.

Unit II Limit theorems of Markov chains (L-8hrs; T-1hr)

Discrete renewal equation and its proof – Absorption probabilities – criteria for recurrence – Queuing models

Chapter 3 : Sections 1 to 7

Unit III Continuous time Markov Chains (L-8hrs; T-1hr)

Poisson process – Pure Birth process – Birth and Death process - Birth and Death process with absorbing states

Chapter 1 : Section 2 (Poisson process) Chapter 4 : Sections 1, 2 and 4to 7 (omit sections 3 and 8)

Unit IV Renewal processes (L-8hrs; T-1hr)

Definition and related concepts – Some special renewal processes

Chapter 5 : sections 1 – 3

Unit V Brownian Motion (L-8hrs; T-1hr)

Definition – Joint probabilities for Brownian Motion – Continuity of paths and the maximum variables – Variations and extensions

Chapter 1 : Section 2 (Brownian Motion) Chapter 6 : sections 1 to 4 and 7

Recommended Text

1. Karlin S. and Taylor H.M., *A first course in stochastic processes*, 2nd edition Academic Press, New York, 1975.

Reference Books

1. E. Cinler, *Introduction to stochastic processes*, Prentice Hall Inc, New Delhi, 1975.
2. D.R.Cox and H.D.Miller, *Theory of stochastic processes* (3rd Edition) Chapman and hall, London, 1983
3. D.Kannan, *An introduction to stochastic processes*, North-Holland, New York, 1979

Website and E-learning Sources

1. https://www.youtube.com/watch?v=tcqsLqIyjmk
2. https://www.youtube.com/watch?v=zr12pnzNoXI

SKILL ENHANCEMENT COURSE (SEC-2)

PROFESSIONAL COMMUNICATION SKILL (SEMINAR PAPER) (P23MA3SEP)

Lecture	Tutorial	Lab practice	Total
3	-	-	3

Split up	Components	K Level	Marks	Total marks
CIA*	Content	K3,K4,K5,K6 Any level can be used	10	40
	Presentation		15	
	Subject Knowledge		15	
ESE	Visual aids and materials: Assessment methods: PowerPoint slides, handouts and other supporting materials		15	60
	Presentation		20	
	Mastery of the seminar topic		20	
	Participation and engagement in seminars		5	

* Students are required to select seminar topics from their Core Courses. As part of the Continuous Internal Assessment (CIA), each student must deliver a minimum of two seminars over the duration of their Course. These seminars should be based on topics from their Core Courses to ensure alignment with the curriculum and to deepen their understanding of the core subjects.

CORE-XI: FUNCTIONAL ANALYSIS (P23MA411)

Lecture Hours	**:85**	**Tutorial Hours : 5**	
Practical Hours	**:-**	**No. of Credits : 5**	
Contact Hours per Semester	**:90**		
Contact hours per Week	**:6**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

Objectives of the Course

The main objective of this Course is

- to provide students with a strong foundation in functional analysis, focusing on spaces, operators and fundamental theorems.
- to develop student's skills and confidence in mathematical analysis and proof techniques.

Course Learning Outcomes (for Mapping with POs and PSOs)

On successful completion of the Course, the students will be able to

CO1 understand the Banach spaces and Transformations on Banach spaces.

CO2 demonstrate about the natural imbedding of N and open mapping theorem.

CO3 analyse Hilbert spaces and its properties.

CO4 evaluate the problems in adjoint of an operator and self adjoint operators.

CO5 derive spectral theorem and find the determinants of spectrum of operator.

CO-PO and PSO Mapping (Course Articulation Matrix)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	3	2	3	3	2	3	3
CO2	2	3	2	1	3	2	2	2	2
CO3	3	3	1	3	2	1	2	1	3
CO4	2	2	2	2	3	1	2	2	2
CO5	3	2	2	3	2	2	2	2	3
Total Contribution of Cos to Pos	**13**	**12**	**10**	**11**	**13**	**9**	**10**	**10**	**13**
Weighted Percentage of COs Contribution to POs	**86.67**	**80**	**66.67**	**73.33**	**86.6**	**60**	**66**	**66.67**	**86.6**

0- No Correlation **1-Weak** **2-Moderate** **3- Strong**

Course Content

Unit I Banach Spaces (L-17hrs;T-1 hr)

Banach Spaces- The definition and some examples-Continuous linear transformations- The Hahn Banach Theorem.

