



**Vidyasagar University**  
Midnapore-721102, West Bengal

**The SYLLABUS for**

**M.Sc.**

**in**

**APPLIED MATHEMATICS**



**[w.e.f. 2025-26]**

## Preamble

The Post-Graduate (M.Sc.) programme in Applied Mathematics provides an in-depth understanding of advanced mathematics with a strong emphasis on Optimization Theory, Operations Research, Meteorology, Data Science, Graph Theory, Fuzzy Mathematics, Soft Computing, Machine Learning, Computational Fluid Dynamics, Mathematical Modelling, and other applied domains. To enhance academic flexibility, the syllabus includes several elective papers, enabling students to select courses that align with their interests and career aspirations. Additionally, students may opt for a MOOC course through SWAYAM, thereby gaining access to a wide range of learning opportunities beyond the department. Furthermore, courses on the Indian Knowledge System (IKS), Intellectual Property Rights (IPR), and the Life and Philosophy of Vidyasagar have been included to foster holistic academic development and broaden intellectual horizons.

The two-year M.Sc. programme in Applied Mathematics with Oceanology and Computer Programming was initiated under the Faculty of Science, Vidyasagar University at the time of its inception in 1985–86. The Ph.D. programme in Mathematics began in 1998, and so far, around 120 scholars have successfully completed their doctoral research from the department. The Choice-Based Credit System (CBCS) was implemented in 2018. From the academic session 2025–26, both the one-year and two-year M.Sc. programmes in Applied Mathematics have been introduced, with the syllabus designed in line with the guidelines of the National Education Policy (NEP) 2020.

The syllabus emphasizes both pure and applied mathematics, while also aligning with the requirements of national-level competitive examinations such as CSIR-NET, UGC-NET, GATE, and state-level examinations such as SET. The programme equips students with strong analytical and computational skills through courses in Python, C++, research projects, field and industry visits, internships, community engagement, and seminar presentations. Project work, introduced in the third semester and carried into the fourth semester, encourages students to undertake independent research in their chosen areas.

The department is enriched with ICT-enabled smart classrooms, virtual classrooms, a programming laboratory, and a departmental library, supported by a team of highly qualified faculty members. It has also received sponsorship from the Department of Science and Technology (DST), Government of India, for the enhancement of laboratory and classroom infrastructure. Advanced Computer Algebra Systems (CAS) such as MATLAB, LINGO, and Mathematica are integrated into the curriculum to strengthen conceptual understanding and promote hands-on skill development.

The thrust areas of research in the department include Optimization and Operations Research, Fuzzy Mathematics, Fluid Dynamics, and allied topics, ensuring that the programme maintains a strong balance of theory, application, and research.

## PROGRAMME OUTLINES

	<b>Type of Program</b>	This is a regular mode M.Sc. programme, based on the guidelines of NEP 2020.
<b>1</b>	<b>Duration and Eligibility Criteria</b>	The department offers two types of M.Sc. programmes in Applied Mathematics. Students who have completed a 3-year Honours degree in Mathematics are eligible for admission to the two-year M.Sc. programme, while those who have completed a 4-year Honours degree in Mathematics (with or without research) are eligible for admission to the one-year M.Sc. programme.
<b>2</b>	<b>Intake capacity</b>	The current intake capacity of the programme is 110 students. Admission is carried out in accordance with the prevailing government norms, and the reservation rules for EWS, OBC, SC, ST, PWD, and other applicable categories are strictly followed.
<b>3</b>	<b>Admission procedure</b>	The university conducts a written admission test as part of the selection process. Admission is based primarily on the performance in the written test, along with consideration of marks obtained in the Undergraduate (UG) programme or in the Higher Secondary (HS) examination, as applicable. The Admission Committee oversees the entire admission process, ensuring that all rules and regulations are properly followed.
<b>4</b>	<b>Evaluation Process</b>	<ul style="list-style-type: none"><li>The students will be assessed through a combination of continuous evaluation and end-semester examination. <b>Continuous Evaluation (CE)</b> carries <b>20% weightage</b>, while the <b>End-Semester Examination</b> accounts for <b>80%</b> of the total</li></ul>

		<p>marks.</p> <ul style="list-style-type: none"> <li>• Two CEs will be conducted for each paper/course, and the average of these two will determine the final CE marks. The CEs may be conducted in diverse formats such as multiple-choice questions (MCQs), open-book examinations, take-home exercises, case studies, assignments, or small projects.</li> <li>• The end-semester examination will comprise short-answer, medium-answer, and long-answer type questions to evaluate the students' understanding and analytical skills comprehensively.</li> </ul>
5	<b>Teaching Methods</b>	<p>To achieve the intended learning outcomes, the following teaching-learning methods will be employed:</p> <ul style="list-style-type: none"> <li>• <b>Lecture-based Learning</b> – Structured delivery of core concepts through classroom lectures.</li> <li>• <b>Group Learning</b> – Collaborative discussions and group activities to promote teamwork and idea-sharing.</li> <li>• <b>Individual Learning</b> – Independent study and self-paced learning to strengthen conceptual clarity.</li> <li>• <b>Technology-based Learning</b> – Use of digital tools, software, and online resources to support interactive learning.</li> <li>• <b>Peer Teaching</b> – Students explaining concepts to peers, encouraging active participation and reinforcement of knowledge.</li> <li>• <b>Problem-solving Approach</b> – Learning through real-world problems, case studies, and exercises to develop analytical and critical thinking skills.</li> </ul>
6	<b>Special Instructions</b>	<p>To align the syllabus with the National Education Policy (NEP) 2020, several general courses such as Indian Knowledge System (IKS), Intellectual Property Rights (IPR), Research Methodology and Ethics, Social Service/Community Engagement, Internship/Industry Visit or Industry-related Project, Field Visit, Research Project, and Life and Philosophy of Vidyasagar have been made compulsory. Alongside these, a set of core courses has been included to strengthen subject foundations. The syllabus also offers elective papers to provide flexibility and choice. In Semesters I and II, each elective paper provides two options, while in Semesters III and IV, each elective paper provides three options. Students are required to choose one elective paper from the available options. In MTM 401 &amp; 402, each elective includes both a theory paper (2 credits) and a practical paper (2 credits), and students must opt for both components from the same elective to ensure coherence in learning.</p>
7	<b>Research Projects</b>	<p>The research project will be distributed by the mentor to the students in third semester and it will be evaluated in final semester.</p>

## Program Outcomes (POs)

On successful completion of the M.Sc in Applied Mathematics program, the students will be able to	
PO1	<b>Advanced Mathematical Knowledge:</b> Acquire advanced knowledge of pure and applied mathematics, including analysis, algebra, topology, mechanics, optimisation, statistics, and computational mathematics.
PO2	<b>Problem Solving and Modelling:</b> Apply mathematical reasoning, abstract thinking, and problem-solving techniques to analyse and model complex real-world problems.
PO3	<b>Computational Proficiency:</b> Develop proficiency in modern computational tools and programming languages (Python, C++, MATLAB, LINGO, etc.) for solving mathematical and interdisciplinary problems.
PO4	<b>Research Skills:</b> Demonstrate research skills through independent inquiry, data collection, analysis, interpretation, and dissemination of findings.
PO5	<b>Interdisciplinary Integration:</b> Integrate mathematical knowledge with other scientific and engineering domains, promoting interdisciplinary problem-solving.

PO6	<b>Communication Skills:</b> Communicate mathematical ideas, proofs, algorithms, and research findings effectively through written, oral, and digital formats.
PO7	<b>Teamwork and Collaboration:</b> Work effectively both independently and collaboratively in academic, professional, and research environments.
PO8	<b>Ethics and Knowledge Systems:</b> Recognise ethical principles, professional responsibilities, and the significance of Indian Knowledge Systems (IKS) and cultural heritage in the development of mathematics.
PO9	<b>Lifelong Learning:</b> Engage in lifelong learning to stay updated with emerging areas in mathematics, data science, machine learning, and scientific research.
PO10	<b>Employability and Entrepreneurship:</b> Demonstrate employability and entrepreneurship skills by applying mathematical knowledge in teaching, research, industry, and innovation.

### Programme Specific Outcomes (PSOs)

After the successful completion of M. Sc. in Applied Mathematics program, the students are expected to:	
PSO1	Apply advanced mathematical concepts from analysis, algebra, mechanics, optimisation, differential equations, functional analysis, stochastic processes, and topology to theoretical and practical problems.
PSO2	Use computational and algorithmic methods, including programming in Python and C++, data science techniques, graph theory, and numerical methods, to solve complex mathematical models.
PSO3	Conduct independent research and projects in areas like fuzzy mathematics, operations research, dynamical systems, fluid mechanics, cryptography, and mathematical modelling in applied sciences.
PSO4	Appreciate the historical and cultural development of mathematics, including Indian Knowledge Systems, and apply mathematical knowledge in socially relevant, ethical, and interdisciplinary contexts.

## M. Sc. in Applied Mathematics

(For the students admitted during the academic year 2025 – 26 onwards)

Semester	Course Code	Title of the Course	Credits (L-T-P)	Maximum Marks		
				IA	End Sem. Exam	Total
I	MTM C 401X1	Measure Theory	2 (1-1-0)	05	20	25
	MTM C 401X2	Complex Analysis	2 (1-1-0)	05	20	25
	MTM C 402X1	Classical Mechanics	2 (1-1-0)	05	20	25
	MTM C 402X2	Abstract Algebra	2 (1-1-0)	05	20	25
	MTM C 403X0	Research Methodology and Ethics	4 (3-1-0)	10	40	50
	MTM E 404A0	<i>One elective must be chosen.</i> Elective-I: Ordinary Differential Equations	4 (3-1-0)	10	40	50
	MTM E 404B1	Elective-II: Data Science	2 (1-1-0)	05	20	25
	MTM E 404B2	Elective-II: Graph Theory	2 (1-1-0)	05	20	25
	MTM E 405A0	<i>One elective must be chosen.</i> Elective-I: Programming in Python	4 (3-1-0)	10	40	50
	MTM E 405B0	Elective-II: Programming in C++	4 (3-1-0)	10	40	50
	MTM O 406VC	Indian Knowledge System (IKS)	2 (1-1-0)	05	20	25
	MTM O 407NC	Life and Philosophy of Vidyasagar <a href="http://ccnet.vidyasagar.ac.in:8450/course/view.php?id=540">http://ccnet.vidyasagar.ac.in:8450/course/view.php?id=540</a> or <a href="https://vidyasagar.ac.in/eLearningMaterials/Default.aspx">https://vidyasagar.ac.in/eLearningMaterials/Default.aspx</a>	Compulsory Non-credit	--	--	25
		<b>Total</b>	22	55	220	275+25
II	MTM C 451X1	Continuum Mechanics	2 (1-1-0)	05	20	25
	MTM C 451X2	Linear Algebra	2 (1-1-0)	05	20	25
	MTM E 452A1	<i>One elective must be chosen.</i> Elective-I: Fluid Mechanics	2 (1-1-0)	05	20	25
	MTM E 452A2	Elective-I: MHD	2 (1-1-0)	05	20	25
	MTM E 452B1	Elective-II: Calculus on $R^n$	2 (1-1-0)	05	20	25
	MTM E 452B2	Elective-II: Operator Theory	2 (1-1-0)	05	20	25
	MTM E 453A0	<i>One elective must be chosen.</i> Elective-I: Partial Differential Equations and Generalized Functions	4 (3-1-0)	10	40	50
	MTM E 453B1	Elective-II: Fuzzy Mathematics	2 (1-1-0)	05	20	25
MTM E 453B2	Elective-II: Soft Computing	2 (1-1-0)	05	20	25	

	MTM E 454A1	<i>One elective must be chosen.</i> Elective-I: Advanced Complex Analysis	2 (1-1-0)	05	20	25	
	MTM E 454A2	Elective-I: Machine Learning	2 (1-1-0)	05	20	25	
	MTM E 454B0	Elective-II: Stochastic Process and Statistical Methods	4 (3-1-0)	10	40	50	
	MTM E 455A1	<i>One elective must be chosen.</i> Elective-I: Integral Transforms	2 (1-1-0)	05	20	25	
	MTM E 455A2	Elective-I: Topology	2 (1-1-0)	05	20	25	
	MTM E 455B1	Elective-II: Differential Geometry	2 (1-1-0)	05	20	25	
	MTM E 455B2	Elective-II: Manifold Theory	2 (1-1-0)	05	20	25	
	MTM E 456A9	<i>One elective must be chosen.</i> Elective I: Hands-on Practical in Python	2 (0-0-4)	--	25	25	
	MTM E 456B9	Elective II: Hands-on Practical in C++	2 (0-0-4)	--	25	25	
		<b>Total</b>	<b>22</b>	<b>50</b>	<b>225</b>	<b>275</b>	
III	MTM O 501X0	MOOCs from SWAYAM	4 (3-1-0)	10	40	50	
	MTM C 502X0	Functional Analysis	4 (3-1-0)	10	40	50	
	MTM C 503X1	Integral Equation	2 (1-1-0)	05	20	25	
	MTM C 503X2	Cryptography	2 (1-1-0)	05	20	25	
	MTM E 504A0	<i>One elective must be chosen.</i> Elective-I: Advanced Optimization	4 (3-1-0)	10	40	50	
	MTM E 504B0	Elective-II: Dynamical Meteorology: Thermodynamics in Atmosphere	4 (3-1-0)	10	40	50	
	MTM E 504C0	Elective-III: Linear and Non-Linear Dynamical Systems	4 (3-1-0)	10	40	50	
	MTM E 505A0	<i>One elective must be chosen.</i> Elective-I: Operational Research Modeling-I	4 (3-1-0)	10	40	50	
	MTM E 505B0	Elective-II: Dynamical Oceanology: Advanced Wave Hydrodynamics	4 (3-1-0)	10	40	50	
	MTM E 505C0	Elective-III: Computational Fluid Dynamics	4 (3-1-0)	10	40	50	
	MTM O 506X0	Social Service / Community Engagement	2 (0-0-4)	--	25	25	
			<b>Total</b>	<b>22</b>	<b>50</b>	<b>225</b>	<b>275</b>

IV	MTM E 551A1	<i>One elective must be chosen.</i> Elective-I: Nonlinear Optimization (Theory)	2 (1-1-0)	05	20	25	
	MTM E 551A9	Elective-I: Nonlinear Optimization (Practical)	2 (0-0-4)	--	25	25	
	MTM E 551B1	Elective-II: Dynamical Meteorology: Dynamics in Atmosphere (Theory)	2 (1-1-0)	05	20	25	
	MTM E 551B9	Elective-II: Dynamical Meteorology: Dynamics in Atmosphere (Practical)	2 (0-0-4)	--	25	25	
	MTM E 551C1	Elective-III: Mathematical Modelling in Ecological Systems (Theory)	2 (1-1-0)	05	20	25	
	MTM E 551C9	Elective-III: Mathematical Modelling in Ecological Systems (Practical)	2 (0-0-4)	--	25	25	
	MTM E 552A1	<i>One elective must be chosen.</i> Elective-I: Operations Research Modelling-II (Theory)	2 (1-1-0)	05	20	25	
	MTM E 552A9	Elective-I: Operations Research Modelling-II (Practical)	2 (0-0-4)	--	25	25	
	MTM E 552B1	Elective-II: Dynamical Oceanology: Coastal Processes (Theory)	2 (1-1-0)	05	20	25	
	MTM E 552B9	Elective-II: Dynamical Oceanology: Coastal Processes (Practical)	2 (0-0-4)	--	25	25	
	MTM E 552C1	Elective-III: Computational and Semi-Analytical Methods (Theory)	2 (1-1-0)	05	20	25	
	MTM E 552C9	Elective-III: Computational and Semi-Analytical Methods (Practical)	2 (0-0-4)	--	25	25	
	MTM C 553X9	Research Project/Dissertation	8 (0-0-16)	--	100	100	
	MTM O 554X9	Field Visit	2 (0-0-4)	--	25	25	
	MTM O 555X9	Internship/Industry Project/Innovative Project	2 (0-0-4)	--	25	25	
	MTM O 556A0	<i>One elective must be chosen.</i> Elective-I: Intellectual Property Rights (IPR)	2 (1-1-0)	05	20	25	
	MTM O 556B0	Elective-II: Skill-Enhanced Course on <b>LaTeX</b>	2 (1-1-0)	05	20	25	
	<b>Total</b>			22	15	260	275
	<b>Grand Total</b>			88	170	380	550

CLASSIFICATION OF THE COURSES						
	MTM C 501X0	MOOC from SWAYAM Online Course*	4	15	35	50
	MTM O407NC	Life and Philosophy of Vidyasagar	--	05	20	25
ETHICS/HUMAN VALUES						
MTM C 403X0	Research Methodology and Ethics		4	10	40	50
MTM O407NC	Life and Philosophy of Vidyasagar		2	--	25	25
MTM O 506X0	Social Service / Community Engagement		2	--	25	25
MTM O406VC	Indian Knowledge System		2	05	20	25
INTELLECTUAL PROPERTY RIGHTS (IPR)						
MTM O556A0	Intellectual Property Rights (IPR)		2	05	20	25
SKILL DEVELOPMENT/JOB ORIENTED COURSES						
MTM E 405A0	Programming in Python		4	10	40	50
MTM E 405B0	Programming in C++		4	10	40	50
MTM E 456A9	Hands-on Practical in Python		2	--	25	25
MTM E 456B9	Hands-on Practical in C++		2	--	25	25
MTM E 551A9	Nonlinear Optimization (Practical)		2	--	25	25
MTM E 551B9	Dynamical Meteorology: Dynamics in Atmosphere (Practical)		2	--	25	25
MTM E 551C9	Mathematical Modelling in Ecological Systems (Practical)		2	--	25	25
MTM E 552A9	Operations Research Modelling-II (Practical)		2	--	25	25
MTM E 552B9	Dynamical Oceanology: Coastal Processes (Practical)		2	--	25	25
MTM E 552C9	Computational and Semi- Analytical Methods (Practical)		2	--	25	25
MTM E 553X9	Research Project/Dissertation		8	--	100	100
MTM O 555X9	Internship/Industry Project/Innovative Project		2	--	25	25
MTM O 556B0	Skill-Enhanced Course on LaTeX		2	05	20	25
EMPLOYABILITY COURSES						
MTM E 405A0	Programming in Python		4	10	40	50
MTM E 405B0	Programming in C++		4	10	40	50
MTM E 456A9	Hands-on Practical in Python		2	--	25	25
MTM E 456B9	Hands-on Practical in C++		2	--	25	25
MTM C 553X9	Research Project/Dissertation		8	--	100	100
MTM O 555X9	Internship/Industry Project/Innovative Project		2	--	25	25
MTM O 556B0	Skill-Enhanced Course on LaTeX		2	05	20	25
DIGITAL CONTENT COURSES						
MTM C 401X2	Complex Analysis		2	05	20	25
MTM C 402X1	Classical Mechanics		2	05	20	25
MTM C 403X0	Research Methodology and Ethics		4	10	40	50
MTM E 405A0	Elective-I: Programming in Python		4	10	40	50
MTM E 405B0	Elective-II: Programming in C++		4	10	40	50
MTM O406VC	Indian Knowledge System (IKS)		2	05	20	25

MTM O407NC	Life and Philosophy of Vidyasagar	Compulsory Non-credit	--	--	25
MTM E 454B0	Elective-II: Stochastic Process and Statistical Methods	4	10	40	50
MTM E 456A9	Elective I: Hands-on Practical in Python	2	05	20	25
MTM E 456B9	Elective II: Hands-on Practical in C++	2	05	20	25
MTM C 503X2	Cryptography	2	05	20	25
MTM E 505A0	Elective-I: Operational Research Modeling-I	4	10	40	50
MTM E 505C0	Elective-III: Computational Fluid Dynamics	4	10	40	50
MTM C 501X0	MOOCs from SWAYAM	4	10	40	50
MTM E 551A9	Elective-I: Nonlinear Optimization (Practical)	2	05	20	25
MTM E 551B9	Elective-II: Dynamical Meteorology: Dynamics in Atmosphere (Practical)	2	05	20	25
MTM E 551C9	Elective-III: Mathematical Modelling in Ecological Systems (Practical)	2	05	20	25
MTM E 552A9	Elective-I: Operations Research Modelling-II (Practical)	2	05	20	25
MTM E 552B9	Elective-II: Dynamical Oceanology: Coastal Processes (Practical)	2	05	20	25
MTM E 552C9	Elective-III: Computational and Semi-Analytical Methods (Practical)	2	05	20	25
<b>ENVIRONMENT/SUSTAINABILITY COURSES</b>					
MTM E 551B1	Dynamical Meteorology: Dynamics in Atmosphere	2	--	25	25
MTM E 552B9	Dynamical Oceanology: Coastal Processes	2	--	25	25
<b>GENDER AND RELATED COURSES</b>					

<b>NEW COURSES INTRODUCED</b>		
<b>COURSE CODE</b>	<b>COURSE NAME</b>	<b>YEAR OF INTRODUCTION</b>
MTM C 403X0	Research Methodology and Ethics	2025-26
MTM E 404B1	Elective II: Unit-I: Data Science	2025-26
MTM E 405A0	Elective-I: Programming in Python	2025-26
MTM E 405B0	Elective-II: Programming in C++	2025-26
MTM O 406VC	Indian Knowledge System (IKS)	2025-26
MTM O 407NC	Vidyasagar: Life and Philosophy	2025-26
MTM E 452B1	Elective-II: Calculus on $R^n$	2025-26
MTM E 452B2	Elective-II: Operator Theory	2025-26
MTM E 454A1	Elective-I: Unit-I: Advanced Complex Analysis	2025-26
MTM E 454A2	Elective-I: Unit-II: Machine Learning	2025-26
MTM E 455B1	Elective-II: Differential Geometry	2025-26
MTM E 455B2	Elective-II: Manifold Theory	2025-26
MTM E 456A9	Elective I: Hands-on Practical in Python	2025-26
MTM E 456B9	Elective II: Hands-on Practical in C++	2025-26
MTM C 501X0	MOOCs from SWAYAM	2025-26
MTM O 506X0	Social Service / Community Engagement	2025-26
MTM O 555X9	Internship/Industry Project/Innovative Project	2025-26
MTM O 556A0	Elective-I: Intellectual Property Rights (IPR)	2025-26
MTM O 556B0	Elective-II: Skill-Enhanced Course on <b>LaTeX</b>	2025-26

MODIFIED COURSES				
COURSE CODE	COURSE NAME	YEAR OF INTRODUCTION	YEAR OF REVISION	% OF TOTAL COURSES MODIFIED (NEW)
MTM C 401X1	Measure Theory	Before 2010	2025-26	50%
MTM C 402X1	Classical Mechanics	Before 2010	2025-26	50%
MTM E 404A0	Elective I: Ordinary Differential Equations	Before 2010	2025-26	10%
MTM C 451X1	Continuum Mechanics	Before 2010	2025-26	50%
MTM E 452A1	Elective-I: Unit-I: Fluid Mechanics	Before 2010	2025-26	60%
MTM E 454B0	Elective-II: Stochastic Process and Statistical Methods	Before 2010	2025-26	40%