Chapter 9 – Sections: 46, 47, 48
Problems: Sections - 46 (1-4), 47 (1-3), 48 (1)

Unit II Imbedding (L-17hrs;T-1 hr)

The Natural Imbedding of N in N**- The open mapping theorem.

Chapter 9 – Sections: 49 & 50
Problems: Sections - 49 (1-3), 50 (2,3)

Unit III Hilbert Spaces (L-17hrs;T-1 hr)

Conjugate of an operator -Hilbert Spaces-The Definition and some simple properties- Orthogonal compliments.

Chapter 9 – Section: 51& Chapter 10 – Sections: 52& 53
Problems: Sections - 51 (1 - 3), 52 (4 &6), 53 (1-4).

Unit IV The Conjugate Space and Adjoint (L-17hrs;T-1 hr)

The Adjoint of an operator- Self adjoint operators.

Chapter 10–Sections: 54 - 57
Problems: Sections - 54 (1 &5), 55 (1-3) & 57 (1&2)

Unit V Spectral Theory (L-17hrs;T-1 hr)

Normal and Unitary operators- projections, Finite dimensional spectral theory- Determinants and the spectrum of an operator- The spectral theorem.

Chapter 10 - Sections 58 & 59, Chapter 11 - Sections 61& 62
Problems: Sections - 58, 59, 61 &62 (1-5)

Recommended Text

1. Simmons G.F., *Introduction to Topology and Modern Analysis*, McGraw – Hill International Editions, 2003.

Reference Books

1.Walter Rudin, *Functional Analysis*, Second Edition, Tata McGraw Hill Edcation Private Ltd, New Delhi, 2011.
2. Chandrasekara Rao K., *Functional Analysis*, Narosa Publishing House, New Delhi, 2009.
3. Kesavan S, *Functional Analysis*, Springer, 2023.

Website and E-learning Sources

1. http://susanka.org/HSforQM/%5BSimmons%5D_Introduction_to_Topology_and_Modern_Analysis.pdf
2. https://www.mimuw.edu.pl/~aswiercz/AnalizaF/lecture.pdf

CORE-XII: MECHANICS (P23MA412)

Lecture Hours	**:85**	**Tutorial Hours**	**: 5**
Practical Hours	**:-**	**No. of Credits**	**:5**
Contact Hours per Semester	**:90**		
Contact hours per Week	**:6**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

Objectives of the Course

The Course aims at giving the knowledge

- to study mechanical systems under generalized coordinate systems, virtual work, energy and momentum.
- to study mechanics developed by Newton, Langrage, Hamilton Jacobi and Theory of Relativity due to Einstein.

Course Learning Outcomes (for Mapping with POs and PSOs)

On successful completion of the Course, the students will be able to

CO1	remember and understand the concept of Mechanics of particle
CO2	apply D'Alembert's Principle and Lagrange formulation
CO3	analyses some techniques of calculus of variations and Hamilton principles.
CO4	evaluate the equations of motions and first integral.
CO5	find the differential equation for the orbit and integrable power law potential.

CO-PO and PSO Mapping (Course Articulation Matrix)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	3	2	3	3	2	2	3
CO2	2	1	3	1	3	3	2	1	2
CO3	3	1	3	1	3	3	2	3	3
CO4	1	2	3	2	3	3	2	2	1
CO5	3	3	2	3	3	3	2	3	3
Total Contribution of COs to POs	**12**	**9**	**14**	**9**	**15**	**15**	**10**	**11**	**12**
Weighted Percentage of COs Contribution to POs	**80**	**60**	**93.33**	**60**	**100**	**100**	**66.67**	**73.33**	**80**

0- No

Correlation **1-Weak** **2-Moderate** **3- Strong**

Course Content

Unit I Mechanics of particle (L-17 hrs; T-1hr)

Mechanics of particle – Mechanics of a system of particles constraints.

Chapter 1 - Sections: 1 - 3, Problems: 2, 4 & 5

Unit II D'Alembert's Principle (L-17 hrs; T-1hr)

D'Alembert's Principle and Lagrange's equation – Velocity dependent potentials and dissipation functions – Simple applications of Lagrangian formulation.

Chapter 1 - Sections: 4 - 6 & Problems: 11, 13 & 17

Unit III Hamilton's Principle (L-17 hrs; T-1hr)

Hamilton's Principle – Some techniques of Calculus of Variation – Derivation of Lagrange's equations from Hamilton's principle – Extension of Hamilton principle to non - holonomic systems.