GLOBAL/NATIONAL/REGIONAL/LOCAL RELAVENCE		
COURSE CODE	COURSE NAME	TYPE OF COURSE (GLOBAL/NATIONAL/REGION/LOCAL)
MTM C 401X1	Measure Theory	Global
MTM C 401X2	Complex Analysis	Global
MTM C 402X1	Classical Mechanics	Global
MTM C 402X2	Abstract Algebra	Global
MTM C 403X0	Research Methodology and Ethics	Global and National
MTM E 404A0	Elective-I: Ordinary Differential Equations	Global
MTM E 404B1	Elective-II: Data Science	Global
MTM E 404B2	Elective-II: Graph Theory	Global
MTM E 405A0	Elective-I: Programming in Python	Global and National
MTM E 405B0	Elective-II: Programming in C++	Global and National
MTM O 406VC	Indian Knowledge System (IKS)	National
MTM O 407NC	Life and Philosophy of Vidyasagar	Local
MTM C 451X1	Continuum Mechanics	Global
MTM C 451X2	Linear Algebra	Global
MTM E 452A1	Elective-I: Fluid Mechanics	Global
MTM E 452A2	Elective-I: MHD	Global
MTM E 452B1	Elective-II: Calculus on $R^n$	Global
MTM E 452B2	Elective-II: Operator Theory	Global
MTM E 453A0	Elective-I: Partial Differential Equations and Generalized Functions	Global
MTM E 453B1	Elective-II: Fuzzy Mathematics	Global
MTM E 453B2	Elective-II: Soft Computing	Global
MTM E 454A1	Elective-I: Advanced Complex Analysis	Global
MTM E 454A2	Elective-I: Machine Learning	Global
MTM E 454B0	Elective-II: Stochastic Process and Statistical Methods	Global
MTM E 455A1	Elective-I: Integral Transforms	Global
MTM E 455A2	Elective-I: Topology	Global
MTM E 455B1	Elective-II: Differential Geometry	Global
MTM E 455B2	Elective-II: Manifold Theory	Global
MTM E 456A9	Elective I: Hands-on Practical in Python	Global and National
MTM E 456B9	Elective II: Hands-on Practical in C++	Global and National
MTM C 501X0	MOOCs from SWAYAM	Global, National and Local

MTM C 502X0	Functional Analysis	Global
MTM C 503X1	Integral Equation	Global
MTM C 503X2	Cryptography	Global
MTM E 504A0	Elective-I: Advanced Optimization	Global
MTM E 504B0	Elective-II: Dynamical Meteorology: Thermodynamics in Atmosphere	Global, National and Local
MTM E 504C0	Elective-III: Linear and Non- Linear Dynamical Systems	Global
MTM E 505A0	Elective-I: Operational Research Modeling-I	Global and National
MTM E 505B0	Elective-II: Dynamical Oceanology: Advanced Wave Hydrodynamics	Global and National
MTM E 505C0	Elective-III: Computational Fluid Dynamics	Global
MTM O 506X0	Social Service / Community Engagement	Local
MTM E 551A1	Elective-I: Nonlinear Optimization (Theory)	Global
MTM E 551A9	Elective-I: Nonlinear Optimization (Practical)	Global
MTM E 551B1	Elective-II: Dynamical Meteorology: Dynamics in Atmosphere (Theory)	Global
MTM E 551B9	Elective-II: Dynamical Meteorology: Dynamics in Atmosphere (Practical)	Global, National and Local
MTM E 551C1	Elective-III: Mathematical Modelling in Ecological Systems (Theory)	Global and National
MTM E 551C9	Elective-III: Mathematical Modelling in Ecological Systems (Practical)	Global and National
MTM E 552A1	Elective-I: Operations Research Modelling-II (Theory)	Global and National
MTM E 552A9	Elective-I: Operations Research Modelling-II (Practical)	Global and National
MTM E 552B1	Elective-II: Dynamical Oceanology: Coastal Processes (Theory)	Global, National and Local
MTM E 552B9	Elective-II: Dynamical Oceanology: Coastal Processes (Practical)	Global, National and Local
MTM E 552C1	Elective-III: Computational and Semi-Analytical Methods (Theory)	Global
MTM E 552C9	Elective-III: Computational and Semi-Analytical Methods (Practical)	Global
MTM C 553X91	Research Project/Dissertation	National and Local
MTM O 554X9	Field Visit	Local
MTM O 555A0	Internship/Industry Project/Innovative Project	Local
MTM O 556A0	Elective-I: Intellectual Property Rights (IPR)	National and Local
MTM O 556B0	Elective-II: Skill-Enhanced Course on <b>LaTeX</b>	Global

# DETAILS OF THE COURSES

## SEMESTER-I

<b>Course code</b>	MTM C 401X1	<b>Measure Theory</b>	<b>Credit 2(1-1-0)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
<p>The main objectives of this course are:</p> <ol style="list-style-type: none"> <li>1. To introduce the fundamental concepts of measurable sets, measurable functions, and Lebesgue measure, and develop an understanding of their role in modern analysis.</li> <li>2. To provide a rigorous foundation of the Lebesgue integral, its properties, and its relationship with the Riemann integral.</li> <li>3. To equip students with convergence theorems and integration techniques essential for applications in pure and applied mathematics, particularly in analysis, probability, and functional spaces.</li> </ol>			
<b>Course Outcomes (COs):</b>			
<b>At the end of this course, students will be able to:</b>			
<b>CO1:</b> Understand the concepts of measurable sets, measurable functions, and Lebesgue measure, and analyze their properties including sets of measure zero and Borel sets.			
<b>CO2:</b> Apply the theory of Lebesgue integration, including simple functions, convergence theorems, and comparison with the Riemann integral, to evaluate and study integrals of measurable functions.			
<b>Syllabus:</b>			
<b>Course content</b>			<b>No. of Lectures</b>
Measurable sets, Measure, simple properties			3
Set of measure zero, Cantor set			2
Borel sets and their measurability, Measurable functions, continuity and measurability, Borel measurable functions, sequence of measurable functions			2
Simple functions and its properties, Integral of nonnegative measurable functions			5
Lebesgue integral on a measurable set: Definition, Basic properties			2
Lebesgue integral of a bounded function over a set of finite measure. Simple Properties			2
Comparison of Lebesgue and Riemann integral, Lebesgue criterion of Riemann Integrability			1
General Lebesgue integral			2
Bounded convergence theorem for a sequence of Lebesgue integrable functions, Fatou's lemma, Classical Lebesgue dominated convergence theorem. Monotone convergence theorem (Statement only)			1
<b>Total Lecture:</b>			<b>20 hours</b>
<b>Further Readings:</b>			
<b>Text Books:</b>			
<ol style="list-style-type: none"> <li>1. W. Rudin, Real and Complex Analysis, International Student Edition, McGraw-Hill.</li> <li>2. Inder K. Rana, An Introduction to Measure and Integration (2nd ed.), Narosa Publishing House, New Delhi.</li> </ol>			
<b>Reference Books:</b>			
<ol style="list-style-type: none"> <li>1. P.R. Halmos, Measure Theory, Graduate Text in Mathematics, Springer-Verlag.</li> <li>2. H.L. Royden, Real Analysis, 3rd ed., Macmillan.</li> </ol>			
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>			

### CO-PO-PSO Mapping (High/Medium/Low)

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	M	L	L	M	L	L	M	L	L	H	L	L	M
CO2	H	H	M	M	H	L	L	L	M	L	H	M	M	L

<b>Course code</b>	<b>MTM C 401X2</b>	<b>Complex Analysis</b>	<b>Credit 2(1-1-0)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
The main objectives of this course are:			
<ol style="list-style-type: none"> <li>To develop a deep understanding of the foundational results in complex analysis, including Cauchy's theorem, integral formulas, series expansions, and maximum modulus principles.</li> <li>To introduce the concepts of singularities, residues, poles, and multivalued functions, and to study their theoretical properties and implications.</li> <li>To equip students with analytical tools such as residue calculus, argument principle, and Rouché's theorem, enabling applications in evaluating integrals, infinite sums, and problems in applied mathematics.</li> </ol>			
<b>Course Outcomes (COs):</b>			
<b>Upon successful completion of this course, students will be able to:</b>			
<b>CO1:</b> Understand the concepts of measurable sets, measurable functions, and Lebesgue measure, and analyze their properties including sets of measure zero and Borel sets.			
<b>CO2:</b> Apply the theory of Lebesgue integration, including simple functions, convergence theorems, and comparison with the Riemann integral, to evaluate and study integrals of measurable functions.			
<b>Syllabus:</b>			
<b>Course content</b>			<b>No. of Lectures</b>
<b>Review of basic complex analysis:</b> Cauchy's theorem, primitives of analytic functions, Fundamental Theorem of Algebra, Cauchy's integral formula. Morer's theorem. Liouville's theorem. Taylor's series, Laurent's series. Maximum modulus principle.			Self Study
Definition of Homotopy, Homotopy version of Cauchy's theorem, Extension of Cauchy's Theorem to Multiply-Connected Regions			2
<b>Multiple valued function:</b> Definition, Branch point and branch cut			2
<b>Residues and Poles:</b> Isolated Singular Points, Residues, Cauchy's Residue Theorem, Residue at Infinity, The Three Types of Isolated Singular Points, Residues at Poles, Zeros of Analytic Functions, Zeros and Poles, Behavior of Functions Near Isolated Singular, Riemann's theorem, Schwarz's lemma, Casorati-Weierstrass's theorem,			5
<b>Application of Residues:</b> Evaluation of Improper Integrals, Improper Integrals from Fourier Analysis, Jordan's Lemma, Indented Paths, An Indentation Around a Branch Point, Integration along a Branch Cut, Definite Integrals Involving Sines and Cosines, other type of contour Integrations, Estimation of Infinite Sums			7
Winding number, Counting zeros Argument Principle, Rouché's Theorem.			4
<b>Total Lecture</b>			<b>20 hours</b>

**Further Readings:****Text Books:**

1. Complex Variable and Applications, J. W. Brown and R. V. Churchill, 8th Edition, McGraw-Hill.

**Reference Books:**

1. Foundations of Complex Analysis, S. Ponnusamy, Narosa, 1995.
  2. Functions of one Complex Variable, J. B. Conway, 2nd edition, Narosa, 1997.
- A Text Book of Complex Analysis, P.K.Nayek and M.R.Seikh, Universities Press, 2018

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]**

**CO-PO-PSO Mapping (High/Medium/Low)**

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	M	L	L	M	L	L	M	L	L	H	L	L	M
CO2	H	H	M	M	H	L	L	L	M	L	H	M	M	L

<b>Course code</b>	<b>MTM C 402X1</b>	<b>Classical Mechanics</b>	<b>Credit 2(1-1-0)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
The main objectives of this course are:			
<ol style="list-style-type: none"> <li>1. To provide a rigorous foundation of classical mechanics through generalized coordinates, constraints, and variational principles, leading to Lagrangian and Hamiltonian formulations.</li> <li>2. To introduce invariance transformations, conservation laws, canonical transformations, and Poisson brackets as essential tools in analytical dynamics.</li> <li>3. To develop a clear understanding of the postulates and mathematical framework of the Special Theory of Relativity, including Lorentz transformations and relativistic dynamics.</li> </ol>			
<b>Course Outcomes (COs):</b>			
<b>Upon successful completion of this course, students will be able to:</b>			
<b>CO1:</b> Understand the principles of motion of a system of particles, constraints, Lagrange's and Hamilton's equations, variational principles, and the derivation of equations of motion for holonomic and non-holonomic systems.			
<b>CO2:</b> Apply the concepts of invariance transformations, conservation laws, Poisson brackets, and the special theory of relativity, including Lorentz transformations and relativistic force and energy equations, to solve physical problems.			
<b>Syllabus:</b>			
<b>Course content</b>			<b>No. of Lectures</b>
Motion of a system of particles. Constraints. Generalized coordinates. Holonomic and non-holonomic systems. Principle of virtual work. D'Alembert's Principle.			4
Lagrange's equations, Hamiltonian. Hamilton's equations. Cyclic coordinates. Routhian equation.			4
Principle of stationary action, Principle of least action, Hamilton's principle. Variational principle, Brachistochrone problem. Lagrange's equations from Hamilton's principle.			4

Invariance transformations. Conservation laws. Space-time transformations. Canonical transformations. Liouville's theorem.	2
Poisson bracket.	2
The special theory of relativity: Postulates of special relativity. Lorentz transformation. Consequences of Lorentz transformation. Force and energy equations	4
<b>Total Lecture</b>	<b>20 hours</b>
<b>Further Readings:</b>	
<b>Text Books:</b>	
1. Goldstein, H. (1950) Classical Mechanics, Addison-Wesley, Cambridge.	
2. Pal, M. (2009) A Course on Classical Mechanics, Narosa, New Delhi, & Alpha Science, Oxford, London.	
<b>Reference Books:</b>	
1. Gupta, A.S. (2005) Calculus of Variations with Applications, Prentice-Hall of India, New Delhi.	
2. Gupta, B.D. and Prakash, S. (1985) Classical Mechanics, Kedar Nath Ram Nath, Meerut.	
3. Kibble, T.W.B. (1985) Classical Mechanics, Orient Longman, London.	
4. Rana, N.C. and Joag, P.S. (2004) Classical Mechanics, Tata McGraw-Hill Publishing Company Limited, New Delhi.	
5. Symon, K.R. (1971) Mechanics, Addison-Wesley Publ. Co., Inc., Massachusetts.	
6. Takwale, R.G. and Puranik, S. (1980) Introduction to Classical Mechanics, Tata McGraw-Hill Publ. Co. Ltd., New Delhi.	
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>	
1. On SWAYAM MOOC <a href="https://onlinecourses.swayam2.ac.in/ini24_ph02/preview">https://onlinecourses.swayam2.ac.in/ini24_ph02/preview</a>	
2. On SWAYAM NPTEL <a href="https://onlinecourses.nptel.ac.in/noc20_ph17/preview">https://onlinecourses.nptel.ac.in/noc20_ph17/preview</a>	

### CO-PO-PSO Mapping (High/Medium/Low)

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	H	L	L	L	M	L	H	M	M	L
CO2	H	H	M	M	H	L	L	L	M	L	H	M	M	L

<b>Course code</b>	<b>MTM C 402X2</b>	<b>Abstract Algebra</b>	<b>Credit 2(1-1-0)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
The main objectives of this course are:			
1. To study the structure and properties of polynomial rings, integral domains, and factorization concepts, with emphasis on unique factorization, Euclidean domains, and principal ideal domains.			
2. To develop an understanding of group-theoretic concepts such as normal and subnormal series, solvability, and their role in algebraic structures.			
3. To explore field extensions, both finite and algebraic, and their applications to classical problems such as ruler and compass constructions.			

**Course Outcomes (COs):**

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

**CO1:** Understand the structure of polynomial rings, divisibility in integral domains, and concepts of unique factorization, Euclidean domains, and principal ideal domains.

**CO2:** Analyze advanced algebraic structures through solvable groups and field extensions, and apply these concepts to classical problems such as ruler and compass constructions.

**Syllabus:**

Course content	No. of Lectures
Polynomial rings over commutative rings, division algorithm and consequences, Eisenstein criterion, and unique factorization in $\mathbb{Z}[x]$	6
Divisibility in integral domains, Unique factorisation domain, Euclidean domain.	5
Principal ideal domain	
Normal series, subnormal series, solvable series, and solvable groups.	4
Field extensions: finite, algebraic, and finitely generated extensions; Classical ruler and compass constructions.	5
<b>Total Lecture</b>	<b>20 hours</b>

**Further Readings:****Text Books:**

1. D. S. Dummit and R. M. Foote, Abstract Algebra, 2nd Edition, John Wiley, 1999.
2. J.A. Gallian, Contemporary Abstract Algebra, 9<sup>th</sup> Edition, Narosa, 2017.

**Reference Books:**

1. M. Artin, Algebra, 2nd Edition, Prentice Hall of India, 2011.
2. N. Jacobson, Basic Algebra, 2nd Edition, Hindustan Publishing Co., 2009.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]****CO-PO-PSO Mapping (High/Medium/Low)**

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	M	L	L	M	L	L	L	M	L	H	L	L	L
CO2	H	H	M	M	H	L	L	L	M	L	H	M	M	M

<b>Course code</b>	<b>MTM C 403X0</b>	<b>Research Methodology and Ethics</b>	<b>Credit 4(3-1-0)</b> <b>Full Marks 50</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>

**Course Objectives:**

The main objectives of this course are:

1. To introduce the fundamental concepts, characteristics, and types of research, and to distinguish between research methods and methodology.
2. To develop the ability to identify and formulate research problems, review literature critically, and frame appropriate research questions and hypotheses.
3. To equip students with knowledge of research design, data collection methods, sampling techniques, and proposal writing skills.
4. To cultivate ethical awareness in research by emphasizing research integrity, academic

honesty, and responsible conduct in data handling and publication.	
5. To familiarize students with research metrics, publication ethics, and modern tools for evaluating the quality and impact of research.	
<b>Course Outcomes (COs):</b>	
<b>Upon successful completion of this course, students will be able to:</b>	
<b>CO1:</b> Understand the fundamental concepts of research, including types of research, research problems, hypothesis formulation, and the research process.	
<b>CO2:</b> Apply research design principles, data collection methods, and sampling techniques to conduct effective and systematic research.	
<b>CO3:</b> Develop skills to review literature, write research proposals, and integrate research findings into coherent reports or projects.	
<b>CO4:</b> Demonstrate knowledge of research ethics, publication ethics, privacy and confidentiality, and evaluate research impact using appropriate metrics.	
<b>Syllabus:</b>	
<b>Course content</b>	<b>No. of Lectures</b>
<b>Basics of Research</b> Definition, importance, and characteristics of research; distinction between method and methodology; types of research – basic, applied, qualitative, quantitative, descriptive, analytical, experimental.	4
<b>Research Problem and Literature Review</b> Identification and formulation of research problem; research questions and objectives; survey of literature – importance, sources, and research gaps.	3
<b>Hypothesis and Research Process</b> Hypothesis – meaning, role, and types (null, alternative, simple, complex, directional, causal); research process – steps from problem identification to report writing.	3
<b>Research Design and Plan</b> Research design – meaning, significance, and types (exploratory, descriptive, analytical, experimental); developing a research plan – statement of problem, objectives, methodology, data plan, timeline, budget. S	3
<b>Data and Data Collection</b> Types of data – primary and secondary; sources of data; methods of data collection – observation, interview, questionnaire, case study, experiment, content analysis.	3
<b>Sampling Methods</b> Concept of sampling; probability sampling – simple random, stratified, cluster, systematic; non-probability sampling – purposive, convenience, quota, snowball.	2
<b>Reviewing and Proposal Writing</b> Reviewing articles – analysis of objectives, methodology, findings; writing a research proposal – title, abstract, problem statement, literature review, methodology, outcomes, references.	2
<b>Integration and Wrap-up</b> Case discussions and practice on research problems, article reviews, and proposals; recap and integration of the research process.	2
<b>Research Ethics</b>	
<b>Introduction to Ethics</b> Definition, nature, and scope of ethics; different branches of ethics; importance of ethics in research and academic life.	3

<b>Research Ethics</b> Meaning and significance; responsibilities of researchers towards fellow researchers, public, and academic community; concept of academic integrity.	3
<b>Ethical Judgments and Scientific Misconduct</b> Ethical judgments in research: scientific misconduct – falsification, fabrication, plagiarism; redundant, duplicate, and overlapping publications; salami slicing; selective reporting; misrepresentation of data.	4
<b>Privacy and Confidentiality</b> Concepts of privacy, autonomy, confidentiality, and anonymity in research; ethical handling of sensitive data.	2
<b>Publication Ethics</b> Definition and importance of publication ethics; publication misconduct; conflict of interest; authorship issues; responsibilities of editors, reviewers, and publishers.	4
<b>Research Metrics</b> Overview of research metrics; impact factor, h-index, g-index, i10-index; altmetrics and their role in evaluating research impact.	4
<b>Total Lecture</b>	<b>40 hours</b>
<b>Further Readings:</b>	
<b>Research methodology</b>	
<ol style="list-style-type: none"> <li>1. Kothari, C. R., &amp; Garg, G. (2019). <i>Research Methodology: Methods and Techniques</i> (4th ed.). New Age International Publishers.</li> <li>2. Kumar, R. (2019). <i>Research Methodology: A Step-by-Step Guide for Beginners</i> (5th ed.). Sage Publications.</li> <li>3. Creswell, J. W., &amp; Creswell, J. D. (2018). <i>Research Design: Qualitative, Quantitative, and Mixed Methods Approaches</i> (5th ed.). Sage Publications.</li> <li>4. Saunders, M., Lewis, P., &amp; Thornhill, A. (2019). <i>Research Methods for Business Students</i> (8th ed.). Pearson Education.</li> <li>5. Bougie, R. &amp; Sekaran, U., (2019). <i>Research Methods for Business: A Skill-Building Approach</i> (8th ed.). Wiley.</li> <li>6. Walliman, N. (2017). <i>Research Methods: The Basics</i> (2nd ed.). Routledge.</li> <li>7. Punch, K. F. (2014). <i>Introduction to Social Research: Quantitative and Qualitative Approaches</i> (3rd ed.). Sage Publications.</li> </ol>	
<b>Research ethics</b>	
<ol style="list-style-type: none"> <li>1. Academic Integrity and Research Quality, University Grants Commission Bahadur Shah Zafar Marg New Delhi, December 2021.</li> <li>2. Resnik, D. B. (2020). <i>The Ethics of Research with Human Subjects: Protecting People, Advancing Science, Promoting Trust</i>. Springer.</li> <li>3. Shamoo, A. E., &amp; Resnik, D. B. (2015). <i>Responsible Conduct of Research</i> (3rd ed.). Oxford University Press.</li> <li>4. COPE (Committee on Publication Ethics). (2017). <i>Code of Conduct and Best Practice Guidelines for Journal Editors</i>. <a href="https://publicationethics.org/membership/code-of-conduct">https://publicationethics.org/membership/code-of-conduct</a></li> <li>5. American Psychological Association. (2020). <i>Publication Manual of the American Psychological Association</i> (7th ed.). APA.</li> <li>6. Steneck, N. H. (2007). <i>ORI Introduction to the Responsible Conduct of Research</i>. Office of Research Integrity, U.S. Department of Health &amp; Human Services.</li> <li>7. Wager, E., &amp; Kleinert, S. (2011). <i>Responsible Research Publication: International Standards for Authors</i>. In Mayer, T., &amp; Steneck, N. (Eds.), <i>Promoting Research Integrity in a Global</i></li> </ol>	

*Environment* (pp. 309–316). World Scientific.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]**

### CO-PO-PSO Mapping (High/Medium/Low)

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	L	H	M	M	L	M	M	L	H	L	H	M
CO2	H	H	M	H	H	M	L	M	M	L	H	M	H	M
CO3	H	H	M	H	H	H	M	M	M	L	H	M	H	M
CO4	H	M	L	H	M	H	L	H	M	L	H	L	M	H

<b>Course code</b>	<b>MTM E 404A0</b>	<b>Elective-I: Ordinary Differential Equations</b>	<b>Credit 4(3-1-0)</b> <b>Full Marks 50</b>
<b>Core/Elective/Other</b>		<b>Elective</b>	<b>Anyone from two Electives</b>
<p><b>Course Objectives:</b> The main objectives of this course are:</p> <ol style="list-style-type: none"> <li>1. To develop a deep understanding of eigenvalue problems and Sturm–Liouville theory, including their properties, applications to boundary value problems, and expansion theorems.</li> <li>2. To introduce the concept of Green’s functions and their role in solving ordinary differential equations and boundary value problems.</li> <li>3. To study systems of linear differential equations, their matrix representation, existence and uniqueness of solutions, and the use of the Wronskian.</li> <li>4. To explore series solutions of differential equations, including Frobenius method, hypergeometric and confluent hypergeometric functions, with emphasis on their analytical properties and applications.</li> <li>5. To understand special functions such as Legendre and Bessel functions, their generating functions, orthogonality properties, recurrence relations, and integral representations in mathematical physics.</li> </ol> <p><b>Course Outcomes (COs)</b> Upon successful completion of this course, students will be able to:</p> <p><b>CO1:</b> Understand the theory of Sturm–Liouville problems, eigenvalues and eigenfunctions, and apply orthogonality and expansion theorems to boundary value problems.</p> <p><b>CO2:</b> Comprehend Green’s functions, their properties, and utilize them to solve ordinary differential equations and boundary value problems.</p> <p><b>CO3:</b> Analyze systems of linear differential equations, homogeneous linear differential equations, and solutions near singularities, including the use of the Frobenius method.</p> <p><b>CO4:</b> Understand and apply special functions, including hypergeometric, Legendre, and Bessel functions, their series and integral representations, generating functions, and recurrence relations for solving physical and engineering problems.</p>			
<b>Syllabus:</b>			
<b>Course content</b>			<b>No. of Lectures</b>
<p><b>Eigen Value Problem:</b> Ordinary differential equations of the Sturm-Liouville type, Properties of Sturm Liouville type, Application to Boundary Value Problems, Eigen values and Eigen functions, Orthogonality theorem, Expansion theorem.</p>			5

<b>Green's Function:</b> Green's Function and its properties, Green's function for ordinary differential equations, Application to Boundary Value Problems.	5
<b>System of Linear Differential Equations:</b> Systems of First order equations and the Matrix form, Representation of nth order equations as a system, Existence and uniqueness of solutions of system of equations, Wronskian of vector functions.	6
<b>Differential Equation:</b> Homogeneous linear differential equations, Fundamental system of integrals, Singularity of a linear differential equation, Solution in the neighborhood of a singularity, Regular integral, Equation of Fuchsian type, Series solution by Frobenius method.	5
<b>Hypergeometric Equation.</b> Hypergeometric functions, Series solution near zero, one and infinity, Integral formula for the hypergeometric function, Differentiation of hypergeometric function, The confluent hypergeometric function, Integral representation of confluent hypergeometric function.	6
<b>Legendre Equation:</b> Legendre functions, Generating function, Legendre functions of first kind and second kind, Laplace integral, Orthogonal properties of Legendre polynomials, Rodrigue's formula, Schlaefli's integral.	8
<b>Bessel Equation:</b> Bessel function, Series solution of Bessel equation, Generating function, Integrals representations of Bessel's functions, Hankel functions, Recurrence relations, Asymptotic expansion of Bessel functions.	5
<b>Total Lecture</b>	<b>40 hours</b>
<b>Further Readings:</b>	
<b>Text Books:</b>	
1. G.F. Simmons: Differential Equations, TMH Edition, New Delhi, 1974.	
2. S.L. Ross: Differential Equations (3rd edition), John Wiley & Sons, New York, 1984.	
<b>Reference Books:</b>	
1. M.S.P. Eastham: Theory of Ordinary Differential Equations, Van Nostrand, London, 1970.	
2. M. Braun: Differential Equations and Their Applications; An Introduction to Applied Mathematics, 3 <sup>rd</sup> Edition, Springer-Verlag.	
3. E.D. Rainville and P.E. Bedient: Elementary Differential Equations, McGraw Hill, New York, 1969.	
4. E.A. Coddington and N. Levinson: Theory of ordinary differential equations, McGraw Hill, 1955.	
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>	

### CO-PO-PSO Mapping (High/Medium/Low)

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	H	L	L	L	M	L	H	M	M	L
CO2	H	H	M	M	H	L	L	L	M	L	H	M	M	L
CO3	H	H	M	M	H	L	L	L	M	L	H	M	M	L
CO4	H	H	M	M	H	L	L	L	M	L	H	M	M	L

<b>Course code</b>	<b>MTM E 404B1</b>	<b>Elective-II: Unit-I: Data Science</b>	<b>Credit 2(1-1-0)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>		<b>Elective</b>	<b>Anyone from two Electives</b>

**Course Objectives:**

The main objectives of this course are:

1. To provide a foundational understanding of data science concepts, life cycle, and mathematical tools including topology of data, distance functions, and dimension reduction techniques.
2. To develop knowledge of probability, statistical methods, and hypothesis testing essential for data analysis and interpretation.
3. To introduce classification methods, data visualization techniques, and modern data science tools (Python, R, Pandas, NumPy) for practical applications.

**Course Outcomes (COs):**

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

**CO1:** Understand the fundamental concepts of Data Science, including data representation, probability, statistics, visualization, and basic classification methods.

**CO2:** Apply essential tools such as Python, R, Pandas, and NumPy to analyze data, perform visualization, and implement classification and dimensionality reduction techniques.

**Syllabus:**

Course content	No. of Lectures
Data Science – Introduction, Brief history of data science, Data science life cycle, Topology of data, Distance function, Euclidean space, Euclidean Norm, Distance between two points in 2D, 3D, and extension to $n$ dimensions.	2
Quadratic function, Maxima, minima, Saddle points, vertex, slope, Principal Component Analysis and Dimension Reduction.	2
Basic concept of probability, Bayes' theorem, Distributions: Uniform, Gaussian, Student's $t$ , Chi-square.	3
Sample statistics such as mean, median, mode, variance, standard deviations, correlation, regression, parametric and non-parametric tests.	2
Frequency plot, box plots, concepts of quartile, whisker, outlier, parity plot, normal probability plot.	2
Classification: Metrics, Bayes' Rule, Linear and Quadratic Discriminant Analysis, K-Nearest Neighbours, Classification with Scikit-learn.	2
Data visualization techniques: Plotting Qualitative and Quantitative Variables, Data visualization in a Bivariate Setting.	4
Data Science Tools: Python, R, Pandas, NumPy	3
<b>Total Lecture</b>	<b>20 hours</b>

**Further Readings:****Text Books:**

1. James, G., Witten, D., Hastie, T., & Tibshirani, R. *An Introduction to Statistical Learning with Applications in R*. Springer.
2. Rajaraman, A., & Ullman, J. D. *Mining of Massive Datasets*. Cambridge University Press.

**Reference Books:**

1. Hastie, T., Tibshirani, R., & Friedman, J. *The Elements of Statistical Learning*. Springer.  
McKinney, W. *Python for Data Analysis*. O'Reilly Media.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]****CO-PO-PSO Mapping (High/Medium/Low)**

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	H	L	L	L	M	L	H	M	M	L
CO2	H	H	H	M	H	M	L	L	M	L	H	H	M	L

<b>Course code</b>	<b>MTM E 404B2</b>	<b>Elective-II: Unit-II: Graph Theory</b>	<b>Credit 2(1-1-0)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Elective</b>		<b>Anyone from two Electives</b>

### Course Objectives:

The main objectives of this course are:

1. To introduce the fundamental concepts of graph theory including paths, cycles, connectivity, trees, and special classes of graphs.
2. To study graph properties such as colouring, planarity, matching, and matrix representations, along with their theoretical significance.
3. To develop problem-solving skills through graph algorithms and explore applications of graphs in optimization problems such as shortest path, spanning trees, and the traveling salesman problem.

### Course Outcomes (COs):

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

**CO1:** Understand the fundamental concepts of graph theory, including paths, cycles, connectivity, trees, planar and directed graphs, and graph coloring.

**CO2:** Apply graph algorithms, matrix representations, and graph-theoretic techniques to solve problems such as shortest path, spanning trees, traveling salesman problem, and intersection graphs.

### Syllabus:

Course content	No. of Lectures
Basic graph theoretical concepts.	2
Paths and cycles.	1
Connectivity, trees, spanning subgraphs, bipartite graphs, Hamiltonian and Euler cycles.	2
Distance and centre.	2
Cut sets and cut vertices.	2
Colouring and matching. Four colour theorem (statement only). Chromatic Polynomial.	3
Planar graphs, Dual graph. Directed graphs and weighted graphs.	2
Matrix representation of graphs	2
Algorithms for shortest path and spanning trees, Applications of graphs in traveling salesman problem	2
Intersection graph	2

**Total Lecture**

**20 hours**

### Further Readings:

#### Text Books:

1. Deo, N. (2017). Graph theory with applications to engineering and computer science. PHI Limited, New Delhi, 1979.
2. West, D. B. (2001). Introduction to graph theory, Upper Saddle River: Prentice hall.

#### Reference Books:

1. Chartrand, G. (2006). Introduction to graph theory. Tata McGraw-Hill Education.
3. Gross, J. L., & Yellen, J. (2005). Graph theory and its applications. CRC Press.

### CO-PO-PSO Mapping (High/Medium/Low)

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	M	L	L	M	L	L	L	M	L	H	M	L	M
CO2	H	H	H	M	H	L	L	L	M	L	H	H	M	M

Course code	MTM E 405A0	Elective-I: Programming in Python	Credit 4(3-1-0) Full Marks 50
Core/Elective/Other		Elective	Anyone from two Electives

#### Course Objectives:

The main objectives of this course are:

1. To introduce the fundamental concepts of Python programming, including data types, variables, expressions, operators, and functions.
2. To develop problem-solving skills using flow control structures such as conditionals, loops, and recursion.
3. To provide knowledge of Python data structures including strings, arrays, lists, tuples, and dictionaries, along with their operations and applications.
4. To familiarize students with essential programming practices such as file handling, debugging, and error management in Python.
5. To introduce object-oriented programming in Python through classes, objects, attributes, and methods, emphasizing mutability and reusability of code.

#### Course Outcomes (COs):

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

**CO1:** Understand the fundamentals of Python programming, including data types, variables, expressions, statements, and functions with proper scope and recursion.

**CO2:** Apply flow control constructs, loops, and conditional statements to develop efficient Python programs for problem-solving.

**CO3:** Utilize Python data structures such as strings, arrays, lists, tuples, and dictionaries, along with file handling and debugging techniques, to write robust programs.

**CO4:** Design and implement classes and objects, including programmer-defined types, attributes, methods, and practical applications, demonstrating object-oriented programming concepts.

#### Syllabus:

Course content	No. of Lectures
<b>Python Basics:</b> Introduction to Python and installation, data types: Int, float, Boolean, string, and list; variables, expressions, statements, precedence of operators, comments; modules, functions and its use, flow of execution, parameters and arguments.	6
<b>Flow control:</b> Boolean values and operators, conditional (if), alternative (if-else), chained conditional (if-elif-else); Iteration: while, for, break, continue.	6
<b>Functions and Array:</b> def Statements with Parameters, return values, parameters, local and global scope, function composition, recursion; Strings, string slices, immutability, string functions and methods, string module; Python arrays, Access the Elements of an Array, array methods.	6
<b>Lists, Tuples, Dictionaries:</b> <b>Lists:</b> list operations, list slices, list methods, list loop, mutability, aliasing, cloning lists, list parameters, list comprehension; <b>Tuples:</b> tuple assignment, tuple as return value, tuple comprehension; <b>Dictionaries:</b> operations	6

and methods, comprehension.	
<b>Reading and Writing Files:</b> Files and File Paths, The os.path Module, The File Reading/Writing Process, Saving Variables with the shelve Module, Saving Variables with the print.format() Function.	5
<b>Debugging:</b> Raising Exceptions, Getting the Traceback as a String, Assertions, Logging, IDLE's Debugger.	5
<b>Classes and objects:</b> Programmer-defined types, Attributes, Rectangles, Instances as return values, Objects are mutable, Copying.	6
<b>Total Lecture</b>	<b>40 hours</b>
<b>Further Readings:</b> <b>Text Books:</b> <ol style="list-style-type: none"> <li>Ramalho, Luciano. Fluent Python: Clear, concise, and effective programming. "O'Reilly Media, Inc.", 2015.</li> <li>Lutz, Mark. Learning python: Powerful object-oriented programming. "O'Reilly Media, Inc.", 2013</li> </ol> <b>Reference Books:</b> <ol style="list-style-type: none"> <li>Fhrer, Claus, Jan Erik Solem, and Olivier Verdier. Computing with Python. Pearson Education, 2013.</li> <li>Summerfield, Mark. Programming in Python 3: a complete introduction to the Python language. Addison-Wesley Professional, 2010.</li> </ol>	
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>	

### CO-PO-PSO Mapping (High/Medium/Low)

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	H	L	L	L	M	L	H	M	M	L
CO2	H	H	H	M	H	L	L	L	M	L	H	H	M	L
CO3	H	H	H	M	H	M	L	L	M	L	H	H	M	L
CO4	H	H	H	M	H	M	L	L	M	L	H	H	M	L

<b>Course code</b>	<b>MTM E 405B0</b>	<b>Elective-II: Programming in C++</b>	<b>Credit 4(3-1-0)</b> <b>Full Marks 50</b>
<b>Core/Elective/Other</b>	<b>Elective</b>		<b>Anyone from two Electives</b>
<b>Course Objectives:</b> The main objectives of this course are: <ol style="list-style-type: none"> <li>To introduce the fundamentals of C++ programming, including data types, operators, variables, expressions, and basic input/output.</li> <li>To develop problem-solving skills using control structures such as conditional statements, loops, and recursion.</li> <li>To provide knowledge of C++ functions, arrays, strings, vectors, pointers, and dynamic memory management for computational applications.</li> <li>To introduce object-oriented programming concepts including classes, objects, constructors, destructors, inheritance, polymorphism, and operator overloading.</li> <li>To familiarize students with file handling and the Standard Template Library (STL) for implementing efficient and reusable code in mathematical and real-world problems.</li> </ol>			

<b>Course Outcomes (COs):</b>	
<p>Upon successful completion of this course, students will be able to:</p> <p><b>CO1:</b> Understand the fundamentals of C++ programming, including data types, variables, operators, control structures, and functions with proper scope and recursion.</p> <p><b>CO2:</b> Apply arrays, strings, vectors, pointers, and dynamic memory allocation to develop efficient programs for mathematical and computational problems.</p>	
<p><b>CO3:</b> Design and implement classes and objects, including constructors, destructors, and object-oriented programming concepts such as inheritance, polymorphism, and operator overloading.</p> <p><b>CO4:</b> Utilize file handling and the Standard Template Library (STL) to manage data and implement mathematical and algorithmic solutions effectively.</p>	
<b>Syllabus:</b>	
<b>Course content</b>	<b>No. of Lectures</b>
<p><b>Introduction to C++</b> Overview of C++ and its features; basic structure of a C++ program; compilation and execution; input/output using <code>cin</code> and <code>cout</code>; comments; data types – int, float, double, char, bool; variables, constants, and literals; arithmetic and relational operators; operator precedence; typecasting.</p>	5
<p><b>Control Structures</b> Conditional statements – if, if-else, nested if, if-else-if ladder, switch-case; loops – for, while, do-while; loop control statements – break, continue; nested loops; examples with mathematical problems.</p>	5
<p><b>Functions and Recursion</b> Defining and calling functions; function arguments – pass by value and pass by reference; return values; scope of variables – local and global; recursion; function overloading; inline functions; mathematical examples using functions.</p>	5
<p><b>Arrays, Strings, and Vectors</b> One-dimensional and two-dimensional arrays – declaration, initialization, and operations; string handling using C-style strings and <code>std::string</code>; introduction to vectors; operations on vectors; examples using mathematical sequences and matrices.</p>	5
<p><b>Pointers and Dynamic Memory</b> Concept of pointers; pointer arithmetic; pointers and functions; dynamic memory allocation using <code>new</code> and <code>delete</code>; arrays and pointers; examples related to matrices and arrays.</p>	5
<p><b>Class and Objects</b> Introduction to classes and objects; defining classes; data members and member functions; access specifiers – private, public, protected; constructors and destructors; <code>this</code> pointer; object creation and usage; examples from mathematical structures (e.g., complex numbers, matrices).</p>	5
<p><b>Overloading and File Handling</b> Function overloading and operator overloading; inheritance – single and multiple; polymorphism and virtual functions; friend functions and classes; static members; file input/output – reading and writing text files; <code>fstream</code>, <code>ifstream</code>, <code>ofstream</code>; simple examples using mathematical applications.</p>	5
<p><b>Standard Template Library</b> Introduction to STL – vector, list, stack, queue, map; basic operations; examples using STL for mathematical problems; recap and integrated exercises.</p>	5
<b>Total Lecture</b>	<b>40 hours</b>

**Further Readings:****Textbooks**

1. Malik, D. S. *C++ Programming: From Problem Analysis to Program Design*. Cengage Learning.
2. Kanetkar, Y. P. *Let Us C++*. BPB Publications.

**Reference Books**

1. Lafore, R. *Object-Oriented Programming in C++*. Sams Publishing.
2. Stroustrup, B. *The C++ Programming Language*. Addison-Wesley.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]**

**CO-PO-PSO Mapping (High/Medium/Low)**

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	H	L	L	L	M	L	H	M	M	L
CO2	H	H	H	M	H	L	L	L	M	L	H	H	M	L
CO3	H	H	H	M	H	M	L	L	M	L	H	H	M	L
CO4	H	H	H	M	H	M	L	L	M	L	H	H	M	L

<b>Course code</b>	<b>MTM O 406VC</b>	<b>Indian Knowledge System (IKS)</b>	<b>Credit 2(1-1-0)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Other</b>		<b>Compulsory</b>

**Course Objectives:**

The main objectives of this course are:

1. To introduce students to the philosophical and historical foundations of Indian mathematical traditions and their epistemological context within the Indian Knowledge System.
2. To explore major sources such as the *Sulba Sutras*, *Vedanga Jyotisha*, and *Lilavati* to understand ancient methods of computation, algebra, and geometry.
3. To develop an appreciation of the continuity, applications, and pedagogical relevance of ancient Indian mathematical concepts in modern mathematics education.

**Course Outcomes (COs):**

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

**CO1:** Understand and analyze the philosophical foundations and historical evolution of mathematical thought in ancient India, including the concept of *Ganita* and its educational significance.

**CO2:** Apply ancient Indian mathematical principles—arithmetic, algebraic, geometric, and trigonometric—to appreciate their continuity and influence on modern mathematical concepts and pedagogy.

**Syllabus:**

Course content	No. of Lectures
<b>Foundations of Indian Knowledge System (IKS)</b> Overview of Indian Knowledge Traditions and Philosophy of Mathematics, Concept of <i>Ganita</i> and its role in Vedic and classical education Sources: <i>Sulba Sutras</i> , <i>Vedanga Jyotisha</i> , and <i>Lilavati</i>	4
<b>Number Systems and Arithmetic Traditions</b> Place value system and development of zero, Operations with integers and fractions in ancient Indian texts, Early algorithms and computational methods	4

<b>Algebra and Geometry in Ancient India</b> Quadratic, indeterminate, and Diophantine equations in <i>Brahmasphutasiddhanta</i> Geometric constructions and approximations in <i>Sulba Sutras</i> Pythagorean triples and the concept of irrational numbers	4
<b>Trigonometry, Series, and Calculus Precursors</b> Contributions of Kerala School: Madhava, Nilakantha, and Jyesthadeva Infinite series for $\pi$ , sine, and cosine, Continuities between Indian and modern calculus concepts	4
<b>Applications, Pedagogical Insights, and Modern Relevance</b> Integration of IKS in modern mathematical education, Comparative study: Indian vs. Greek mathematical traditions, Ethical and philosophical dimensions of mathematical knowledge	4
<b>Total Lecture</b>	<b>20 hours</b>
<b>Further Readings:</b> <b>Textbooks</b> <ol style="list-style-type: none"> <li>1. <i>Lilavati</i> by Bhāskara II</li> <li>2. <i>Brahmasphutasiddhanta</i> by Brahmagupta</li> <li>3. <i>Aryabhatiya</i> by Aryabhata</li> <li>4. <i>Yuktibhasa</i> by Jyesthadeva</li> </ol> <b>Reference Books</b> <ol style="list-style-type: none"> <li>1. Datta, B. &amp; Singh, A.N. <i>History of Hindu Mathematics</i>, Asia Publishing House.</li> <li>2. Sarasvati Amma, T.A. <i>Geometry in Ancient and Medieval India</i>, Motilal Banarsidass.</li> <li>3. Joseph, G.G. <i>The Crest of the Peacock: Non-European Roots of Mathematics</i>, Penguin.</li> <li>4. Sen, S.N. &amp; Bag, A.K. <i>The Sulba Sutras</i>, Indian National Science Academy.</li> <li>5. Rajesh Kochhar, <i>Explorations in Indian Science: From Vedic to Modern Times</i>, NBT India</li> </ol>	
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>	

### CO-PO-PSO Mapping (High/Medium/Low)

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	M	L	M	M	H	L	H	M	L	H	L	L	H
CO2	H	H	M	M	H	M	L	H	M	M	H	H	M	H

<b>Course code</b>	<b>MTM O 407NC</b>	<b>Life and Philosophy of Vidyasagar</b>	<b>Non-Credit Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Other</b>		<b>Compulsory</b>

#### Course Objectives:

The main objectives of this course are:

To introduce students to the life, education, and socio-cultural context of Ishwar Chandra Vidyasagar.

To study Vidyasagar's contributions to education, social reform, literature, and women's empowerment.

To analyze Vidyasagar's philosophical principles of rationalism, humanitarianism, and social justice, and their relevance to contemporary society.

**Course Outcomes (COs):**  
 Upon successful completion of this course, students will be able to:  
**CO1:** Understand the life, education, and historical context of Ishwar Chandra Vidyasagar.  
**CO2:** Analyze Vidyasagar’s contributions to education, social reform, literature, and women’s empowerment.  
**CO3:** Apply Vidyasagar’s philosophical principles of rationalism, humanitarianism, and social justice to contemporary societal and educational issues.