Chapter 2 - Sections: 1 – 4 & Problems: 1 – 3

Unit IV The equations of motion and first Integrals (L-17 hrs; T-1hr)

Reduction to the equivalent one - body problem – The equations of motion and first Integrals – The equivalent one dimensional problem and classification of orbits - The virial theorem.

Chapter 3 - Sections: 1 - 4, Problems: 2 – 4

Unit V The Kepler problem (L-17 hrs; T-1hr)

The differential equation for the orbit and integrable power law potentials – The Kepler problem: Inverse square law of force – The motion in time in the Kepler problem – The Laplace – Runge – Lenz vector.

Chapter 3 - Sections: 5 & 7 – 9

Recommended Text

1. Mondal C.R., *Classical Mechanics*, Prentice Hall of India, 2007.

Reference Books

1. Sankara Rao K., *Classical Mechanics*, Prentice Hall of India, 2005.
2. Herbert Goldstein, *Classical Mechanics*, Second Edition, Narosa, 1994.
3. Tom. W. B. Kible, Frank H. Berkshire, *Classical Mechanics*, Fifth edition, Imperial College Press, 2004.

Website and E-Learning Sources

1. https://detritus.fundacioace.com/pub/books/Classical_Mechanics_Goldstein_3ed.pdf
2. https://sistoput.files.wordpress.com/2014/10/classical-mechanics.pdf

CORE ELECTIVE - VI: RING THEORY AND LATTICES (P23MA4E6A)

Lecture Hours	**:70**	**Tutorial Hours:5**	
Practical Hours	**:-**	**No. of Credits :3**	
Contact Hours per Semester	**:75**		
Contact hours per Week	**:5**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

Objectives of the Course

The main objective of the Course is to provide

- the knowledge about Rings and lattices.
- the concepts of polynomial rings and commutative rings.

Course Learning Outcomes (for Mapping POs and PSOs)

On successful completion of the Course, the students will be able to

CO-PO and PSO

CO1 remember and understand the basic ideas of ring homomorphisms, ideals and quotient rings.

CO2 demonstrate the concept of particular Euclidean ring.

CO3 analyse the polynomial rings over commutative rings and rational fields.

CO4 discuss about the partially ordered sets and lattices.

CO5 acquire the knowledge about Mobius function of a partially ordered set.

Mapping (Course Articulation Matrix)

0- No Correlation **1-Weak** **2-Moderate** **3- Strong**

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	PSO3
CO1	3	2	3	2	3	3	2	3	3
CO2	2	2	2	1	3	2	2	2	2
CO3	3	2	1	3	2	1	2	3	3
CO4	2	2	1	2	3	1	2	1	2
CO5	3	2	2	3	2	2	3	3	3
Total Contribution of COs to POs	**13**	**10**	**9**	**11**	**13**	**9**	**11**	**12**	**13**
Weighted Percentage of COs Contribution to POs	**86.67**	**66.67**	**60**	**73.33**	**86.67**	**60**	**73.33**	**80**	**86.67**

Course Content

Unit I Ring Homomorphism (L-14 hrs; T-1 hr)

Ring Homomorphism – Ideals and Quotient rings – field of quotient of integral domain.
Chapter-3 Section: 3.3 - 3.6

Unit II Euclidean Rings (L-14 hrs; T-1 hr)

Euclidean Rings- A particular Euclidean ring.
Chapter -3 Section: 3.7 & 3.8

Unit III Polynomial Rings (L-14 hrs; T-1 hr)

Polynomial Rings – Polynomials over Rational field – Polynomial rings over commutative rings.
Chapter -3 Section: 3.9 - 3.11.

Unit IV Posets and Lattices (L-14 hrs; T-1 hr)

Partially Ordered sets and Lattices – Distributivity and Modularity – The Thoerem of Jordan Holder – Dedekind
Chapter – 8 Section: 8.1 - 8.3.

Unit V Boolean Algebras (L-14 hrs; T-1 hr)

The Lattice of subspaces of Vector space – Boolean Algebras – The Mobius function of a partially ordered set.
Chapter -8 Section: 8.4 - 8.6.

Recommended Text

1. Herstein. I. N., *Topics in Algebra*, Second Edition, Wiley Student Edition, 1975.
2. Nathan Jacobson, *Basic Algebra -I*, Hindustan Publishing Corporation, 1974.