**Syllabus:**  
**Common for all students of the University**

Course content	No. of Lectures
<b>A) Early Life and Education:</b> 1. Birth and Lineage 2. A Journey from Iswar Chandra Bondopadhaya to Iswar Chandra Vidyasagar	3
<b>B) Vidyasagar and Indian Education:</b> 1. The then Indian education system 2. Vidyasagarian plan for reformation of Indian education- Vidyasagar as teacher, Vidyasagar as writer, planner and reformer of Indian education.	4
<b>C) Vidyasagar and Women Emancipation: (4 Classers)</b> 1. Introduction of widow remarriage 2. Struggle to stop child marriage	4
<b>D) Philanthropist Vidyasagar ( 2 Classes)</b> 1. Vidyasagar’s philanthropy as narrated by others	2
<b>E) Vidyasagar : Traditions and modernity( 6 Classes)</b> 1. Tradition 2. Modernity 3. Vidyasagara as Traditional moderniser	4
<b>F) Relevance of Vidyasagarian thoughts and values ( 4 Classes)</b> 1. Vidyasagar and the then Society of Bengal 2. Lesson for future generations	3
<b>Total Lecture</b>	<b>20 hours</b>

**Further Readings:** Online course. Available on the University website.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]**

**CO-PO-PSO Mapping (High/Medium/Low)**

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	M	L	M	M	L	L	H	M	L	M	L	L	H
CO2	H	M	M	M	H	L	L	H	M	L	M	M	L	H
CO3	H	H	M	M	H	L	L	H	M	L	M	M	M	H

## SEMESTER-II

<b>Course code</b>	MTM C 451X1	<b>Continuum Mechanics</b>	<b>Credit 2(1-1-0)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
<p>The main objectives of this course are:</p> <ol style="list-style-type: none"> <li>1. To develop a fundamental understanding of the concepts of stress, strain, and deformation in continuous media, and to establish the mathematical relationships between forces, stresses, and displacements.</li> <li>2. To equip students with analytical and tensorial tools necessary for formulating and solving problems related to equilibrium, compatibility, and constitutive behavior in isotropic and elastic materials.</li> <li>3. To apply the principles of linear elasticity and continuum theory to model and analyze real-world problems in solid mechanics, material science, and applied mathematics using formulations such as Airy's stress function and Navier's equations.</li> </ol>			
<b>Course Outcomes (COs):</b>			
<p>Upon successful completion of this course, students will be able to:</p> <p><b>CO1:</b> Understand the fundamental concepts of stress, strain, stress–strain relations, and apply transformation laws, principal stresses/strains, Mohr's circle, and compatibility equations to analyze deformable bodies under different loading conditions.</p> <p><b>CO2:</b> Apply the theory of linear elasticity, including Hooke's law, isotropic material properties, Navier's equations, and Airy's stress function, to solve engineering and mathematical problems involving elastic solids.</p>			
<b>Syllabus:</b>			
<b>Course content</b>			<b>No. of Lectures</b>
Stress: Body force, Surface forces, Cauchy's stress principle			1
Stress vector, State of stress at a point, Stress tensor, The stress vector –stress tensor relationship			2
Force and moment equilibrium. Stress tensor symmetry stress quadric of Cauchy			3
Stress transformation laws, Principal stress, Stress invariant, Stress ellipsoid, maximum and minimum shear stress, Mohr's Circles for stresses			2
Strain: Deformation Gradients, Displacement Gradient Deformation tensor, Finite strain tensors			1
Small deformation theory-infinitesimal strain tensor, Relative displacement, Linear rotation tensor, Interpretation of the linear strain tensors			2
Strength ratio, Finite strain interpretation, Principal strains, Strain invariant			2
Cubical dilatation, Compatibility equation for linear strain, Strain energy function			2
Linear Elastic Solid: Hook's law. Saint –Venant's principal. Isotropic media. Elastic constrains. Moduli of elasticity of isotropic bodies and their relation. Beltrami-Michell compatibility equations for stress components. Plain state of stress and strain, Airy's stress function. Navier's equations. (The concept of elasticity in terms of strain and stress.)			5
<b>Total Lecture</b>			<b>20 hours</b>
<b>Further Readings:</b>			
<b>Text Books:</b>			
<ol style="list-style-type: none"> <li>1. R.N.Chatterjee, Mathematical Theory of Continuum Mechanics, Narosa Publishing House.</li> <li>2. A.J.M. Spencer, Continuum Mechanics, Longman, 1980.</li> </ol>			
<b>Reference Books:</b>			

1. T.J.Chung, Continuum Mechanics, Prentice – Hall.
2. Gedrg R. Mase, Continuum Mechanics: Schaum’s Outline of Theory and Problem of Continuum Mechanics, McGraw Hill.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]**

### CO-PO-PSO Mapping (High/Medium/Low)

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	M	M	L	M	L	L	H	M	M	L
CO2	H	H	H	M	H	M	L	M	M	M	H	H	H	M

<b>Course code</b>	<b>MTM C 451X2</b>	<b>Linear Algebra</b>	<b>Credit 2(1-1-0)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
The main objectives of this course are: <ol style="list-style-type: none"> <li>1. To provide an in-depth understanding of advanced concepts of linear algebra including dual spaces, linear operators, and canonical forms.</li> <li>2. To develop the ability to analyze and apply inner product spaces, orthogonality, and spectral theorem to solve mathematical and applied problems.</li> <li>3. To enhance problem-solving and analytical skills through the study of bilinear and quadratic forms and their geometric and computational interpretations.</li> </ol>			
<b>Course Outcomes (COs):</b>			
<b>Upon successful completion of this course, students will be able to:</b>			
<b>CO1:</b> Understand the concepts of dual spaces, eigenvalues and eigenvectors, diagonalization, canonical forms, inner product spaces, and bilinear and quadratic forms, along with their properties and theoretical foundations.			
<b>CO2:</b> Apply the principles of linear transformations, spectral theorem, Gram–Schmidt process, and reduction of quadratic forms to solve problems in linear algebra and related mathematical applications.			
<b>Syllabus:</b>			
<b>Course content</b>			<b>No. of Lectures</b>
<b>Dual Space:</b> The dual Space, Dual Basis, Double Dual, Transpose of a Linear Transformation and its matrix w. r. t. dual basis			4
<b>Diagonalization and Canonical Forms:</b> Eigen spaces of a linear operator, diagonalizability, invariant subspaces, Projection operator and its relation with the eigen values of a linear operator, the minimal polynomial for a linear operator, primary decomposition theorem, Nilpotent operator, Invariant factors and elementary divisors, Rational and Jordan canonical forms of a linear operator.			6
<b>Inner Product Spaces:</b> Inner product spaces, orthogonal and orthonormal inner product spaces, Gram-Schmidt orthogonalization process, the adjoint of linear operator, normal and self-adjoint operators, Hermitian, unitary and normal transformations, spectral theorem.			5
<b>Bilinear Forms:</b> Bilinear forms, symmetric and skew-symmetric bilinear forms, quadratic form, rank, signature and index of a quadratic form, reduction of a quadratic form to its normal form, Sylvester's law of inertia.			5
<b>Total Lecture</b>			<b>20 hours</b>

**Further Readings:****Text Books:**

1. K. Hoffman and R. Kunze, Linear Algebra, Pearson Education (India), 2003. Prentice-Hall of India, 1991.
2. S. Freidberg. A. Insel, and L Spence, Linear Algebra, Fourth Edition, Pearson, 2015.

**Reference Books:**

1. I. N. Herstein, Topics in Algebra, 2nd Ed., John Wiley & Sons, 2006.
2. Ramachandra Rao and P. Bhimasankaram, Linear Algebra, Hindustan, 2000.
3. S. Lang, Linear Algebra, Springer-Verlag, New York, 1989.
4. M. Artin, Algebra, Prentice Hall of India, 1994.
5. G. Strang, Linear Algebra and its Applications, Brooks/Cole Ltd., New Delhi, Third Edition, 2003.
6. K. B. Datta, Matrix and Linear Algebra, Prentice Hall India Pvt.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]**

**CO-PO-PSO Mapping (High/Medium/Low)**

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	M	M	M	M	M	L	M	L	L	H	M	M	M
CO2	H	H	H	M	H	M	L	M	M	M	H	H	H	M

<b>Course code</b>	<b>MTM E 452A1</b>	<b>Elective-I: Fluid Mechanics</b>	<b>Credit 2 (1-1-0)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Elective</b>		<b>Compulsory</b>

**MTM E 452A1. Elective-I: Fluid Mechanics****Course Objectives:**

The main objectives of this course are:

1. To introduce the fundamental principles and governing equations of fluid mechanics and their physical significance.
2. To develop analytical and mathematical skills to model, derive, and solve fluid flow problems under different physical conditions.
3. To familiarize students with real and ideal fluids, Navier–Stokes equations, boundary conditions, and applications in engineering and applied sciences.

**Course Outcomes (COs):**

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

**CO1:** Understand the fundamental concepts of fluid mechanics, including types of fluids and flows, continuum hypothesis, coordinate systems, and the derivation and physical interpretation of governing equations such as continuity, momentum, and energy equations.

**CO2:** Apply non-dimensionalization techniques, Reynolds number analysis, and exact solutions of the Navier-Stokes equations to solve practical fluid flow problems in engineering applications.

**Syllabus:**

<b>Course content</b>	<b>No. of Lectures</b>
<b>Basics:</b> The concept of a fluid mechanics, fluid as continuum, Units of Measurements, Viscosity, classification of fluid (real/ideal fluid, nanofluid, ferrofluid, compressible/incompressible, Newtonian/Non-Newtonian), types of fluid flow (rotational/irrotational flows, steady/unsteady flow, uniform/non uniform Flow, 1D/2D/3D flow, laminar or turbulent flow).	5
<b>Flow Visualization:</b> stream functions, streamlines, streamtubes, Pathlines, vorticity, iso-	

vorticity line.	
<b>Preliminaries for the derivation of governing equation:</b> Coordinate systems (Lagrangian description and Eulerian description), Models of the flow (Finite Control Volume and Infinitesimal Fluid Element), Substantial Derivative, Source of Forces, Examples	3
<b>Derivation of Governing Equations along with Initial and Boundary Conditions:</b> Derivation of Continuity Equation, Four Forms (non-conservation/conservation, partial differential /integral) of Continuity Equations, Derivation of Momentum (Navier-Stokes) Equation for a compressible viscous flow in non-conservation and conservation forms, Special case (Incompressible Newtonian Fluid), Physical interpretation of each term, Equivalent forms of Navier-Stokes in Spherical and Cylindrical Coordinate system, Derivation of Energy Equation, Similarity/dissimilarity between Navier-Stokes and Energy equations, Associated typical Initial and Boundary Conditions for velocity and thermal fields.	7
<b>Inviscid fluid Flows:</b> Euler's equation of motion, Bernoulli's equation and its applications	3
<b>Non-dimensionalization:</b> Non-dimensionalization, Reynolds number, Importance of Reynolds number to Navier-Stokes Equation, Exact Solution of Navier-Stokes Equation (Couette-Poiseuille flow)	2
<b>Total Lecture</b>	<b>20 hours</b>
<b>Further Readings:</b>	
<b>Text Books:</b>	
1. Fluid Mechanics. P. K. Kundu & I. M. Cohen, 4 <sup>th</sup> edition (Academic Press, 2008)	
2. Computational Fluid Dynamics (The Basics with Applications), John D. Anderson Jr., McGraw-Hill Series in Mechanical Engineering.	
<b>Reference Books:</b>	
1. An Introduction to Fluid Dynamics, G. K. Batchelor, Cambridge University Press.	
2. Fluid Mechanics (4 <sup>th</sup> Edition), Frank M. White, WCB McGraw-Hill.	
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>	
<b>MTM E 452A2. Elective-I: Magneto Hydrodynamics</b>	<b>Credit 2 (1-1-0)</b> <b>Full Marks 25</b>
<b>Course Objectives:</b>	
The main objectives of this course are:	
1. To introduce the fundamental concepts and governing equations of magnetohydrodynamics (MHD) combining fluid dynamics and electromagnetism.	
2. To develop the ability to model and analyze MHD flow problems under various physical and boundary conditions.	
3. To provide understanding of magnetic effects such as Lorentz force, Alfvén waves, Hall currents, and their implications in engineering and astrophysical contexts	
<b>Syllabus:</b>	
<b>Course content</b>	<b>No. of Lectures</b>
Maxwell's electromagnetic field equations when medium in motion.	2
Lorentz's force. The equations of motion of a conducting fluid. Basic equations.	2

Simplification of the electromagnetic field equation.	2
Magnetic Reynolds number. Alfven theorem.	2
Magnetic body force. Ferraro's law of isorotation.	2
Laminar Flow of a viscous conducting liquid between parallel walls in transverse magnetic fields.	2
M.H.D. Flow Past a porous flat plate without induced magnetic field.	2
MHD Couelte Flow under diff4th Editionerent boundary conditions	2
Magneto hydro dynamics waves. Hall currents.	2
MHD flow past a porous flat plate without induced magnetic field.	2
<b>Total lectures</b>	<b>20</b>
<b>Further Readings:</b>	
<b>Text Book:</b>	
1. P. A. Davidson, An Introduction to Magneto-hydrodynamics, 2001, Cambridge University Press	
<b>Reference Book:</b>	
1. Hosking, Roger J., Dewar, Robert, 2016, Fundamental Fluid Mechanics and Magneto-hydrodynamics, Springer	
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>	

### CO-PO-PSO Mapping (High/Medium/Low) (For Fluid Mechanics)

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	M	L	L	M	M	L	M	L	L	H	M	L	M
CO2	H	H	H	M	H	M	L	L	M	M	H	H	M	L

### CO-PO-PSO Mapping (High/Medium/Low) (For MHD)

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	M	L	L	M	M	L	M	L	L	H	M	L	M
CO2	H	H	H	M	H	M	L	L	M	M	H	H	M	L

<b>Course code</b>	<b>MTM E 452B1</b>	<b>Elective-II: Calculus on R<sup>n</sup></b>	<b>Credit 2(1-1-0)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>		<b>Elective</b>	<b>Compulsory</b>
<b>MTM E 452B1. Unit I: Calculus on R<sup>n</sup></b>			
<b>Course Objectives:</b>			
The main objectives of this course are:			
<ol style="list-style-type: none"> <li>To develop a strong understanding of scalar and vector fields, differentiability, and the geometric interpretation of multivariable functions.</li> <li>To enable students to apply derivative-based theorems, such as the mean value, Taylor's, inverse, and implicit function theorems, to analyze functions of several variables.</li> <li>To build analytical and problem-solving skills in multivariable calculus with applications to higher mathematics and applied sciences.</li> </ol>			
<b>Course Outcomes (COs):</b>			
Upon successful completion of this course, students will be able to:			
<b>CO1:</b> Understand the concepts of scalar and vector fields, continuity, directional and total derivatives, Jacobian matrix, and the chain rule in multivariable functions.			
<b>CO2:</b> Apply the mean value theorem, Taylor's formula, inverse and implicit function theorems to solve problems and analyze functions of several variables.			

<b>Syllabus:</b>	
<b>Course content</b>	<b>No. of Lectures</b>
Scalar and vector fields; continuity of multivariable functions; directional derivative.	3
Total derivative; total derivative in terms of partial derivatives; Jacobian matrix; chain rule; matrix form of chain rule.	4
Mean value theorem for differentiable functions; sufficient condition for differentiability; equality of mixed partial derivatives.	4
Taylor's formula for functions from $\mathbb{R}^n \rightarrow \mathbb{R}^1$ ; applications.	3
Inverse function theorem; implicit function theorem; applications.	6
<b>Total Lecture</b>	<b>20 Hrs</b>
<b>Further Readings:</b>	
<b>Text Books:</b>	
1. T. M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi.	
2. T. Marsden, Basic Multivariate Calculus, Springer, 2013.	
<b>Reference Books:</b>	
1. C. Goffman, Calculus of Several Variables, A Harper International Student reprint, 1965.	
2. Tom M. Apostol, Calculus, Volume II, Wiley India Pvt. Limited, 2002.	
3. Michael Spivak, Calculus on Manifolds, Westview Press, 1965.	
4. James R. Munkres, Analysis on Manifolds, Westview Press, 1990.	
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>	
<b>MTM E 452B2. Unit II: Operator Theory</b>	<b>Credit 2(1-1-0)</b> <b>Full Marks 25</b>
<b>Course Objectives:</b>	
The main objectives of this course are:	
1. To introduce the concepts of resolvent set, spectrum, spectral radius, and numerical range associated with bounded linear operators.	
2. To develop analytical understanding of spectral properties, Banach algebras, and their applications in functional analysis.	
3. To enable students to apply spectral theorems, numerical radius relations, and algebraic structures to solve advanced operator theory problems.	
<b>Course Outcomes (COs):</b>	
Upon successful completion of this course, students will be able to:	
<b>CO1:</b> Understand the concepts of resolvent set, spectrum, spectral radius, numerical range, and the properties of bounded linear operators in normed and Banach spaces.	
<b>CO2:</b> Apply the spectral mapping theorem, numerical radius relations, and properties of normed and Banach algebras to analyze and solve problems in functional analysis.	
<b>Syllabus:</b>	
<b>Course content</b>	<b>No. of Lectures</b>
Resolvent set of a bounded linear operator; examples and basic properties.	2
Spectrum of a bounded linear operator; point spectrum (eigenvalues); continuous spectrum; residual spectrum; approximate point spectrum; illustrative examples.	3
Spectral radius of a bounded linear operator; Gelfand's formula; examples and applications.	2
Spectral properties of bounded linear operators; spectral mapping theorem for polynomials; problem-solving and examples.	3

Numerical range; convexity of numerical range (Toeplitz–Hausdorff theorem); closure of numerical range contains the spectrum; examples.	3
Numerical radius; relation between numerical radius and norm of a bounded linear operator; applications.	2
Normed algebra; Banach algebra; examples; singular and non-singular elements.	3
Spectrum of an element in a Banach algebra; spectral radius of an element; illustrative examples.	2
<b>Total Lecture</b>	<b>20</b>

**Further Readings:**

**Text Books:**

1. Erwin Kreyszig, Introductory Functional Analysis with Applications, John Wiley and Sons.
2. G. Bachman and L. Narici, Functional Analysis, Dover Publications.

**Reference Books:**

1. Kadison and Ringrose, Fundamentals of operator theory, Vol. I and II, Academic press.
2. A Taylor and D. Lay, Introduction to Functional Analysis, John Wiley and Sons.
3. N. Dunford and J.T. Schwartz, Linear Operators – 3, John Wiley and Sons.
4. P.R. Halmos, Introduction to Hilbert space and the theory of Spectral Multiplicity, Chelsea Publishing Co., N.Y.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]**

**CO–PO–PSO Mapping (High/Medium/Low) (For Calculus on  $R^n$ )**

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	M	L	L	M	M	L	M	L	L	H	M	L	M
CO2	H	H	M	M	H	M	L	L	M	M	H	H	M	L

**CO–PO–PSO Mapping (High/Medium/Low) (For Operator Theory)**

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	M	L	L	M	M	L	M	L	L	H	M	L	M
CO2	H	H	M	M	H	M	L	L	M	M	H	H	M	L

<b>Course code</b>	<b>MTM E 453A0</b>	<b>Elective-I :Partial Differential Equations and Generalized Functions</b>	<b>Credit 4 (3-1-0)</b> <b>Full Marks 50</b>
<b>Core/Elective/Other</b>		<b>Elective</b>	<b>Compulsory</b>

**Course Objectives:**

The main objectives of this course are:

1. To introduce the fundamental concepts, formation, and classification of partial differential equations (PDEs) of various types.
2. To develop analytical and problem-solving skills for solving first-order and higher-order PDEs with different initial and boundary conditions.
3. To familiarize students with classical solution techniques such as separation of variables, D’Alembert’s solution, and Fourier series methods.
4. To study Dirichlet and Neumann boundary value problems, Poisson’s integral formula, and Green’s functions for Laplace’s equation.
5. To understand the concept of generalized functions, including Dirac delta function, and apply Fourier transforms to solve PDEs arising in applied sciences.

**Course Outcomes (COs):**

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

**CO1:** Understand and classify first-order and higher-order partial differential equations, including semi-linear, quasi-linear, and constant coefficient equations.

**CO2:** Apply analytical methods such as separation of variables and D'Alembert's solution to solve classical PDEs, including Laplace, wave, and heat equations.

**CO3:** Solve Dirichlet and Neumann boundary value problems, utilize Poisson's integral formula, and apply Green's functions to two-dimensional Laplace equations.

**CO4:** Understand the theory and operations of generalized functions, including Dirac delta function, and apply Fourier transforms to solve problems in PDEs.

**Syllabus:**

Course content	No. of Lectures
First order PDE in two independent variables and the Cauchy problem. Semi-linear and quasilinear equations in two-independent variables	5
Higher order PDE with constant coefficient	4
Adjoint and self-adjoint equations	2
Laplace, Wave and Heat equations	3
Equation of vibration of a string. Existence. Uniqueness and continuous dependence of the solution on the initial conditions. Method of separation of variables. D'Alembert's solution for the vibration of an infinite string. Domain of dependence	5
Heat equation - Heat conduction problem for an infinite rod – Heat conduction in a finite rod - existence and uniqueness of the solution	5
Fundamental solution of Laplace's equations in two variables. Harmonic function. Characterization of harmonic functions by their mean value property. Uniqueness. Continuous dependence and existence of solutions. Method of separation of variables for the solutions of Laplace's equations. Dirichlet's and Neumann's problems	5
Solution of Dirichlet's and Neumann's problems for some typical problems, like a disc and a sphere. Poisson's integral formula	3
Green's functions for the Laplace equations in two dimensions	3
Test functions. Regular and singular generalized functions. Dirac delta function. Operations on generalized functions. Derivatives. Transformation properties of generalized functions. Fourier transform of generalized functions	5

**Total Lecture**      **40 hours**

**Further Readings:**

**Text Books:**

1. Y. Pinchover and J. Rubinstein, An Introduction to Partial Differential Equations, Cambridge University Press, 2005.
2. S. Rao, Introduction to Partial Differential Equations, 3rd Edition, PHI Learning Private Limited, New Delhi, 2011.
3. J. J. Duistermaat and J. A. C. Kolk, Distributions Theory and Applications, Birkhäuser Basel, 2010.

**Reference Books:**

1. F. John, Partial Differential Equations, Springer-Verlag, New York, 1978.
2. Gelfand, I. M. and Shilov, G.E., Generalized Functions, AMS, Recent Edition, 2016.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]**

### CO-PO-PSO Mapping (High/Medium/Low)

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	M	L	L	M	M	L	M	L	L	H	M	L	M
CO2	H	H	M	M	H	M	L	L	M	M	H	H	M	L
CO3	H	H	M	M	H	M	L	L	M	M	H	H	M	M
CO4	H	H	H	M	H	M	L	L	M	M	H	H	H	M

<b>Course code</b>	<b>MTM E 453B1</b>	<b>Elective-II: Fuzzy Mathematics</b>	<b>Credit 2 (1-1-0)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>		<b>Elective</b>	<b>Compulsory</b>

#### Course Objectives:

The main objectives of this course are:

1. To introduce the basic concepts and properties of fuzzy sets, fuzzy relations, and fuzzy numbers for modeling uncertainty.
2. To develop analytical skills in applying fuzzy measures, defuzzification techniques, and fuzzy decision-making methods.
3. To apply fuzzy ranking and fuzzy linear programming techniques for solving real-life optimization and management problems.

#### Course Outcomes (COs):

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

**CO1:** Understand the fundamental concepts of fuzzy sets, fuzzy relations, fuzzy numbers, and fuzzy measures, along with their properties and representations.

**CO2:** Apply defuzzification techniques, fuzzy ranking methods, and fuzzy linear programming to solve decision-making and optimization problems in uncertain environments.

#### Syllabus:

Course content	No. of Lectures
Basic concept and definition of fuzzy sets. Standard fuzzy set operations and their properties.	3
Basic terminologies such as Support, $\alpha$ -Cut, Height, Normality, Convexity, etc..	1
Fuzzy relations, Properties of $\alpha$ -Cut, Zadeh's extension principle, Interval number and its arithmetic.	3
Fuzzy numbers and their representation, Arithmetic of fuzzy numbers..	3
Fuzzy measures. Evidence theory. Necessity measure. Possibility measure. Possibility distribution.	2
Defuzzification: centre of area, centre of maxima, and mean of maxima methods	1
Decision Making in Fuzzy Environment- Individual decision making. Multiperson decision making. Multicriteria decision making. Multistage decision making.	3
Fuzzy ranking methods. Fuzzy linear programming.	4
<b>Total Lecture</b>	<b>20</b>

**Further Readings:**

**Text Books:**

1. Klir, G.J. and Yuan, B.(1995) Fuzzy sets and fuzzy logic, Prentice-Hall of India, New Delhi.
2. Dubois, D.J.(1980) Fuzzy sets and systems: theory and applications, Academic press.

**Reference Books:**

1. Bector, C.R. and Chandra, S. (2005) Fuzzy mathematical programming and fuzzy matrix games, Berlin: Springer.
2. Zimmermann, H. J. (1991) Fuzzy set theory and its Applications, Allied Publishers Ltd, New Delhi

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]**

**MTM E 453B2. Elective-II: Soft Computing**

**Credit 2(1-1-0)**  
**Full Marks 25**

**Course Objectives:**

The main objectives of this course are:

1. To introduce the fundamental concepts and architectures of soft computing techniques such as neural networks, genetic algorithms, and fuzzy logic.
2. To develop problem-solving and optimization skills using biologically inspired and uncertainty-based computing methods.
3. To enable students to apply soft computing tools in real-world engineering, scientific, and decision-making problems.

**Course Outcomes (COs):**

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

**CO1:** Understand the fundamental concepts of soft computing, including artificial neural networks, genetic algorithms, and fuzzy logic, along with their architectures, principles, and applications.

**CO2:** Apply soft computing techniques to solve real-life optimization, decision-making, and problem-solving tasks in engineering and scientific domains.

**Syllabus:**

Course content	No. of Lectures
<b>Introduction</b> Evolution of Computing: Soft Computing Constituents, "Soft" versus "Hard" computing, Characteristics of Soft computing, Some applications of Soft computing techniques	3
<b>Artificial Neural Network</b> Biological neurons and their working, Simulation of biological neurons to problem-solving, Different ANNs architectures, Learning rules and various activation functions, Basic models of ANN, Single layer Perceptrons, and Applications of ANNs to solve some real-life problems.	7
<b>Genetic Algorithm</b> Goals of optimization, Concept of "Genetics" and "Evolution" and its application to probabilistic search techniques, Basic GA framework and different GA architectures, Working Principle, Various Encoding methods, Fitness function, GA Operators- Reproduction, Crossover, Mutation, Solving single-objective optimization problems using GAs.	5
<b>Fuzzy Logic</b> Fuzzy relations, rules, propositions, implications and inferences, De-fuzzification techniques, Fuzzy logic controller design, and some applications of Fuzzy logic.	5
<b>Total Lecture</b>	
	<b>20 hours</b>

**Further Readings:****Text Books:**

1. Sivanandam, S.N. and Deepa, S.N., 2007. PRINCIPLES OF SOFT COMPUTING, John Wiley & Sons
2. Jang, J.S.R., Sun, C.T. and Mizutani, E., 1997. Neuro-fuzzy and soft computing; a computational approach to learning and machine intelligence. Prentice Hall, Upper Saddle River NJ (1997).

**Reference Books:**

1. Ogly Aliev, R.A. and Aliev, R.R., 2001. Soft computing and its applications, World Scientific.
2. Karray, F.O. and De Silva, C.W., 2004. Soft computing and intelligent systems design: theory, tools, and applications. Pearson Education.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]**

**CO-PO-PSO Mapping (High/Medium/Low) (For Fuzzy Mathematics)**

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	M	L	L	M	M	L	M	L	L	H	M	L	M
CO2	H	H	H	M	H	M	L	L	M	M	H	H	M	L

**CO-PO-PSO Mapping (High/Medium/Low) (For Soft Computing)**

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	M	L	L	M	M	L	L	L	L	H	M	M	L
CO2	H	H	H	M	H	M	L	M	M	M	H	H	M	M

Course code	MTM E 454A1	Elective-I: Advanced Complex Analysis	Credit 2(1-1-0) Full Marks 25
Core/Elective/Other	Elective		Compulsory
<p><b>MTM E 454A1. Elective-I: Advanced Complex Analysis</b></p> <p><b>Course Objectives:</b></p> <p>The main objectives of this course are:</p> <ol style="list-style-type: none"> <li>1. To introduce the theory of complex mappings and transformations, including linear and bilinear transformations.</li> <li>2. To develop understanding of conformal mappings and their geometric and physical interpretations.</li> <li>3. To apply conformal mapping and analytic continuation techniques to solve boundary value problems in physical sciences and engineering.</li> </ol>			
<p><b>Course Outcomes (COs):</b></p> <p>Upon successful completion of this course, students will be able to:</p> <p><b>CO1:</b> Understand the fundamental concepts of complex mappings, including linear and bilinear transformations, branches of functions, Riemann surfaces, and analytic continuation.</p> <p><b>CO2:</b> Apply conformal mapping techniques to solve boundary value problems in heat conduction, fluid flow, and other two-dimensional physical systems.</p>			
<b>Syllabus:</b>			
<b>Course content</b>			<b>No. of Lectures</b>
<p><b>Mapping by Elementary Functions:</b> Linear Transformations, Translation, Rotation-Dilation, Contraction, Inversion, Mappings by <math>1/z</math>, Bilinear/Linear Fractional Transformations and its properties, An Implicit Form: Cross ratios, Fixed points of Bilinear Transformation, Normal/Canonical Form of Bilinear Transformation.</p>			6

Mappings of the Upper Half Plane, The Transformation $w = \sin z$ , Mappings by $z^2$ and Branches of $z^{\frac{1}{2}}$ , Square Roots of Polynomials, Riemann Surfaces	
<b>Conformal Mapping:</b> Preservation of Angles, Scale Factors, Local Inverses, Harmonic Conjugates, Transformations of Harmonic Functions, Transformations of Boundary Conditions	6
<b>Application of Conformal Mapping:</b> steady temperature, steady temperature in a half plane and related problems, two-dimensional fluid flow	4
<b>Analytic Continuation:</b> Direct and indirect analytic continuation, indirect analytic continuation using power series and along curve, regular and singular points.	4
<b>Total Lecture</b>	<b>20hours</b>

**Further Readings:**

**Text Books:**

1. Complex Variable and Applications, J. W. Brown and R. V. Churchill, 8th Edition, McGraw Hill.
2. A Text Book of Complex Analysis, P.K.Nayek and M.R.Seikh, Universities Press, 2018.

**Reference Books:**

1. Foundations of Complex Analysis, S. Ponnusamy, Narosa, 1995.
2. Functions of one Complex Variable, J. B. Conway, 2nd edition, Narosa, 1997.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]**

**MTM E 454A2. Elective-I: Machine Learning**

**Credit 2(1-1-0)**  
**Full Marks 25**

**Course Objectives:**

The main objectives of this course are:

1. To introduce the foundational principles, models, and algorithms of machine learning and their mathematical underpinnings.
2. To develop the ability to implement supervised, unsupervised, and reinforcement learning models for data-driven problem solving.
3. To enable students to critically analyze and interpret the performance of machine learning algorithms in real-world applications.

**Course Outcomes (COs):**

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

**CO1:** Understand the fundamental concepts, models, and algorithms of machine learning, including supervised, unsupervised, and reinforcement learning, as well as computational learning theory.

**CO2:** Apply regression, classification, clustering, and reinforcement learning techniques to solve real-world problems and analyze data-driven decision-making scenarios.

**Syllabus:**

Course content	No. of Lectures
Basic definitions; types of learning; hypothesis space and inductive bias; evaluation and cross-validation; computational learning theory; PAC learning model; sample complexity; VC dimension; ensemble learning; numerical computation and optimization; introduction to machine learning packages.	4
Linear regression with one variable; linear regression with multiple variables; bias/variance tradeoff; regularization; variants of gradient descent; maximum likelihood estimation (MLE); maximum a posteriori (MAP); applications.	4
Logistic regression; support vector machines (SVM); kernel functions and kernel SVM; Bayesian regression; binary decision trees; random forests; Naïve Bayes; applications.	4
k-Means clustering; k-Nearest Neighbors (kNN); Gaussian mixture models (GMM); expectation-maximization algorithm; applications.	4

Introductory concepts of reinforcement learning; Markov decision processes (MDP); examples and applications in sequential decision-making.	4
<b>Total Lectures</b>	<b>20hrs</b>
<b>Further Readings:</b>	
<b>Text Books:</b>	
1. Alpaydin, Ethem. Introduction to machine learning. MIT press, 2020.	
2. Daumé, Hal. A course in machine learning. Alanna Maldonado, 2023.	
<b>References Books:</b>	
1. Shalev-Shwartz, Shai, and Shai Ben-David. Understanding machine learning: From theory to algorithms. Cambridge University Press, 2014.	
2. Pradhan, Manaranjan, and U. Dinesh Kumar. Machine learning using Python. Wiley, 2019.	
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>	

### CO-PO-PSO Mapping (High/Medium/Low) (For **Advanced Complex Analysis**)

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	M	L	L	M	M	L	L	L	L	H	M	M	L
CO2	H	H	H	M	H	M	L	M	M	M	H	H	M	M

### CO-PO-PSO Mapping (High/Medium/Low) (For **Machine Learning**)

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	H	M	L	L	L	M	H	M	M	L
CO2	H	H	H	H	H	M	M	M	L	M	H	H	M	M

<b>Course code</b>	<b>MTM E 454B0</b>	<b>Elective-II: Stochastic Process and Statistical Methods</b>	<b>Credit 4(3-1-0)</b> <b>Full Marks 50</b>
<b>Core/Elective/Other</b>	<b>Elective</b>		<b>Anyone from two Electives</b>
<b>Course Objectives:</b>			
The main objectives of this course are:			
1. To introduce the basic concepts and classifications of stochastic processes, including Markov chains and continuous-time Markov processes.			
2. To explain the long-term and limiting behavior of stochastic models and their applications in various scientific and engineering contexts.			
3. To develop an understanding of multiple regression, correlation, and estimation techniques for analyzing multivariate data.			
4. To familiarize students with the principles and applications of Analysis of Variance (ANOVA) for interpreting experimental and observational data.			
5. To introduce time series analysis and forecasting models (AR, MA, ARMA) for modeling stochastic trends and making data-driven predictions.			

**Course Outcomes (COs):**

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

**CO1:** Understand the fundamental concepts of stochastic processes, including Markov chains, continuous-time processes, birth-death processes, Wiener process, and branching processes.

**CO2:** Analyze the limiting behavior, stationary distributions, and applications of Markov processes in discrete and continuous state spaces.

**CO3:** Apply multiple regression, correlation analysis, linear estimation, and ANOVA techniques to model and interpret real-world data.

**CO4:** Understand and implement time series analysis methods, including smoothing, AR, MA, and ARMA models, for forecasting and data-driven decision-making.

**Syllabus:**

Course content	No. of Lectures
<b>Markov Chains:</b> Markov chains with finite and countable state space; classification of states; limiting behavior of n-step transition probabilities; stationary distribution; random walk; gambler's ruin problem; examples and applications.	8
<b>Continuous-Time Markov Processes:</b> Markov processes in continuous time; birth and death processes; examples and applications.	6
<b>Markov Processes with Continuous State Space:</b> Wiener process; branching process; applications in stochastic modelling; illustrative examples.	6
<b>Multiple Regression and Correlation:</b> Multiple regression; partial correlation; multiple correlations; estimation and interpretation of coefficients; examples and problem-solving.	6
<b>Linear Estimates:</b> Linear estimation theory; ordinary and best linear unbiased estimates; applications.	4
<b>Analysis of Variance (ANOVA):</b> One-way and two-way ANOVA; assumptions; interpretation of results; applications.	4
<b>Time Series Analysis:</b> Introduction to time series analysis; components of a time series; moving averages; smoothing techniques. AR, MA, ARMA models; forecasting techniques; examples and applications in stochastic processes.	6
<b>Total Lecture</b>	<b>40hrs</b>

**Further Readings:****Text Books:**

1. J. Medhi, Stochastic Process, New Age International Publisher, 2ed, 1984.
2. Suddhendu Biswas and G. L. Sriwastav, Mathematical Statistics: A Textbook, Narosa, 2011.

**Reference Books:**

1. Goon, A.M., Gupta, M.K. and Dasgupta, B. (1968) Fundamentals of Statistics, Vol. 1 & 2, Calcutta: The World Press Private Ltd.
2. Montgomery, D.C., Peck, E.A. and Geoffrey, G. (2012) Vining, Introduction to Linear Regression Analysis, 5ed, Wiley.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]****CO-PO-PSO Mapping (High/Medium/Low)**

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	L	M	L	L	L	L	M	H	M	M	L
CO2	H	H	H	M	H	M	L	L	L	M	H	H	M	M
CO3	H	H	H	H	H	M	M	M	L	M	H	H	M	M

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO4	H	H	H	H	H	H	M	M	M	M	H	H	H	M

<b>Course code</b>	<b>MTM E 455A1</b>	<b>Elective-I: Integral Transforms</b>	<b>Credit 2(1-1-0)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Elective</b>		<b>Compulsory</b>

### MTM E 455A1. Elective-I: Integral Transforms

#### Course Objectives:

The main objectives of this course are:

1. To introduce the theoretical foundations and mathematical formulations of Fourier, Laplace, and Wavelet transforms.
2. To understand the properties, inversion formulas, and convolution theorems associated with various integral transforms.
3. To develop problem-solving skills for applying these transforms to differential equations, signal processing, and image analysis.

#### Course Outcomes (COs):

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

**CO1:** Understand the fundamental concepts and properties of Fourier, Laplace, and Wavelet transforms, including inversion formulas, convolution, and Parseval's relation.

**CO2:** Apply Fourier, Laplace, and Wavelet transforms to solve ordinary and partial differential equations, and analyze signals and images in engineering and scientific applications.

#### Syllabus:

Course content	No. of Lectures
<b>Fourier Transform:</b> Fourier Transform, Properties of Fourier transform, Inversion formula, Convolution, Parseval's relation, Multiple Fourier transform, Bessel's inequality, Application of transform to Heat, Wave and Laplace equations (Partial differential equations).	8
<b>Laplace Transform:</b> Laplace Transform, Properties of Laplace transform, Inversion formula of Laplace transform (Bromwich formula), Convolution theorem, Application to ordinary and partial differential equations.	6
<b>Wavelet Transform:</b> Time-frequency analysis, Multi-resolution analysis, Spline wavelets, Sealing function, Short-time Fourier transforms, Wavelet series, Orthogonal wavelets, Applications to signal and image processing.	6
<b>Total Lecture</b>	<b>20 hours</b>

#### Further Readings:

##### Text Books:

1. P.P.G.Dyke, An Introduction to Laplace Transforms and Fourier Series, Springer, 2001, Springer-Verlag London Limited.
2. Lokenath Debnath, Integral Transforms and Their Applications, CRC Press, 1995.
3. D. F. Walnut, An introduction to Wavelet Analysis, Birkhauser, 2002.
4. R.P. Kanwal, Linear Integral Equations; Theory & Techniques, Academic Press, NewYork, 1971.

##### Reference Books:

1. I.N. Sneddon: The use of Integral Transforms, Tata McGraw Hill, Publishing Company Ltd, New Delhi, 1974
2. H.T. Davis: Introduction to Nonlinear Differential and Integral Equations, Dover Publications, 1962.
3. M.L. Krasnov: Problems and Exercises Integral Equations, Mir Publication Moscow, 1971.
4. F.B. Hildebrand: Methods of Applied Mathematics, Dover Publication, 1992.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]****MTM E 455A2. Elective-I: Topology****Credit 2(1-1-0)**  
**Full Marks 25****Course Objectives:**

The main objectives of this course are:

1. To introduce the foundational concepts and structures of topological spaces, including open and closed sets, bases, continuity, and convergence.
2. To develop an understanding of key topological properties such as connectedness, compactness, and countability.
3. To apply separation axioms, metrization theorems, and topological constructions to analyze mathematical spaces and their applications in analysis.

**Course Outcomes (COs):**

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

**CO1:** Understand the fundamental concepts of topological spaces, including open and closed sets, neighborhoods, bases, subspaces, continuity, connectedness, and compactness.**CO2:** Apply separation axioms, metrization theorems, and topological properties to analyze and solve problems in mathematical analysis and related fields.**Syllabus:**

Course content	No. of Lectures
Topological spaces, Examples, open sets, closed sets, neighborhoods, basis, sub-basis	4
Subspace topology, Limit points, Closure, interiors	3
Continuous functions, homeomorphisms	2
Product topology, metric topology, order topology, Quotient Topology	2
Connected spaces, connected subspaces of the real line, Components and local connectedness	2
Compact spaces, Local-compactness, Tychonoff's theorem on compact spaces	3
First and second countable spaces, Hausdorff spaces, Regularity, Complete Regularity, Normality	3
Urysohn Lemma, Urysohn Metrization Theorem, Tietze Extension theorem (statement only)	1
<b>Total Lecture</b>	<b>20hrs</b>

**Further Readings:****Text Books:**

1. J. R. Munkres, Topology, 2nd Ed., Pearson Education (India), 2000.
2. M. A. Armstrong, Basic Topology, Springer (India), 1983.

**Reference Books:**

1. K. D. Joshi, Introduction to General Topology, New Age International Private Limited, New Delhi, 2014.
2. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, New York, 1963.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]****CO-PO-PSO Mapping (High/Medium/Low) (For Integral Transforms)**

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	M	L	L	L	L	M	H	M	M	L
CO2	H	H	H	H	H	M	M	M	L	M	H	H	M	M

**CO–PO–PSO Mapping (High/Medium/Low) (For Topology)**

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	M	L	L	L	L	L	H	M	M	L
CO2	H	H	M	H	H	M	L	M	L	M	H	H	M	M

<b>Course code</b>	<b>MTM E 455B1</b>	<b>Elective-II: Differential Geometry</b>	<b>Credit 2 (1-1-0)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Elective</b>		<b>Compulsory</b>
<b>MTME 455B1. Elective-II: Differential Geometry</b>			
<b>Course Objectives:</b>			
The main objectives of this course are:			
<ol style="list-style-type: none"> <li>To introduce the fundamental concepts of curves, surfaces, and their geometric properties such as curvature and torsion.</li> <li>To develop an understanding of affine and Riemannian connections, covariant differentiation, and curvature tensors.</li> <li>To apply the concepts of differential geometry in the analysis of geometric structures, geodesics, and conformal symmetries.</li> </ol>			
<b>Course Outcomes (COs):</b>			
Upon successful completion of this course, students will be able to:			
<b>CO1:</b> Understand the fundamental concepts of curves, surfaces, and Riemannian manifolds, including arc-length, fundamental forms, curvature, torsion, and affine connections.			
<b>CO2:</b> Apply the concepts of covariant differentiation, Riemann curvature, Ricci tensor, Weyl tensor, and geodesics to analyze geometric structures and solve problems in differential geometry.			
<b>Syllabus:</b>			
<b>Course content</b>			<b>No. of Lectures</b>
Curves in plane and space; arc-length; reparameterization; closed curves; simple closed curves; Four-vertex theorem; examples and applications.			<b>4</b>
Regular surfaces; tangents and normals; orientability; first fundamental form; developable surfaces; second fundamental form; Gauss's formula; Weingarten formula; Gauss & Codazzi equations; curvatures.			<b>4</b>
Affine connection (Koszul); torsion and curvature tensor fields; covariant differentiation; parallel transport; illustrative examples.			<b>4</b>
Riemannian manifold; Riemannian connection; Riemann curvature tensor; Bianchi identity; Ricci tensor; scalar curvature; Einstein manifold; examples.			<b>4</b>
Semi-symmetric metric connection; Weyl conformal curvature tensor; conformally symmetric Riemannian manifolds; consequences; geodesics; applications.			<b>4</b>
<b>Total Lecture</b>			<b>20 hours</b>
<b>Further Readings:</b>			
<b>Text Books:</b>			
<ol style="list-style-type: none"> <li>A. Pressley, Elementary Differential Geometry, Springer, 2<sup>nd</sup> Volume, 2010.</li> <li>S. Kumaresan, A Course in Differential Geometry and Lie Groups, Hindustan Book Agency.</li> </ol>			
<b>Reference Books:</b>			
<ol style="list-style-type: none"> <li>W.M. Boothby, An Introduction to Differentiable Manifolds and Riemannian Geometry, Academic Press, Revised 2003.</li> </ol>			
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>			

**MTM E 455B2. Elective-II: Manifold Theory****Credit 2(1-1-0)**  
**Full Marks 25****Course Objectives:**

The main objectives of this course are:

1. To introduce the fundamental concepts of topological and differentiable manifolds and their importance in modern geometry and mathematical physics.
2. To develop an understanding of tangent and cotangent spaces, vector fields, and submanifolds, and their applications in geometric analysis.
3. To enable students to apply smooth maps, push-forward and pull-back operations, and differential forms to study transformations and structures on manifolds.