Reference Books

1. Stuat A. Steinberg, *Lattice ordered Rings and Modules*, Springer, 2009.
2. George Gratzer, *lattice theory*, Dover Publication inc, 2009.
3. Dinesh Khattar , Neha Agrawal, *Ring Theory*, Springer, 2023.

Website and E-Learning Sources

1. **https://images.app.goo.gl/JjizkFwi75XbKw1r9**
2. **https://images.app.goo.gl/boCEazu34owVL1er5**

Core Elective -VI: ALGEBRAIC TOPOLOGY (P23MA4E6B)

Lecture Hours	**:70**	**Tutorial Hours:5**	
Practical Hours	**:-**	**No. of Credits :3**	
Contact Hours per Semester	**:75**		
Contact hours per Week	**:5**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

Objectives of the Course

The main objective of the Course is

- to explain the fundamental concepts of algebraic topology and their role in modern mathematics and applied contexts.
- To prove topological result by using algebraic methods

Course Learning Outcomes (For mapping POs and PSOs)

On successful completion of the Course, the students will be able to

CO1 remember and understand the concepts of homotopy, their basic properties and relationships.

CO2 demonstrate the fundamental group of circle**.**

CO3 analyse covering spaces and universal covering spaces.

CO4 study homotopy lemma, Jordan separation theorem, Borsuk lemma and invariance of domain.

CO5 explain the fundamental concepts of algebraic topology and their applications in group theory and graph theory.

CO-PO Mapping (Course Articulation Matrix)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	3	3	2	3	2	3	2	3	3
CO2	2	2	2	1	3	2	3	2	2	2
CO3	3	3	1	3	2	1	3	2	1	3
CO4	2	1	1	2	3	2	2	2	1	2
CO5	3	3	2	3	2	2	3	2	2	3
Total Contribution of COs to POs	**13**	**12**	**9**	**11**	**13**	**9**	**14**	**10**	**9**	**13**
Weighted Percentage of COs Contribution to POs	**86.6**	**80**	**60**	**73.5**	**86.6**	**60**	**93.3**	**66**	**60**	**86.6**

0- No

Correlation 1-Weak 2-Moderate 3- Strong

Course Content

Unit I Homotopy of Paths (L-14hrs ; T- 1hr)

Homotopy of paths, fundamental group of a topological space, homotopy of maps of topological spaces, contractible and simply connected spaces.

Chapter 9: Sec: 51, 52.

Unit II Fundamental group of Circle (L-14hrs ; T- 1hr)

The Fundamental group of the circle, Path lifting lemma, Retractions and fixed points, Brouwer's fixed- point theorem for the disc, The fundamental Theorem of Algebra.

Chapter 9: Sec: 54, 55, 56

Unit III Covering Spaces (L-14hrs ; T- 1hr)

Covering spaces, Equivalence of covering spaces, The general lifting lemma, The universal covering space.

Chapter 9 : Sec: 53, Chapter 13: Sec: 79, 80

Unit IV Homotopy Lemma (L-14hrs ; T- 1hr)

Separation theorems in the plane, Null homotopy lemma, The Jordan separation theorem, A general separation theorem, Homotopy Extension lemma, Borsuk lemma, Invariance of domain.

Chapter 10: Sec: 61, 62

Unit V Fundamental Group of a Graph (L-14hrs ; T- 1hr)

Applications to Group theory: Covering spaces of a graph, The fundamental group of a graph.

Chapter 14: Sec 83, 84.

Recommended Text

1. James R. Munkres, *Topology*, Prentice Hall of India, New Delhi, Second Edition, 2002.

Reference Books

1. M.K.Agoston, *Algebraic topology*- A First Course, Marcel Dekker, 1962
2. Satya Deo, *Algebraic Topology*, Hindustan Book Agency, New Delhi, 2003.
3. M.Greenberg and Harper, *Algebraic Topology-A First course*, Benjamin Cummings, 1981.

Website and E-Learning Sources

1. http://www.hindbook.com/index.php/algebraic-topology-a-primer
2. http://www.alefenu.com/libri/topologymunkres.pdf

Core Elective-VI CALCULUS OF VARIATION AND INTEGRAL EQUATIONS (P23MA4E6C)

Lecture Hours	**:70**	**Tutorial Hours**	**:5**
Practical Hours	**:-**	**No. of Credits**	**:3**
Contact Hours per Semester	**:75**		
Contact hours per Week	**:5**		
Internal Marks	**:25**		
External Marks	**:75**		
Total Marks	**:100**		

Objectives of the Course

The main objective of this Course is

- to gather knowledge in Calculus of Variations and Integral Equations.
- to demonstrate the causes and effect of linear equations

Course Learning Outcomes (For mapping with POs and PSOs)

On successful completion of the Course, the students will be able to

CO1 remember and understand calculus of variations and its applications.