**Course Outcomes (COs):**

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

**CO1:** Understand the fundamental concepts of topological and differentiable manifolds, tangent and cotangent spaces, vector fields, and submanifolds.**CO2:** Apply the theory of smooth maps, push-forward and pull-back operations, differential forms, and transformation groups to analyze geometric structures on manifolds.**Syllabus:**

Course content	No. of Lectures
Topological manifolds; differentiable manifolds; smooth maps and diffeomorphisms; curves in a manifold; tangent vectors; examples and applications.	4
Vector fields; integral curves of a vector field; push-forward mapping; f-related vector fields; immersion and submersion; submanifolds; examples.	4
Four-parameter group of transformations (local and global); complete vector fields; illustrative examples and applications.	4
Cotangent space; r-forms; exterior product; exterior differentiation; pull-back of differential forms; examples and applications.	4

**Total Lecture**      **16 hours****Further Readings:**

1. L.W. Tu, An Introduction to Manifolds, Springer, 2007.

**Reference Books:**

1. J.M. Lee, Introduction to Smooth Manifolds, Springer, 2003.
2. S. Lang, Introduction to Differential Manifolds, John Wiley & Sons, New York, 1962.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]****CO-PO-PSO Mapping (High/Medium/Low) (For Differential Geometry)**

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	M	L	L	L	L	L	H	M	M	L
CO2	H	H	M	H	H	M	L	M	L	M	H	H	M	M

**CO-PO-PSO Mapping (High/Medium/Low) (For Manifold Theory)**

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	M	L	L	L	L	L	H	M	M	L
CO2	H	H	M	H	H	M	L	M	L	M	H	H	M	M

<b>Course code</b>	<b>MTM E 456A9</b>	<b>Elective I: Hands-on Practical in Python</b>	<b>Credit 2(0-0-4)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Elective</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
<p>The main objectives of this course are:</p> <ol style="list-style-type: none"> <li>1. To introduce students to Python programming for solving mathematical problems and performing symbolic and numerical computations.</li> <li>2. To develop computational thinking and problem-solving skills through algorithmic implementation and data analysis using Python.</li> <li>3. To enable students to apply Python libraries such as NumPy, Pandas, and Matplotlib for mathematical modelling, visualisation, and real-world data interpretation.</li> </ol>			
<b>Course Outcomes (COs):</b>			
Upon successful completion of this course, students will be able to:			
<b>CO1:</b> Apply Python programming to solve mathematical problems involving algebra, calculus, linear algebra, probability, and statistics.			
<b>CO2:</b> Develop problem-solving skills through hands-on practice with Python libraries (NumPy, Pandas, Matplotlib) for computation, data handling, and visualization in mathematical applications.			
<b>Syllabus:</b>			
<b>Course content</b>			<b>No. of Lectures</b>
Writing simple Python programs to perform arithmetic operations, evaluate algebraic expressions, implement conditional statements, and generate number sequences using loops.			2
Defining and using functions to compute factorial, Fibonacci sequence, prime numbers, greatest common divisor (GCD), least common multiple (LCM), and solving recursion-based problems.			2
Problems involving lists, tuples, sets, and dictionaries, such as matrix representation using nested lists, polynomial addition, frequency counting, and set operations.			2
Using NumPy to solve mathematical problems: array operations, solving systems of linear equations, computing eigenvalues and eigenvectors, performing matrix factorizations, and applying vectorized operations.			3
Importing datasets, calculating descriptive statistics (mean, median, variance, correlation), filtering and grouping data, constructing frequency tables, and summarizing mathematical data.			3
Plotting mathematical functions (e.g., sine, cosine, exponential, polynomial), creating bar charts, histograms, scatter plots, and visualizing statistical data with customized axes, legends, and labels.			3
Numerical differentiation and integration, solving differential equations using Euler's method, root finding (Bisection/Newton-Raphson method), optimization of quadratic functions, and applications in probability distributions.			3
Students will complete a small project integrating computation, data handling, and visualization (e.g., analyzing real data, solving an optimization problem, or visualizing probability distributions).			2
<b>Total Lecture</b>			<b>20 hours</b>

**Further Readings:****Textbooks**

1. Lutz, M. *Learning Python*. O'Reilly Media.
2. Downey, A. *Think Python: How to Think Like a Computer Scientist*. O'Reilly Media.

**Reference Books**

1. McKinney, W. *Python for Data Analysis*. O'Reilly Media.
2. Langtangen, H. P. *A Primer on Scientific Programming with Python*. Springer.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]****CO-PO-PSO Mapping (High/Medium/Low)**

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	H	H	M	L	M	L	M	H	H	M	M
CO2	H	H	H	H	H	M	L	M	L	M	H	H	M	H

<b>Course code</b>	<b>MTM E 456B9</b>	<b>Elective II: Hands-on Practical in C++</b>	<b>Credit 2(0-0-4)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Elective</b>		<b>Compulsory</b>

**Course Objectives:**

The main objectives of this course are:

1. To introduce students to C++ programming as a tool for solving mathematical and computational problems.
2. To develop algorithmic thinking and modular programming skills for implementing mathematical methods efficiently.
3. To train students in using object-oriented concepts, file handling, and numerical methods for mathematical modeling and data analysis.

**Course Outcomes (COs):**

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

**CO1:** Apply C++ programming constructs (functions, arrays, pointers, classes, file I/O) to implement mathematical algorithms in algebra, calculus, and linear algebra.

**CO2:** Develop, test, and evaluate computational solutions for mathematical problems (e.g., matrix operations, root-finding, numerical integration/differentiation) with clean code, modular design, and appropriate documentation.

**Syllabus:**

1. Write a program to compute factorial, Fibonacci sequence, and check prime numbers using loops and conditional statements.
2. Implement recursive functions for factorial, greatest common divisor (GCD), and Tower of Hanoi.
3. Perform addition, subtraction, and multiplication of two matrices using arrays.
4. Write a program to compute the determinant and inverse of a matrix (using arrays).
5. Represent polynomials using arrays; perform polynomial addition, multiplication, and evaluation at a given point.
6. Implement Bisection Method and Newton–Raphson Method to find approximate roots of equations.
7. Write a program to compute derivative of a function numerically; implement Trapezoidal Rule and Simpson’s Rule for numerical integration.
8. Define a class for complex numbers; implement addition, subtraction, and multiplication

using operator overloading.

9. Create classes for vector and matrix; implement operations like scalar multiplication, dot product, and transpose.
10. Write a program to read student records (name, roll, marks) from a file and compute average/maximum marks.
11. Implement a stack to evaluate postfix expressions.
12. Implement a queue to simulate a simple mathematical process (e.g., series generation).
13. Develop a small C++ project combining mathematical computation, OOP, and file handling.  
Example topics:
  - a. Solving a system of linear equations using Gaussian elimination.
  - b. Statistical analysis of a dataset (mean, variance, standard deviation, correlation).
  - c. Numerical solution of differential equations (Euler's method).

#### Further Readings:

##### Textbooks

1. Malik, D. S. *C++ Programming: From Problem Analysis to Program Design*. Cengage Learning.
2. Kanetkar, Y. P. *Let Us C++*. BPB Publications.

##### Reference Books

1. Lafore, R. *Object-Oriented Programming in C++*. Sams Publishing.
2. Stroustrup, B. *The C++ Programming Language*. Addison-Wesley.

#### Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]

#### CO-PO-PSO Mapping (High/Medium/Low)

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	H	M	H	M	L	L	M	M	H	H	M	M
CO2	H	H	H	H	H	M	M	L	M	M	H	H	H	M

## SEMESTER-III

<b>Course code</b>	<b>MTM C 501X0</b>	<b>MOOC from SWAYAM</b>	<b>Credit 4(3-1-0)</b> <b>Full Marks 50</b>
<p>The course will be selected based on its availability on the SWAYAM platform and must be compatible with the Applied Mathematics curriculum. The chosen MOOC should carry 4 credits. The University will conduct the examination and evaluation in accordance with the guidelines prescribed for the respective MOOC.</p>			
<b>Course code</b>	<b>MTM C 502X0</b>	<b>Functional Analysis</b>	<b>Credit 4(3-1-0)</b> <b>Full Marks 50</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
<p>The main objectives of this course are:</p> <ol style="list-style-type: none"> <li>1. To introduce the fundamental concepts of normed, Banach, and Hilbert spaces and their interrelations.</li> <li>2. To develop an understanding of bounded linear operators, dual spaces, and important theorems in functional analysis.</li> <li>3. To explain the structure and properties of inner product spaces, orthogonality, and projection theorems.</li> <li>4. To apply key results like the Hahn–Banach, Open Mapping, and Uniform Boundedness theorems in solving analytical problems.</li> <li>5. To cultivate the ability to formulate and analyze problems in abstract vector spaces with applications in pure and applied mathematics.</li> </ol>			
<p>Upon successful completion of this course, students will be able to:</p> <p>CO1: Explain and analyze the structure and properties of normed, Banach, and Hilbert spaces with relevant examples.</p> <p>CO2: Apply fundamental theorems (Hahn–Banach, Open Mapping, Closed Graph, Uniform Boundedness) to solve analytical and operator-related problems.</p> <p>CO3: Demonstrate proficiency in orthogonality, Fourier expansions, and minimization of norms in inner product spaces.</p> <p>CO4: Identify and examine bounded linear operators, including self-adjoint, normal, unitary, and positive operators, and their mathematical implications.</p>			
<b>Syllabus:</b>			
<b>Course content</b>			<b>No. of Lectures</b>
Normed spaces, Examples and related theorems, Bounded linear transformation, equivalent norms and their properties, finite dimensional normed linear spaces, Set of all bounded linear transformation $B(X, Y)$ from NLS $X$ into NLS $Y$ is a NLS, Continuity of linear maps			5
Banach spaces with examples, $B(X, Y)$ is a Banach space if $Y$ is a Banach space, quotient spaces and its completeness property, consequences of quotient spaces, Riesz lemma and its applications in Banach spaces, space of all square integrable functions over $[a, b]$ and its properties			4
Hahn-Banach Extension theorem and Its applications			3
Banach spaces, series in Banach spaces, convergence of a series in Banach spaces, A NLS is Banach if and only if every absolutely convergent series is convergent. Conjugate spaces, Reflexive spaces			2
Open Mapping Theorem and their applications, Inverse Mapping Theorem, Closed Graph Theorem			4
Uniform Boundedness Principle and its applications			2
Inner product spaces, Inner product is a continuous operator. Relation between IPS and NLS			3
Orthogonal and orthonormal vectors, Bessel's inequality. Parseval's identity, Cauchy-Schwarz inequality, Parallelogram law			3

Hilbert spaces, Orthonormal basis. Complete orthonormal basis	3
Projection theorem	2
Minimization of norm problems in inner product spaces, Riesz Fischer theorem, Riesz representation theorem for bounded linear functional on a Hilbert space, Fourier expansion	4
Definition of self-adjoint operator, Normal, Unitary and Positive operators, Related theorems	5
<b>Total Lecture</b>	<b>40 hours</b>
<b>Further Readings:</b>	
<b>Text Books:</b>	
1. B.V. Limaye, Functional Analysis, 2nd Edition, New Age International Private Limited New Delhi, 2014.	
2. J. B. Conway, A Course in Functional Analysis, 2nd Edition, Springer-Verlag New York, 1985.	
<b>Reference Books:</b>	
1. E. Kreyzig, Introduction to Functional Analysis with Applications, John Wiley & Sons, New York, 1989.	
2. A. Taylor and D. Lay, Introduction to Functional Analysis, Wiley, New York, 1980.	
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>	

### CO-PO-PSO Mapping (High/Medium/Low)

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	H	M	H	M	L	L	M	M	H	H	M	M
CO2	H	H	H	H	H	M	M	L	M	M	H	H	H	M
CO3	H	M	L	M	M	M	L	L	L	L	H	M	L	L
CO4	H	H	L	M	L	L	L	L	L	M	H	M	M	L

<b>Course code</b>	<b>MTM C 503X1</b>	<b>Integral Equation</b>	<b>Credit 2(1-1-0)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
The main objectives of this course are:			
<ol style="list-style-type: none"> <li>To introduce the formulation, classification, and properties of linear integral equations, emphasizing Fredholm and Volterra types and their connections with boundary value problems.</li> <li>To develop the ability to apply analytical and computational methods—including successive approximations, resolvent kernels, Laplace transforms, and Fredholm theory—for solving diverse classes of integral equations.</li> <li>To provide insight into Hilbert–Schmidt theory, symmetric kernels, and eigenfunction expansions, enabling students to analyse the existence, uniqueness, and applications of solutions in physical and engineering contexts.</li> </ol>			
<b>Course Outcomes (COs):</b>			
<b>Upon successful completion of this course, students will be able to:</b>			
<b>CO1:</b> Understand the formulation, types, and properties of linear integral equations, including Fredholm and Volterra equations, symmetric kernels, and convolution-type equations.			
<b>CO2:</b> Apply various solution techniques such as successive approximations, resolvent kernels, Laplace transforms, and Hilbert-Schmidt theory to solve integral equations arising in physical and engineering problems.			

**Syllabus:**

Course content	No. of Lectures
Formulation of integral equations; linear integral equations of first and second kinds – Fredholm and Volterra types; relation between integral equations and initial and boundary value problems; examples.	4
Existence and uniqueness of continuous solutions of Fredholm and Volterra integral equations of the second kind; solution by successive approximations; iterated kernels; reciprocal kernels; Volterra's solution of Fredholm integral equations; resolvent kernel method; integral equations with degenerate kernels; Abel's integral equation; integral equations of convolution type and solutions using Laplace transform.	6
Fredholm theory for the solution of Fredholm integral equations; Fredholm's determinant ( $\lambda$ ); Fredholm's first minor; Fredholm's fundamental relations and theorems; Fredholm's alternatives; illustrative examples.	5
Integral equations with symmetric kernels; Hilbert-Schmidt theory of symmetric kernels; properties of symmetric kernels; existence of eigenvalues for real symmetric kernels; complete set of eigenvalues and complete orthonormal system of eigenfunctions; expansion of iterated kernels in terms of eigenfunctions; Schmidt's solution of Fredholm integral equations.	5

**Total Lecture**      **20 hours**

**Further Readings:****Text Books:**

1. Kanwal, R.P. (1971) Linear Integral Equations; Theory & Techniques, Academic Press, New York.
2. Lovitt, Linear Integral Equations, Dover Publications, New York, 1950
3. Tricomi, Integral Equations, Inter Science Publishers, New York, 1957

**Reference Books:**

1. H.T. Davis: Introduction to Nonlinear Differential and Integral Equations, Dover Publications, 1962.
2. M.L. Krasnov: Problems and Exercises Integral Equations, Mir Publication Moscow, 1971.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]**

**CO-PO-PSO Mapping (High/Medium/Low)**

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	H	M	L	L	M	M	H	M	M	M
CO2	H	H	H	H	H	M	M	L	M	H	H	H	H	M

<b>Course code</b>	<b>MTM C 503X2</b>	<b>Cryptography</b>	<b>Credit 2(1-1-0)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>

**Course Objectives:**

The main objectives of this course are:

1. To introduce the fundamental principles and terminology of cryptography and computer security, including classical and modern encryption methods.
2. To develop proficiency in analyzing and applying cryptographic algorithms and protocols, such as block ciphers, public-key systems, digital signatures, and hashing functions.
3. To enable students to design secure communication systems by integrating mathematical reasoning with cryptographic and information security principles.

**Course Outcomes (COs):**

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

**CO1:** Understand the fundamental concepts of cryptography, classical and modern encryption techniques, block ciphers, public-key cryptosystems, digital signatures, and secure hashing.

**CO2:** Apply cryptographic algorithms and protocols to design and analyze secure systems, ensuring confidentiality, integrity, and authentication in computer security applications.

**Syllabus:**

Course content	No. of Lectures
Cryptographic algorithms and protocols, Computer security concepts, Fundamental security design principles	2
Classical Encryption Techniques: Basic terminology: Ciphertext, encryption, decryption, cryptanalysis and cryptology	2
Substitution techniques: Caesar Cipher, Monoalphabetic Cipher, Play-fair Cipher, Hill Cipher, Poly-alphabetic Cipher, Transposition techniques	4
Traditional Block Cipher Structure: Stream Ciphers and Block Ciphers, Motivation for the Feistel Cipher Structure, Feistel Cipher	4
Public-Key Encryption: Public-Key cryptosystems, decryption algorithm.	2
Digital Signatures: One-time signatures, Rabin and ElGamal signatures schemes, Digital Signature Standard (DSS).	4
Hashing: Motivation and applications, Cryptographically Secure Hashing.	2

**Total Lecture      20 hours**

**Further Readings:****Text Books:**

1. W. Stallings, Cryptography and Network Security, 4th Ed, Prentice Hall PTR, Upper Saddle River, NJ, 2006
2. W. Trappe and L. C. Washington, Introduction to cryptography with coding Theory, Prentice-Hall, 2nd ED, 2006.

**Reference Books:**

1. D. R. Stinson, Cryptography: Theory and Practice, Third Edition, Chapman & Hall/ CRC, 2005
2. W. Mao, "Modern Cryptography – Theory and Practice", Pearson Education.
3. Charles P. Pfleeger, Shari Lawrence Pfleeger – Security in computing – Prentice Hall of India.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]**

**CO-PO-PSO Mapping (High/Medium/Low)**

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	H	H	L	L	M	H	H	M	M	M
CO2	H	H	H	H	H	H	M	L	M	H	H	H	H	M

Course code	MTM E 504A0	<b>Elective-I: Advanced Optimization</b>	<b>Credit 4(3-1-0)</b> <b>Full Marks 50</b>
Core/Elective/Other	Core		Compulsory
<b>Course Objectives:</b>			
The main objectives of this course are:			
1. To impart advanced knowledge of optimization theory, including linear, nonlinear, and dynamic programming methods.			

2. To develop analytical and computational skills for solving complex linear and nonlinear programming problems using advanced simplex-based techniques.
3. To familiarize students with integer, quadratic, and goal programming approaches and their practical applications in industry and management.
4. To introduce numerical algorithms for unconstrained and constrained optimization, including penalty, barrier, and augmented Lagrangian methods.
5. To enable students to apply optimization techniques in real-life scenarios, conduct performance analysis, and interpret solutions for effective decision-making.

**Course Outcomes (COs):**  
**Upon successful completion of this course, students will be able to:**  
**CO1:** Understand and apply revised and dual simplex methods, post-optimal analysis, and sensitivity analysis for linear programming problems.  
**CO2:** Formulate and solve integer programming, quadratic programming, and goal programming problems using appropriate algorithms.  
**CO3:** Analyze and solve dynamic programming and unconstrained optimization problems using numerical and analytical methods.  
**CO4:** Apply constrained optimization techniques, including penalty and barrier methods, augmented Lagrangian methods, and sequential quadratic programming, to solve practical engineering and management optimization problems.

<b>Syllabus:</b>	
<b>Course content</b>	<b>No. of Lectures</b>
<b>Revised simplex method:</b> With and without artificial variable, Dual simplex method, Modified dual simplex method.	<b>4</b>
<b>Post-optimal analysis:</b> Changes in the cost vector and the resource vector, Addition of a variable, Deletion of an existing variable, and Addition of a new constraint.	<b>4</b>
<b>Integer Programming:</b> Gomory's cutting plane algorithm, Gomory's mixed-integer problem algorithm, and the branch-and-bound algorithm.	<b>4</b>
<b>Quadratic Programming</b> Wolfe's modified simplex method, Beale's method, and convex programming.	<b>4</b>
<b>Goal Programming</b> Introduction, Concept of Goal Programming (GP), Difference between LP and GP, formulation, graphical solution, modified simplex method.	<b>4</b>
<b>Unconstrained Optimization Techniques</b> General structure of a numerical method for unconstrained optimization problems, exact and inexact line search, trust region method, Dogleg technique, Fibonacci section method and its convergence, Golden section method and its convergence, Newton's method (for line search) and its convergence, Steepest descent and its convergence, Newton's method (for several variable optimizations) and its convergence, Conjugate direction method, Conjugate gradient methods: Beale's and preconditioned methods, Global convergence and convergence rate of conjugate gradient methods	<b>15</b>
<b>Constrained optimization techniques</b> Penalty and barrier function method, Augmented Lagrangian Method, Feasible direction methods: Reduced gradient and projected gradient methods, Sequential quadratic programming techniques: Lagrange-Newton and Watch-dog technique	<b>5</b>
<b>Total Lecture</b>	<b>40 hours</b>

<p><b>Further Readings:</b></p> <p><b>Text Books:</b></p> <ol style="list-style-type: none"> <li>1. S. S. Rao. Engineering optimization: theory and practice. John Wiley &amp; Sons, 2009.</li> <li>2. Belegundu, Ashok D., and Tirupathi R. Chandrupatla. Optimization concepts and applications in engineering. Cambridge University Press, 2011.</li> </ol> <p><b>Reference Books:</b></p> <ol style="list-style-type: none"> <li>1. Taha, Hamdy A. Operations research: An introduction. Pearson Education India, 2004.</li> <li>2. Sharma, S. D. Operations Research, Kedar Nath Ram Nath &amp; Co., Meerut.</li> </ol> <p><b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b></p>
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### CO-PO-PSO Mapping (High/Medium/Low)

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	H	M	L	L	M	H	H	M	M	L
CO2	H	H	H	M	H	M	L	L	M	H	H	H	M	M
CO3	H	H	H	H	H	M	M	L	M	H	H	H	H	M
CO4	H	H	H	H	H	H	M	L	M	H	H	H	H	H

<b>Course code</b>	<b>MTM E 504B0</b>	<b>Elective-II: Dynamical Meteorology: Thermodynamics in Atmosphere</b>	<b>Credit 4(3-1-0)</b> <b>Full Marks 50</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
The main objectives of this course are:			
<ol style="list-style-type: none"> <li>1. To provide a clear understanding of the physical structure, composition, and thermodynamic properties of the atmosphere.</li> <li>2. To introduce the fundamental thermodynamic laws and their applications to atmospheric processes such as hydrostatic equilibrium and pressure variation.</li> <li>3. To develop analytical skills to study the stability of dry and moist air using adiabatic lapse rates and potential temperature concepts.</li> <li>4. To explain moist thermodynamics and various temperature parameters including dew point, wet-bulb, and equivalent temperatures.</li> <li>5. To enable students to apply thermodynamic diagrams and quantitative stability indices (CAPE, CINE) for assessing atmospheric convection and stability.</li> </ol>			
<b>Course Outcomes (COs):</b>			
<b>Upon successful completion of this course, students will be able to:</b>			
<b>CO1:</b> Understand the structure, composition, and fundamental thermodynamic laws governing the atmosphere, including hydrostatic equilibrium and thermodynamic processes.			
<b>CO2:</b> Analyze the variation of atmospheric pressure, temperature, and stability of dry and moist air, including adiabatic lapse rates and potential temperature.			
<b>CO3:</b> Apply concepts of moist thermodynamics, including dew point, equivalent temperature, wet-bulb temperature, and pseudo-adiabatic processes, to atmospheric phenomena.			
<b>CO4:</b> Utilize thermodynamic diagrams, CAPE, CINE, and stability analysis methods to assess atmospheric stability, convective activity, and vertical and horizontal air mass mixing.			
<b>Syllabus:</b>			
<b>Course content</b>			<b>No. of Lectures</b>

Structure and composition of the atmosphere, Equation of state for dry, Laws of thermodynamics	3
Different thermodynamic processes and its applications in atmosphere, Hydrostatic Equation and its application	3
Pressure and its variation with height, variation of temperature with height, stability of dry air, potential temperature	3
Equation of state of moist air, Virtual temperature, Humidity Parameters	3
Standard Atmosphere, Barometric Altimetry, Hypsometric Equation	3
Adiabatic lapse rate for moist unsaturated air, effect of ascent and descent on lapse rate and stability.	4
Clausius – Clapeyron equation, saturated adiabatic lapse rate and stability, saturation by Isobaric cooling	4
Dew point changes in adiabatic motion, saturation by adiabatic ascent, Pseudo- adiabatic process	3
Equivalent Temperature, Equivalent Potential Temperature, Wet-bulb temperature, Wet-bulb potential temperature	3
Thermodynamic Diagrams. Uses of thermodynamic diagrams: LCL, LFC, Precipitable Water Vapor	4
Role of Convective Available Potential Energy (CAPE) and Convective Inhibition Energy (CINE) in thunderstorm development, Reduction of pressure to sea level	3
Stability and Instability of Atmosphere: Parcel Method, Slice method of stability analysis, Horizontal mixing of air masses, vertical mixing of air masses.	4
<b>Total Lecture</b>	<b>40 hours</b>
<b>Further Readings:</b>	
<b>Text Books:</b>	
1. Dynamical and Physical Meteorology: George J. Haltiner and Frank L.Martin, McGraw Hill	
2. An introduction to Dynamical Meteorology: Holton J.R., Academic Press	
<b>Reference Books:</b>	
1. Physical and Dynamical Meteorology: D. Brunt, Cambridge University Press	
2. Atmospheric Thermodynamics: Iribarne, J.V. and Godson, W.L.	
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>	

### CO–PO–PSO Mapping (High/Medium/Low)

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	H	M	L	L	M	M	H	M	L	L
CO2	H	H	H	M	H	M	M	L	M	M	H	H	M	L
CO3	H	H	H	H	H	M	M	L	M	M	H	H	H	M
CO4	H	H	H	H	H	H	M	L	M	H	H	H	H	M

<b>Course code</b>	<b>MTM E 504C0</b>	<b>Elective-III: Linear and Non-Linear Dynamical Systems</b>	<b>Credit 4(3-1-0)</b> <b>Full Marks 50</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
The main objectives of this course are:			
1. To introduce the fundamental principles of autonomous and non-autonomous dynamical systems and their qualitative behavior.			
2. To provide knowledge of existence and uniqueness theorems for differential equations describ			

3. To develop analytical techniques for identifying and classifying equilibrium points and studying local and asymptotic stability.
4. To enable students to apply advanced theorems such as Liapunov stability, Floquet's theorem, and Hartman–Grobman theorem for global stability and periodic solutions.
5. To familiarize students with Poincaré maps and bifurcation theory to analyze qualitative transitions and predict nonlinear phenomena in dynamical systems.

**Course Outcomes (COs):**

**Upon successful completion of this course, students will be able to:**

**CO1:** Understand the fundamental concepts of dynamical systems, including autonomous and non-autonomous systems, existence and uniqueness theorems, and discrete and continuous dynamics.

**CO2:** Analyze equilibrium points, classify saddles, nodes, foci, and centers, and determine stability and asymptotic stability using phase space and Jordan canonical forms.

**CO3:** Apply advanced stability analysis techniques, including Liapunov functions, Floquet's theorem, Hartman–Grobman theorem, and periodic solution concepts, to study global behavior.

**CO4:** Utilize Poincaré maps and bifurcation theory to investigate local and global bifurcations and predict qualitative changes in the behavior of dynamical systems.

**Syllabus:**

Course content	No. of Lectures
Dynamical System, autonomous and non-autonomous	3
Fundamental existence uniqueness theorem, discrete and continuous	4
Equilibrium point: saddles, nodes, foci, centres	4
Jordan canonical form, stability, asymptotic stability, configuration space and phase space	4
Floquet's theorem, Hartman – Grobman Theorem	4
Liapunov function, periodic solution	4
Global stability: limit sets, attractors, periodic orbit, limit cycles	4
Poincare Map, Poincare – Bendixson Theorem	5
Bifurcation analysis, local: Hof bifurcation saddle – node bifurcation, transcritical	4
bifurcation, global: homoclinic bifurcation, heteroclinic bifurcation, infinite period bifurcation	4
<b>Total Lecture</b>	<b>40 hours</b>

**Further Readings:**

**Text Books:**

1. Differential Equations and Dynamical Systems, Lawrence Perko, Springer

**Reference Books:**

1. An Introduction to Dynamical System, D. K. Arrow smith, Cambridge University Press;
2. Nonlinear Dynamics and Chaos: with Applications to Physics, Biology, Chemistry and Engineering, Strogatz, S. H., CRC Press.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]**

**CO-PO-PSO Mapping (High/Medium/Low)**

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	H	M	L	L	M	M	H	M	M	L
CO2	H	H	H	M	H	M	M	L	M	M	H	H	M	M
CO3	H	H	H	H	H	M	M	L	M	M	H	H	H	M
CO4	H	H	H	H	H	H	M	L	M	H	H	H	H	M

<b>Course code</b>	<b>MTM E 505A0</b>	<b>Elective-I: Operational Research Modeling-I</b>	<b>Credit 4(3-1-0)</b> <b>Full Marks 50</b>
<b>Core/Elective/Other</b>	<b>Elective</b>		<b>Anyone from two Electives</b>
<b>Course Objectives:</b>			
The main objectives of this course are:			
<ol style="list-style-type: none"> <li>1. To provide an in-depth understanding of deterministic, probabilistic, and dynamic inventory models and their applications in supply chain management.</li> <li>2. To develop analytical and computational skills for project planning and control using PERT and CPM techniques under uncertainty.</li> <li>3. To familiarize students with replacement and maintenance decision models and queuing systems for efficient system management.</li> <li>4. To introduce simulation methodologies for modeling and analyzing stochastic systems using random numbers and Monte Carlo techniques.</li> <li>5. To enable students to apply dynamic programming principles for solving multi-stage decision-making problems in production, scheduling, and routing contexts.</li> </ol>			
<b>Course Outcomes (COs)</b>			
<b>Upon successful completion of this course, students will be able to:</b>			
<b>CO1:</b> Understand and apply deterministic, probabilistic, and dynamic inventory control models, including multi-item and price-break scenarios, within the framework of supply chain management.			
<b>CO2:</b> Analyze project networks using PERT and CPM techniques, perform critical path analysis, and evaluate project time–cost trade-offs under uncertainty.			
<b>CO3:</b> Formulate and solve replacement and maintenance problems, queuing models, and simulate stochastic systems using Monte Carlo and other simulation techniques.			
<b>CO4:</b> Apply dynamic programming principles to optimize multi-stage decision processes, production scheduling, and routing problems in deterministic and stochastic environments.			
<b>Syllabus:</b>			
<b>Course content</b>			<b>No. of Lectures</b>
<b>Inventory control:</b> Deterministic including price breaks and Multi-item with constraints, Probabilistic inventory control (with and without lead time), and Dynamic inventory models. Basic concept of supply–chain management.			7
<b>Network analysis:</b> PERT and CPM: Basic difference between PERT and CPM, Steps of PERT/CPM Techniques, PERT/CPM Network components and precedence relationships, Critical path analysis, Probability in PERT analysis, Project time–cost, trade-off.			8
<b>Replacement and Maintenance Models:</b> Failure Mechanism of items, Replacement of items deteriorates with time, Replacement policy for equipment when value of money changes with constant rate during the period, Replacement of items that fail completely – individual replacement policy and group replacement policy, Other replacement problems–staffing problem, equipment renewal problem.			6
<b>Simulation:</b> Steps of simulation process, Advantages and disadvantages of simulation, Stochastic simulation and random numbers— Monte Carlo simulation, Random number, Generation, Simulation of inventory Problems, Simulation of queuing problems, Role of computers in simulation, Applications of simulations.			6
<b>Queueing theory:</b> Basic Structures of queuing models, Poisson queues –M/M/1, M/M/C for finite and infinite queue length, Machine-Maintenance (steady state).			7
<b>Dynamic Programming:</b> Introduction, Nature of dynamic programming, Deterministic processes, Non-Sequential discrete optimisation, Allocation problems, Assortment problems, Sequential discrete optimisation, Long-term planning problem, Multi-stage decision process. Application of Dynamic Programming in production scheduling and routing problems.			6

<b>Total Lecture</b>	<b>40 hours</b>
<b>Further Readings:</b> <b>Text Books:</b> <ol style="list-style-type: none"> <li>Sharma, S. D. Operations Research, Kedar Nath Ram Nath &amp; Co., Meerut.</li> <li>Sharma J.K. (2006) Operations Research: theory and application, Macmillan Publishers.</li> </ol> <b>Reference Books:</b> <ol style="list-style-type: none"> <li>Taha, H. A. (2004) Operations research: An introduction. Pearson Education India.</li> <li>Hillier, F.S., (2012) Introduction to operations research. Tata McGraw-Hill Education.</li> </ol>	
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>	

### CO-PO-PSO Mapping (High/Medium/Low)

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	H	M	H	M	L	L	M	H	H	H	M	L
CO2	H	H	H	H	H	M	M	L	M	H	H	H	H	M
CO3	H	H	H	H	H	M	M	L	M	H	H	H	H	M
CO4	H	H	H	H	H	H	M	L	M	H	H	H	H	M

<b>Course code</b>	<b>MTM E 505B0</b>	<b>Elective-II: Dynamical Oceanology: Advanced Wave Hydrodynamics</b>	<b>Credit 4(3-1-0)</b> <b>Full Marks 50</b>
<b>Core/Elective/Other</b>		<b>Elective</b>	<b>Anyone from two Electives</b>

### Course Objectives:

The main objectives of this course are:

- To introduce the basic principles governing liquid surface waves, including the mathematical formulation of wave motion.
- To develop analytical understanding of progressive and stationary waves, with emphasis on kinematical and pressure conditions at free surfaces.
- To study the energy characteristics, steady motions, and velocity approximations associated with surface waves in various physical conditions.
- To explore wave behaviors in systems involving multiple liquid interfaces, variable bottom topographies, and varying depths.
- To examine the influence of external factors such as capillarity, wind, and long-wave effects, including solitary waves and their physical interpretations.

### Course Outcomes (COs)

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

**CO1:** Understand the fundamental concepts of liquid surface waves, including progressive and stationary waves, and the kinematical and pressure conditions at the free surface.

**CO2:** Analyze surface waves in canals and deep water, evaluating kinetic and potential energy distributions for different wave types.

**CO3:** Apply steady motion theories to surface waves, including wave propagation over varying depths, interfaces of two liquids, and sinuous bottoms, using first and second order approximations.

**CO4:** Examine the effects of capillarity, wind, and long-wave phenomena, including solitary waves, and interpret their applications in hydrodynamics and coastal engineering.

### Syllabus:

Course content	No. of Lectures
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Liquid Surface Waves: Introduction, General equation of wave motion, Mathematical representation of (a) Progressive waves (b) Stationary waves.	4
Kinematical condition at the free surface, Pressure condition at the free surface	2
Surface waves: (a) Progressive waves on the surface of a canal of finite depth (b) Progressive waves on deep water (c) Stationary waves on the surface of a canal of finite depth (d) Stationary waves on deep water	6
Kinetic and Potential energy of stationary waves	4
Steady motion: (a) Progressive waves on the surface of a canal of finite depth (b) Progressive waves on deep water (i) First order approximation to the wave speed (ii) Second order approximation to the wave speed (c) Progressive waves at an interface of two liquids (d) Progressive waves at an interface of two liquids when upper surface is free (e) Waves over a sinuous bottom	8
Group velocity, Dynamical significance of group velocity,	4
Capillary waves, Effect of capillarity on surface waves, Effect of capillarity on surface waves at an interface	6
Effect of wind on deep water, Long waves, Steady motion for long waves, Solitary waves	6
<b>Total Lecture</b>	<b>40 hours</b>
<b>Further Readings:</b>	
<b>Text Books:</b>	
1. Gupta A.: Groundwork of mathematical fluid dynamics, Academic Publishers, 2013.	
2. Batchelor G. K.: An Introduction to fluid dynamics, Cambridge University Press, 1967.	
3. Frank M. White: Fluid mechanics. Tata McGraw - Hill publishing company, New Delhi, 2008.	
<b>Reference Books:</b>	
1. Milne-Thomson L.M.: Theoretical hydrodynamics, The Macmillan Company, New York, 1950.	
2. Streeter V.L.: Fluid dynamics, McGraw Hill Book Company Inc. New York, 1948.	
3. Streeter V.L.: Handbook of Fluid dynamics, McGraw Hill Book Company Inc. New York, 1948.	
4. Yuan S.W.: Foundations of fluid mechanics, Prentice-Hall of India Pvt. Ltd., New Delhi, 1969	
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>	

### CO-PO-PSO Mapping (High/Medium/Low)

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	M	L	L	L	M	H	H	M	L	L
CO2	H	H	H	H	H	M	M	L	M	H	H	H	H	M
CO3	H	H	H	H	H	M	M	L	M	H	H	H	H	M
CO4	H	H	H	H	H	M	M	L	M	H	H	H	H	M

<b>Course code</b>	<b>MTM E 505C0</b>	<b>Elective-III: Computational Fluid Dynamics</b>	<b>Credit 4(3-1-0)</b> <b>Full Marks 50</b>
<b>Core/Elective/Other</b>		<b>Elective</b>	<b>Anyone from two Electives</b>
<b>Course Objectives:</b>			
The main objectives of this course are:			
1. To introduce the fundamental principles, advantages, and scope of Computational Fluid Dynamics.			
2. To develop knowledge of grid generation, variable arrangements, and boundary condition			

- implementation in computational domains.
3. To enable students to apply finite difference and finite volume methods to various types of partial differential equations governing fluid flow and heat transfer.
  4. To analyze numerical schemes for convergence, consistency, stability, and accuracy using theoretical frameworks.
  5. To train students in implementing and assessing discretization schemes for solving convection–diffusion and Navier–Stokes equations in steady and unsteady flows.

### Course Outcomes (COs)

**Upon successful completion of this course, students will be able to:**

**CO1:** Understand the fundamentals of CFD, including computational grids, variable arrangements, boundary condition implementation, and solution techniques for discretized equations.

**CO2:** Apply finite difference methods to solve parabolic and hyperbolic partial differential equations, using explicit, implicit, and semi-implicit schemes.

**CO3:** Analyze convergence, consistency, stability, and accuracy of numerical methods, and evaluate solutions using theoretical principles such as the Lax Equivalence Theorem and Von Neumann stability analysis.

**CO4:** Implement finite volume methods and discretization schemes, including central difference and upwind-biased schemes, to solve steady and unsteady convection-diffusion and Navier-Stokes equations for practical fluid flow problems.

### Syllabus:

Course content	No. of Lectures
<b>Preliminaries for Computational Fluid Dynamics(CFD):</b> Advantage of CFD, overview of CFD, Size of Computational Domain, Consideration of Grid (uniform/non-uniform), Variable arrangement (Cell center / Collocated arrangement and Staggered Grid), Space discretization and Time discretization (Explicit Algorithm, Implicit Algorithm, and Semi-implicit Algorithm), Implementation of boundary conditions (inlet/outlet/wall boundary) for collocated and staggered grid, Solution of discretised equation: Tri-diagonal matrix algorithm, Line-Gauss Seidel method, relaxation method	7
<b>Finite Difference Methods (FDM):</b> Space discretisation (Simple and general methods based on Taylor’s series), Accuracy of the Discretisation Process, <i>Conceptual Implementation to</i> (i) <i>Parabolic type:</i> 1D transient heat conduction (diffusion) problem and Couette Flow using FTCS , DuFort-Frankel, Richardson , Leap-frog schemes and Crank-Nicolson methods, and (ii) <i>Hyperbolic:</i> 1D first order Linear Convection-dominated problems and second order linear Wave Problems using FTCS, Upwind and the CFL conditions, Lax-Friedrich, Leap Frog, Lax-Wendroff, Crank-Nicolson, linear convection of a truncated sine wave	12
<b>Theoretical Background:</b> Convergence (Lax Equivalence Theorem, Analytical Treatment of Convergence), Consistency (FTCS, Fully Implicit Scheme), Stability ( Matrix Method and Von Neumann Method) and Solution Accuracy (Richardson Extrapolation )	8
<b>Finite Volume Method (FVM):</b> Equations with First order Derivatives Only, with second order Derivatives, The Finite Volume Method for Steady/unsteady one/two/three-dimensional heat conduction equation, Steady/unsteady one/two/three-dimensional convection and diffusion equation, continuity, Navier-Stokes Equation, Central Difference Scheme (CDS), Different Upwind Schemes for uniform and non-uniform grids: First Order Upwind (FOU) , Second Order Upwind Scheme (SOU), Third Order Upwind differencing (QUICK), Assessment (Conservativeness, Boundedness, Transportiveness and Accuracy ) of CDS, FOU and Stability problems of QUICK and remedies, Generalisation of upwind-biased discretization schemes	13
<b>Total Lecture</b>	<b>40 hours</b>

**Further Readings:****Text Books:**

1. C. A. J. Fletcher- Computational Techniques for Fluid Dynamics, Vol-I, Springer, 1988.
2. H.K.Versteeg and W Malalasekera, An Introduction to Computational Fluid Dynamics, Pearson, 2008.

**Reference Books:**

1. G.D.Smith, Numerical Solution of Partial Differential Equations: Finite Difference Methods (Oxford Applied Mathematics & Computing Science Series) by G. D. Smith, Oxford University Press.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]**

**CO-PO-PSO Mapping (High/Medium/Low)**

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	M	L	L	L	M	H	H	M	L	L
CO2	H	H	H	H	H	M	M	L	M	H	H	H	H	M
CO3	H	H	H	H	H	M	M	L	M	H	H	H	H	M
CO4	H	H	H	H	H	M	M	L	M	H	H	H	H	M

Course code	MTM O 506X0	Social Service / Community Engagement	Credit 2(0-0-4) Full Marks 25
<p>The Social Service / Community Engagement component aims to develop students' sense of social responsibility, empathy, and community participation. Students will engage in activities such as literacy and health awareness campaigns, plantation drives, cleanliness programs, voluntary service in rural or tribal areas, and participation in social welfare or NGO-led projects. Each student must complete a prescribed number of service hours under the supervision of a faculty coordinator. They are required to maintain a record of their activities in a logbook and submit a brief report with supporting evidence at the end of the semester. Evaluation will be based on regularity, quality of work, report, and presentation or viva, following the university's grading system. The program will be monitored by the concerned department.</p>			

## SEMESTER-IV

<b>Course code</b>	MTM E 551A1	<b>Elective-I: Nonlinear Optimization (Theory)</b>	<b>Credit 2 (1-1-0)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
<p>The main objectives of this course are:</p> <ol style="list-style-type: none"> <li>1. To provide a comprehensive understanding of stochastic, geometric, and multi-objective nonlinear programming models and their applications in optimization.</li> <li>2. To familiarize students with game-theoretic approaches and their relation to nonlinear programming for solving interactive decision-making problems.</li> <li>3. To develop the ability to apply concepts of optimality, differentiability, and duality to formulate and solve real-world nonlinear optimization problems effectively.</li> </ol>			
<b>Course Outcomes (COs):</b>			
<p>Upon successful completion of this course, students will be able to:</p> <p><b>CO1:</b> Analyze and solve stochastic, geometric, and multi-objective nonlinear programming problems using appropriate optimization techniques and game-theoretic approaches.</p> <p><b>CO2:</b> Apply the principles of optimality, differentiability, and duality in nonlinear programming to formulate and solve real-world optimization problems.</p>			
<b>Syllabus:</b>			
<b>Course content</b>			<b>No. of Lectures</b>
<b>Stochastic Programming:</b> Chance constraint programming technique.			2
<b>Geometric Programming:</b> Geometric programming (unconstraint) with positive and negative degree of difficulty.			2
<b>Games:</b> Preliminary concept of continuous game, Bi-matrix games, Nash equilibrium, and solution of bi-matrix games through quadratic programming (relation with nonlinear programming).			3
<b>Multi-objective Non-linear Programming:</b> Introductory concept and solution procedure. Fuzzy Multi-objective Nonlinear Programming			3
<b>Non-Linear Optimization:</b> The general nonlinear programming problem, The nature of optimization and scope of the theory,			1
<b>Optimality without differentiability:</b> Convex sets and separation theorem, Optimality in the absence of differentiability and constraint qualification, Karlin's constraint qualification, Kuhn-Tucker's saddle point necessary optimality theorem, Fritz-John saddle point optimality theorem			3
<b>Optimality with differentiability:</b> Differentiable convex and concave functions, Optimality criterion with differentiability and Convexity, Kuhn-Tucker's sufficient optimality theorem, Fritz-John stationary point optimality theorem,			4
<b>Duality in non-linear programming:</b> Duality in non-linear programming, Weak duality theorem, Wolfe's duality theorem, Duality for quadratic programming.			2
<b>Total Lecture</b>			<b>20 hours</b>
<b>Further Readings:</b>			
<b>Text Books:</b>			
<ol style="list-style-type: none"> <li>1. Olvi L.Mangasarian, Nonlinear Programming, Society for Industrial and Applied Mathematics, 1994.</li> <li>2. S.S. Rao, Engineering Optimization: Theory and Practice, John Wiley &amp; Sons, 1996.</li> </ol>			
<b>Reference Books:</b>			
<ol style="list-style-type: none"> <li>1. Mokhtar S. Bazaraa, Hanif D. Sherali and C.M. Shetty, Nonlinear Programming: Theory and</li> </ol>			

Algorithms, John Wiley & Sons, 2006.