CO2 demonstrate the constraints and Lagrange's Multiplier and Strum Liouville problems.

CO3 analyse the integral equations and relation between integral and differential equations.

CO4 study about the causes and effects of linear equations.

CO5 solve equations of second kind.

CO-PO Mapping (Course Articulation Matrix)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	3	2	3	3	2	2	3
CO2	2	2	2	1	3	2	2	1	2
CO3	3	2	1	3	2	1	2	3	3
CO4	2	2	1	2	3	1	2	2	2
CO5	3	2	2	3	2	2	2	3	3
Total Contribution of COs to POs	**13**	**10**	**9**	**11**	**13**	**9**	**10**	**11**	**13**
Weighted Percentage of COs Contribution to POs	**86.67**	**66.67**	**60**	**73.33**	**86.67**	**60**	**66.67**	**73.33**	**86.67**

0- No

Correlation 1-Weak 2-Moderate 3- Strong

Course Content

Unit I Calculus of Variations and Applications (L -14hrs ; T-1 hr)

Calculus of Variations and Applications – The Maxima and Minima – The simplest case- illustrative examples – The variational notation – the more general case.

Unit II Lagrange's equation (L- 14hrs ; T-1 hr)

Constraints and Lagrange's multipliers – Variable end points – Stum Liouville Problems – Hamilton's Principles – Lagrange's Equations.

Unit III Integral Equations (L -14hrs ; T-1 hr)

Introduction – Relation between Integral and Differential equations – The Greens function – alternative definitions.

Unit IV Linear Equations (L- 14hrs ; T-1 hr)

Linear equations in Cause and Effect – The influence function – Fredholm equations with separable kernals – examples.

Unit V Hilbert Schmidt Theory (L- 14hrs ; T-1 hr)

Hilbert Schmidt theory - methods for solving equations of second kind – Fredholm theory.

Recommended Text

1. Francis B. Hildebrand, Methods of Applied Mathematics, Dover publications, 1992.
   Chapter – 2 Section: 2.1 – 2.11.
   Chapter – 3 Section: 3.1-3.9 and 3.11.

Reference Books

1. Gupta. A.S., *Calculus of Variations with Applications*, PHI learning private Ltd., 12th edition, 2015.
2. Filip Rindler, *Calculus of Variations*, Springer, 2018.
3. Goyal. A.K., *Linear Integral Equations*, Jaipur Publishing House, 2020.

Website and E-Learning Sources

1. **https://images.app.goo.gl/KgjchBmiRPqUwxfR6**
2. **https://images.app.goo.gl/rfZCiC6tW7PpTBdC6**

CORE- 5: REAL ANALYSIS -I (P23MA102)
For the students those admitted in the academic year 2024-2025 and onwards
Course Content

Unit I Functions of bounded variation (L-17hrs; T-1hr)

Introduction - Properties of monotonic functions - Functions of bounded variation - Total variation - Additive property of total variation - Total variation on [a, x] as a function of x - Functions of bounded variation expressed as the difference of two increasing functions - Continuous functions of bounded variation.

Chapter – 6 : Sections 6.1 to 6.8

Unit II The Riemann Stieltjes Integral (L-17hrs; T-1hr)

Introduction - Notation - The definition of the Riemann - Stieltjes integral - Linear Properties - Integration by parts- Change of variable in a Riemann - Stieltjes integral - Monotonically increasing integrators, Upper and lower integrals - Additive and linearity properties of upper, lower integrals - Riemann's condition - Comparison theorems.

Chapter - 7 : Sections 7.1 to 7.6, 7.11- 7.14

Unit III The Riemann-Stieltjes Integral (L-17hrs; T-1hr)

Integrators of bounded variation-Sufficient conditions for the existence of Riemann-Stieltjes integrals-Necessary conditions for the existence of RS integrals- Mean value theorems -integrals as a function of the interval – Second fundamental theorem of integral calculus-Change of variable -Second Mean Value Theorem for Riemann integral- Riemann-Stieltjes integrals depending on a parameter.

Chapter - 7 : Sections 7.15 to 7.23

Unit IV Infinite Series and infinite Products (L-17hrs; T-1hr)

Absolute and conditional convergence - Dirichlet's test and Abel's test - Rearrangement of series - Riemann's theorem on conditionally convergent series - Double sequences - Double series - Rearrangement theorem for double series - A sufficient condition for equality of iterated series - Multiplication of series – Cesaro summability - Infinite products.

Chapter - 8 : Sections 8.8, 8.15, 8.17, 8.18, 8.20, 8.21 to 8.26

Unit V Sequences of Functions (L-17hrs; T-1hr)

Uniform convergence and continuity - Cauchy condition for uniform convergence - Uniform convergence of infinite series of functions - Riemann - Stieltjes integration – Non-uniform Convergence and Term-by-term Integration - Uniform convergence and differentiation - Sufficient condition for uniform convergence of a series - Mean convergence.

Chapter - 9: Sections 9.1 to 9.6, 9.9, 9.10, 9.11.

Recommended Text

1. Tom M.Apostol, *Mathematical Analysis*, 2nd Edition, Addison-Wesley Publishing Company Inc. New York, 1974.

Reference Books

1. Rudin W, *Principles of Mathematical Analysis*, 3rd Edition. McGraw Hill Company, New York, 1976.
2. Malik S C and Savita Arora, *Mathematical Anslysis*, Wiley Eastern Limited.New Delhi, 1991.
3. Sanjay Arora and Bansi Lal, *Introduction to Real Analysis*, SatyaPrakashan, New Delhi, 1991.

Website and E-learning Sources

1. http://mathforum.org
2. http://ocw.mit.edu/ocwweb/Mathematics

CORE- 6: PARTIAL DIFFERENTIAL EQUATIONS (P23MA206)
For the students those admitted in the academic year 2024-2025 and onwards

Course Content

Unit I Mathematical Models and Classification of second order equation (L-17hrs;T-1hr)

Classical equations-Vibrating string – Vibrating membrane – waves in elastic medium – Conduction of heat in solids – Gravitational potential – Second order equations in two independent variables – canonical forms – equations with constant coefficients – general solution.

Chapter 3 : Sections 3.1 to 3.6
Chapter 4 : Sections 4.1 to 4.4

Unit II Cauchy Problem (L-17hrs;T-1hr)

The Cauchy problem – Cauchy-Kowalewsky theorem – Homogeneous wave equation – Initial Boundary value problem- Non-homogeneous boundary conditions – Finite string with fixed ends – Non-homogeneous wave equation – Riemann method – Goursat problem – spherical wave equation – cylindrical wave equation.

Chapter 5 : Sections 5.1 to 5.11

Unit III Method of separation of variables (L-17hrs;T-1hr)

Separation of variable- Vibrating string problem – Existence and uniqueness of solution of vibrating string problem - Heat conduction problem – Existence and uniqueness of solution of heat conduction problem – Laplace and beam equations.

Chapter 7 : Sections 7.1 to 7.7

Unit IV Boundary Value Problems (L-17hrs;T-1hr)

Boundary value problems – Maximum and minimum principles – Uniqueness and continuity theorem – Dirichlet Problem for a circle- Dirichlet Problem for a circular annulus, a rectangle.

Chapter 9 : Sections 9.1 to 9.7

Unit V Dirichlet Problem and Neumann problem (L-17hrs;T-1hr)

Dirichlet problem involving Poisson equation – Neumann problem for a circle and a rectangle – Higher-Dimensional Boundary value problems: Dirichlet Problem for a Cube, Cyclinder, Sphere.

Chapter 9 : Sections 9.8, 9.9 **Chapter 10 :** Sections 10.1 to 10.4

Recommended Text

1. Tyn Myint U, Lokenath Debnath, *Partial Differential Equations for Scientists and Engineers*, Fourth Edition, North Holland, New York, 1987.

Reference Books

1. Sankara Rao K., *Introduction to Partial Differential Equations*, 2009.
2. Copson E.T., *Partial differential equations***,** S. Chand and Company Ltd., New Delhi, 1984.
3. Sharma J.N. and Kehar Singh, *Partial Differential Equations for Engineers and Scientists*, Second Edition, Narosa Publishing House, 2009.

Website and E-learning Sources

1. http://www.iitg.ac.in/swaroop/Lecture5-PDE-2016.pdf
2. https://mathquerry.blogspot.com/2020/01/pfaffian-differential-equations-and-its.html