2. [Kaisa Miettinen](#), Nonlinear Multi-objective Optimization, Kluwer Academic Publishers, Boston, 1999.
3. Frederick S. Hillier and Gerald J. Lieberman, Introduction to Operations Research, McGraw-Hill, 2010.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]**

**CO-PO-PSO Mapping (High/Medium/Low)**

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	M	L	L	M	L	L	M	L	L	H	L	L	M
CO2	H	H	M	M	H	L	L	L	M	L	H	M	M	L
CO3	M	H	H	M	H	M	L	L	H	H	H	H	M	M

<b>Course code</b>	<b>MTM E 551A9</b>	<b>Elective-I: Nonlinear Optimization (Practical)</b>	<b>Credit 2 (0-0-4)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
<p>The main objectives of this course are:</p> <ol style="list-style-type: none"> <li>1. To enable students to apply computational tools such as MATLAB and LINGO for solving advanced optimization and operations research problems.</li> <li>2. To enhance students' analytical and problem-solving abilities in modeling real-life optimization scenarios.</li> <li>3. To develop interpretation skills through analysis of computational outputs and their relevance to decision-making processes.</li> </ol>			
<b>Course Outcomes (COs):</b>			
<p>Upon successful completion of this course, students will be able to:</p> <p><b>CO1:</b> Solve Operations Research and advanced optimization problems, including LPP, QPP, Fuzzy LPP, Goal Programming, Stochastic Programming, Bi-matrix Games, and Nonlinear Optimization using MATLAB and LINGO.</p> <p><b>CO2:</b> Interpret and analyze computational results effectively, applying software tools to practical optimization and decision-making scenarios.</p>			
<b>Syllabus:</b>			
<b>OR methods using MATLAB and LINGO</b>			
<p>Problems on Advanced Optimization and Operations Research are to be solved by using MATLAB (one question carrying 09 marks) and LINGO (one question carrying 06 marks) (Total: 15 Marks) Lab Note: 5 Marks, Viva-Voce : 5 Marks</p> <p>Problems on LPP, QPP, Fuzzy LPP, Goal Programming Problem, Stochastic Programming, Bi-matrix Game, Nonlinear Optimization with Equality and Inequality Constraints.</p>			
<b>Further Readings:</b>			
<b>Text Books:</b>			
<ol style="list-style-type: none"> <li>1. Gilat, A. (2008) MATLAB: an Introduction with Applications. New York: Wiley.</li> <li>2. Palm III, W. J. (2011) Introduction to MATLAB for Engineers. New York: McGraw-Hill.</li> </ol>			
<b>Reference Books:</b>			
<ol style="list-style-type: none"> <li>1. Chapman, S. J. (2012) MATLAB programming with applications for engineers. Cengage Learning.</li> <li>2. Lopez, C. (2014) MATLAB programming for numerical analysis. Apress.</li> </ol>			

### CO-PO-PSO Mapping (High/Medium/Low)

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	H	M	H	L	L	L	M	H	H	H	M	L
CO2	M	H	M	H	M	M	L	L	H	H	M	H	H	M

<b>Course code</b>	<b>MTM E 551B1</b>	<b>Elective-II: Dynamical Meteorology: Dynamics in Atmosphere (Theory)</b>	<b>Credit 2 (1-1-0) Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
The main objectives of this course are: <ol style="list-style-type: none"> <li>To introduce students to the fundamental principles governing atmospheric motion and the various forces acting on air parcels.</li> <li>To develop understanding of the balance of forces and the formation of different types of atmospheric winds.</li> <li>To apply thermodynamic and dynamic equations to analyze energy, circulation, and vorticity in the atmosphere.</li> </ol>			
<b>Course Outcomes (COs):</b>			
Upon successful completion of this course, students will be able to: <b>CO1:</b> Analyze fundamental atmospheric forces, equations of motion, and force balances, including geostrophic, gradient, inertial, cyclostrophic, and thermal winds. <b>CO2:</b> Apply thermodynamic energy equations, and concepts of circulation, vorticity, and divergence to understand atmospheric motion and dynamic processes.			
<b>Syllabus:</b>			
<b>Course content</b>			<b>No. of Lectures</b>
Fundamental atmospheric forces, inertial and non-inertial frame of references			3
Equation of momentum of an air parcel: in vector form, Cartesian coordinates spherical coordinates, natural coordinates and isobaric coordinates			4
Balance of forces: Geostrophic wind, Gradient wind, inertial wind			3
Cyclostrophic wind and Thermal wind			2
Thermodynamic energy equation, Atmospheric energy equation			3
Circulation, vorticity, divergence. Surface of discontinuity			5
<b>Further Readings:</b>			
<b>Text Books:</b> <ol style="list-style-type: none"> <li>Dynamical and Physical Meteorology: George J. Haltiner and Frank L. Martin, McGraw Hill</li> <li>An introduction to Dynamical Meteorology: Holton J.R., Academic Press</li> </ol>			
<b>Reference Books:</b> <ol style="list-style-type: none"> <li>Physical and Dynamical Meteorology: D. Brunt, Cambridge University Press</li> <li>Atmospheric Thermodynamics: Iribarne, J.V. and Godson, W.L.</li> </ol>			
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>			

### CO-PO-PSO Mapping (High/Medium/Low)

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	H	L	L	L	M	H	H	M	M	L
CO2	H	H	M	H	H	M	L	L	M	H	H	M	H	M

<b>Course code</b>	<b>MTM E 551B9</b>	<b>Elective-II: Dynamical Meteorology: Dynamics in Atmosphere (Practical)</b>	<b>Credit 2 (0-0-4) Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
The main objectives of this course are: <ol style="list-style-type: none"> <li>To familiarize students with the measurement techniques and principles of key atmospheric parameters such as temperature, pressure, humidity, and wind.</li> <li>To develop practical skills in analyzing meteorological data using instruments, T–diagrams, and station models.</li> <li>To enable students to interpret and correlate observed atmospheric data with theoretical meteorological concepts for weather analysis and forecasting.</li> </ol>			
<b>Course Outcomes (COs):</b>			
Upon successful completion of this course, students will be able to:			
<b>CO1:</b> Measure and analyze key atmospheric parameters including surface temperature, potential temperature, virtual temperature, wet-bulb temperature, pressure, humidity, mixing ratio, vapor pressure, wind speed and direction, and rainfall.			
<b>CO2:</b> Interpret T-diagrams, station models, and experimental data from meteorological laboratories to understand and apply practical concepts in atmospheric and weather analysis.			
<b>Syllabus:</b>			
<b>Course content</b>			<b>No. of Lectures</b>
Surface temperature, potential temperature, virtual temperature, wet bulb temperature, pressure			4
Relative humidity, specific humidity, mixing ratio, saturation pressure, vapor pressure, Wind speed and direction measurements			4
Rainfall and rain measurements			2
T- diagram: Geopotential height by isotherm / adiabatic method, To find dry bulb and wet bulb temperature, potential, virtual, equivalent, potential, dew point temperatures and mixing ratio.			6
Station model analysis			2
Students should go to one of the University/Institute/Organization laboratory to understand experimental set-ups in advance meteorology.			2
<b>Total Lecture</b>			<b>20 hours</b>
<b>Further Readings:</b>			
<b>Text Books:</b>			
<ol style="list-style-type: none"> <li>Haltiner, G. J. and Martin, F. L. Dynamical and Physical Meteorology, McGraw Hill.</li> <li>Holton, J.R. An introduction to Dynamical Meteorology, Academic Press.</li> </ol>			
<b>Reference Books:</b>			
<ol style="list-style-type: none"> <li>Brunt, D. Physical and Dynamical Meteorology, Cambridge University Press.</li> <li>Iribarne, J.V. and Godson, W.L. Atmospheric Thermodynamics.</li> </ol>			
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>			

### CO–PO–PSO Mapping (High/Medium/Low)

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	H	M	L	M	M	L	H	M	M	M

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO2	M	H	M	H	H	H	M	M	M	L	M	H	H	H

<b>Course code</b>	<b>MTM E 551C1</b>	<b>Elective-III: Mathematical Modeling in Ecological Systems (Theory)</b>	<b>Credit 2 (1-1-0)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
The main objectives of this course are:			
<ol style="list-style-type: none"> <li>To introduce students to the formulation and analysis of population dynamics models for single and multiple species.</li> <li>To develop the ability to model real-world biological and epidemiological systems using mathematical frameworks.</li> <li>To equip students with analytical and computational skills for interpreting population and epidemic models, emphasizing the role of parameters such as the basic reproductive number.</li> </ol>			
<b>Course Outcomes (COs):</b>			
Upon successful completion of this course, students will be able to:			
<b>CO1:</b> Analyze and solve mathematical models for single-species population dynamics including Malthus, Logistic, and Gompertz models.			
<b>CO2:</b> Develop, interpret, and analyze models for interacting species and epidemiological systems, including Lotka–Volterra, Kolmogorov, prey–predator models, SIR, SIRS, SCI, SIS models, and compute the basic reproductive number.			
<b>Syllabus:</b>			
<b>Course content</b>			<b>No. of Lectures</b>
Models for single species: Malthus model, Logistic model, Gompertz model and its analysis			6
Models for interacting Species: Lotka-Volterra model, Kolmogorov model, Prey-predator System and its analysis			6
Models in Epidemiology: Kermack- McKendrick epidemic model, SIR, SIRS, SCI, SIS			6
The Basic Reproductive Number			2
<b>Total Lecture</b>			<b>20 hours</b>
<b>Further Readings:</b>			
<b>Text Books:</b>			
<ol style="list-style-type: none"> <li>Dynamical Systems for Biological Modeling: An Introduction, Fred Brauer, Christopher Kribs, CRC Press</li> <li>Mathematical Models in Population Biology and Epidemiology, Fred Brauer, Carlos Castillo-Chavez, Springer.</li> </ol>			
<b>Reference Books:</b>			
<ol style="list-style-type: none"> <li>Dynamical Systems with Applications using MATLAB, Stephen Lynch, Springer International Publishing.</li> <li>Population Ecology: An Introduction to Computer Simulations, Ruth Bernstein, John Wiley &amp; Sons.</li> <li>Mathematical Modeling and Simulation with MATLAB, Lee, S., Buzby, M.</li> </ol>			
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>			

### CO–PO–PSO Mapping (High/Medium/Low)

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	M	L	L	L	M	L	H	M	M	L

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO2	H	H	H	H	H	M	M	L	M	M	H	H	H	M

<b>Course code</b>	<b>MTM E 551C9</b>	<b>Elective-III: Mathematical Modeling in Ecological Systems (Practical)</b>	<b>Credit 2 (0-0-4)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
<p>The main objectives of this course are:</p> <ol style="list-style-type: none"> <li>1. Develop computational proficiency in MATLAB for analyzing nonlinear dynamical systems in population and epidemiological models.</li> <li>2. Enable students to simulate and visualize phase portraits, limit cycles, bifurcations, and periodic behaviors of mathematical models.</li> <li>3. Interpret and evaluate the results of computational simulations to study system stability and transitions in dynamic models.</li> </ol>			
<b>Course Outcomes (COs):</b>			
<p>Upon successful completion of this course, students will be able to:</p> <p><b>CO1:</b> Implement MATLAB programs to visualize and analyze phase portraits, limit cycles, bifurcation diagrams, periodic orbits, and Poincaré maps for population and epidemiological models.</p> <p><b>CO2:</b> Interpret computational results to understand the dynamics of single-species, interacting species, and epidemiological systems, including stability, periodicity, and bifurcation behavior.</p>			
<b>Syllabus:</b>			
<b>Course content</b>			<b>No. of Lectures</b>
MATLAB Programs to draw and analyse phase portraits of the above-mentioned models			9
MATLAB Programs to draw and analyse limit cycles, bifurcation diagram map of the above-mentioned models			8
MATLAB Programs to draw and analyse periodic orbits, Poincaré map of the above-mentioned models			8
<b>Total Lecture</b>			<b>25 hours</b>
<b>Further Readings:</b>			
<b>Text Books:</b>			
<ol style="list-style-type: none"> <li>3. Brauer, F. and Kribs, C. Dynamical Systems for Biological Modeling: An Introduction, CRC Press.</li> <li>4. Brauer, F. and Castillo-Chavez, C. Mathematical Models in Population Biology and Epidemiology, Springer.</li> </ol>			
<b>Reference Books:</b>			
<ol style="list-style-type: none"> <li>1. Lynch, S. Dynamical Systems with Applications using MATLAB, Springer International Publishing.</li> <li>2. Bernstein, R. Population Ecology: An Introduction to Computer Simulations, <a href="#">John Wiley &amp; Sons</a>.</li> <li>3. Lee, S. and Buzby, M. Mathematical Modeling and Simulation with MATLAB.</li> </ol>			
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>			

### CO-PO-PSO Mapping (High/Medium/Low)

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	M	H	H	M	H	L	L	L	M	M	M	H	H	L
CO2	M	H	M	H	H	M	L	L	M	M	M	H	H	M

<b>Course code</b>	<b>MTM E 552A1</b>	<b>Operations Research Modelling-II (Theory)</b>	<b>Credit 2 (1-1-0)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
The main objectives of this course are: <ol style="list-style-type: none"> <li>1. Understand the fundamental principles of optimal control, reliability engineering, and information theory in applied mathematical contexts.</li> <li>2. Develop analytical and computational skills to model, analyze, and optimize control systems, reliability models, and communication processes.</li> <li>3. Apply mathematical and statistical reasoning to evaluate real-world systems for performance, reliability, and information efficiency.</li> </ol>			
<b>Course Outcomes (COs):</b>			
Upon successful completion of this course, students will be able to:			
<b>CO1:</b> Apply principles of optimal control, including calculus of variations and Pontryagin's principle, to solve engineering and mechanical optimization problems, including bang–bang control scenarios.			
<b>CO2:</b> Analyze system reliability, maintainability, and information theory concepts, including entropy, mutual information, and encoding techniques, to evaluate and optimize engineering systems and communication processes.			
<b>Syllabus:</b>			
<b>Course content</b>			<b>No. of Lectures</b>
Optimal Control: Performance indices, Methods of calculus of variations, transversal conditions, Simple optimal problems of mechanics, Pontryagin's principle (with proof assuming smooth condition), Bang–bang Controls.			6
Reliability: Concept, reliability definition, System Reliability, System Failure rate, Reliability of the Systems connected in Series or/and parallel. MTBF, MTTF, optimization using reliability, reliability and quality control comparison, reduction of the life cycle with reliability, maintainability, availability, Effect of age, stress, and mission time on reliability.			5
Information Theory: Introduction, Communication Processes- memoryless channel, the channel matrix, Probability relation in a channel, noiseless channel. A Measure of information- Properties of Entropy function, Marginal and joint entropies, conditional entropies, expected mutual information,			5
Encoding-Objectives of Encoding. Shannon-Fano Encoding Procedure, Necessary and Sufficient Condition for Noiseless Encoding.			4
<b>Total Lecture</b>			<b>20 hours</b>
<b>Further Readings:</b>			
<b>Text Books:</b>			
<ol style="list-style-type: none"> <li>1. Sharma, S.D. Operations Research, Ram Nath, Kedar Bath &amp; Co. Meerut.</li> <li>2. Swarup, K., Gupta, P.K and Man, M. Operations Research, Sultan Chand &amp; Sons.</li> </ol>			
<b>Reference Books:</b>			
<ol style="list-style-type: none"> <li>1. Sharma, J.K Operation Research – Theory and Application, Macmillan.</li> <li>2. Gupta, P.K. and Hira, D.S., Operations Research, S. Chand &amp;Co.Ltd.</li> <li>3. Taha, H.A., Operations Research –an Introduction, PHI.</li> <li>4. Bronson, R. and Naadimuthu. G., Theory and Problems of Operations Research, Schaum's Outline Series, McGraw-Hill.</li> </ol>			
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>			

### CO–PO–PSO Mapping (High/Medium/Low)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	H	M	L	M	M	M	H	H	M	M

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO2	H	H	H	M	M	M	L	M	H	M	H	H	H	H

<b>Course code</b>	<b>MTM E 552A9</b>	<b>Operations Research Modeling-II (Practical)</b>	<b>Credit 2 (0-0-4) Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
<p>The main objectives of this course are:</p> <ol style="list-style-type: none"> <li>1. Understand and implement computational methods for solving advanced optimization and operations research problems.</li> <li>2. Apply software tools such as MATLAB, LINGO, C++, and Python to model and analyze real-world decision-making systems.</li> <li>3. Develop analytical, programming, and problem-solving skills for engineering, industrial, and management applications.</li> </ol>			
<b>Course Outcomes (COs):</b>			
<p>Upon successful completion of this course, students will be able to:</p> <p><b>CO1:</b> Formulate and solve advanced Operations Research and optimization problems, including queuing theory, inventory models, Monte Carlo simulation, dynamic programming, and reliability, using MATLAB, LINGO, C++, or Python.</p> <p><b>CO2:</b> Analyze and interpret computational results effectively, applying software tools to practical decision-making and optimization scenarios in engineering and management contexts.</p>			
<b>Syllabus:</b>			
<p>Problems on Advanced Optimization and Operations Research are to be solved by using MATLAB/LINGO/C++/Python</p> <p>Problems with Queuing Theory, Inventory, Monte Carlo Simulation Technique, Dynamic Programming, and Reliability.</p>			
<b>Further Readings:</b>			
<b>Text Books:</b>			
<ol style="list-style-type: none"> <li>1. Sharma, S.D. Operations Research, Ram Nath, Kedar Bath &amp; Co. Meerut.</li> </ol>			
<b>Reference Books:</b>			
<ol style="list-style-type: none"> <li>1. Sharma, J.K Operation Research – Theory and Application, Macmillan.</li> <li>2. Gupta, P.K. and Hira, D.S., Operations Research, S. Chand &amp;Co.Ltd.</li> <li>3. Taha, H.A., Operations Research –an Introduction, PHI.</li> <li>4. Bronson, R. and Naadimuthu. G., Theory and Problems of Operations Research, Schaum’s Outline Series, McGraw-Hill.</li> </ol>			
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>			

### CO-PO-PSO Mapping (High/Medium/Low)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	H	M	H	M	L	M	M	H	H	H	H	M
CO2	H	H	H	M	M	H	M	M	H	H	H	H	M	H

<b>Course code</b>	<b>MTM E 552B1</b>	<b>Elective II: Dynamical Oceanology: Coastal Processes (Theory)</b>	<b>Credit 2 (1-1-0) Full Marks 25</b>
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Core/Elective/Other	Core	Compulsory
<b>Course Objectives:</b>		
<p>The main objectives of this course are:</p> <ol style="list-style-type: none"> <li>1. Understand the fundamental theories and governing principles of surface gravity waves and their interactions with coastal and oceanic environments.</li> <li>2. Develop the ability to analyze wave transformation processes such as shoaling, refraction, diffraction, reflection, and breaking under varying bathymetric and current conditions.</li> <li>3. Apply mathematical and physical models to tsunami propagation, wave–seabed interaction, and sediment transport in coastal engineering and oceanography.</li> </ol>		
<b>Course Outcomes (COs):</b>		
<p>Upon successful completion of this course, students will be able to:</p> <p><b>CO1:</b> Analyze and evaluate wave propagation phenomena including shoaling, refraction, diffraction, reflection, wave breaking, run-up, and the effects of currents.</p> <p><b>CO2:</b> Apply principles of tsunami propagation, wave interaction with real seabeds, and sediment transport to predict inundation, wave deformation, and long-shore sediment movement.</p>		
<b>Syllabus</b>		
<b>Course content</b>		<b>No. of Lectures</b>
Wave Propagation: Wave Shoaling, Refraction, Diffraction, Reflection		2
Effect of Currents, Wave Breaking, Wave Set up and Set down, Wave Run-up.		2
Tsunamis, Properties of tsunamis, Inundation levels, Conservation of mass equation, Prediction of storm surge		4
Waves over Real Sea beds: Waves over smooth, rigid, impermeable bottoms		4
Water waves over a viscous mud bottom, Waves over rigid porous bottoms		4
Wave deformation		2
Sediment characteristics and long-shore sediment transport		2
<b>Total Lecture</b>		<b>20 hours</b>
<b>Further Readings:</b>		
<b>Text Books:</b>		
<ol style="list-style-type: none"> <li>1. Robert G. Dean and Robert A. Dalrymple, Water Wave Mechanics for Engineers and Scientists, World Scientific Publishing Co. Pte. Ltd., Volume 2, 2002.</li> <li>2. M. C. Deo, Waves and Structures, 2013.</li> <li>3. Silvester, R. and Hsu, J.R.C. Coastal Stabilisation, Advances on Ocean Engineering-Volume 14, World Scientific, 1997.</li> </ol>		
<b>Reference Books:</b>		
<ol style="list-style-type: none"> <li>1. Kamphius, J.W. Introduction to Coastal Engineering and Management, Advances on Ocean Engineering-Volume 16, World Scientific, 2002.</li> <li>2. Goldstein S.: Modern Developments in Fluid Dynamics, Oxford University Press, New York, 1938.</li> <li>3. Lamb H.: Hydrodynamics, Dover Publications, New York, 1932.</li> <li>4. McCormack P. D. and L. Crane: Physical Fluid Dynamics, Academic Press, New York, 1973.</li> </ol>		
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>		

### CO-PO-PSO Mapping (High/Medium/Low)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	H	M	L	M	M	M	H	M	M	M
CO2	H	H	M	H	H	M	L	M	H	M	H	H	H	H

<b>Course code</b>	<b>MTM E 552B9</b>	<b>Elective II: Dynamical Oceanology: Coastal Processes (Practical)</b>	<b>Credit 2 (0-0-4)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
<p>The main objectives of this course are:</p> <ol style="list-style-type: none"> <li>1. Understand the experimental techniques for measuring and analyzing velocity profiles and turbulence characteristics in open-channel and laboratory wave-current flows.</li> <li>2. Develop the ability to process, compute, and visualize velocity and turbulence data using statistical and probabilistic methods.</li> <li>3. Gain hands-on experience with laboratory instrumentation and data analysis tools to interpret flow behavior and turbulence mechanisms.</li> </ol>			
<b>Course Outcomes (COs):</b>			
<p>Upon successful completion of this course, students will be able to:</p> <p><b>CO1:</b> Measure and analyze stream-wise, transverse, and wall-normal mean velocities, turbulence intensity, and Reynolds shear stress profiles for current-only and wave-current flows using vertical velocity measurements.</p> <p><b>CO2:</b> Compute and interpret statistical parameters including skewness, kurtosis, probability density functions, and joint probability density functions to characterize turbulence and flow behavior in laboratory experiments.</p>			
<b>Syllabus:</b>			
<b>Course content</b>			<b>No. of Lectures</b>
Determine the distribution of stream-wise, transverse, wall-normal mean velocity from 15 vertical measurements for current only flow.			5
Determine the turbulence intensity and Reynolds shear stress profile from 15 vertical measurements for current only flow.			4
Evaluate the coefficient of skewness and kurtosis, distribution of probability density function and Joint probability density function from 15 vertical measurements for the current only flow.			5
Determine the distribution of stream-wise, transverse, wall-normal mean velocity from 15 vertical measurements for wave-current flow.			5
Determine the turbulence intensity and Reynolds shear stress profile from 15 vertical measurements for wave-current flow.			4
Evaluate the coefficient of skewness and kurtosis, distribution of probability density function and Joint probability density function from 15 vertical measurements for wave-current flow.			5
<b>Further Readings:</b>			
<b>Text Books:</b>			
1. Nezu I, Nakagawa H. Turbulence in Open-Channel Flows. A.A. Balkema, CRC Press, Rotterdam 1993.			
<b>Reference Books:</b>			
1. Pope S.B. Turbulent Flows, Cambridge University Press, Cambridge, 1-771, 2000.			
2. Dey, S. Fluvial Hydrodynamics – Hydrodynamic and Sediment Transport Phenomena, Springer, 2014.			
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>			

### CO-PO-PSO Mapping (High/Medium/Low)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	H	M	H	M	L	M	M	M	H	H	M	M
CO2	H	H	H	H	M	M	L	M	H	M	H	H	H	H

<b>Course code</b>	<b>MTM E 552C1</b>	<b>Elective III: Computational and Semi-Analytical Methods (Theory)</b>	<b>Credit 2 (1-1-0)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
<p>The main objectives of this course are:</p> <ol style="list-style-type: none"> <li>1. Understand the fundamental principles of numerical and semi-analytical techniques for solving nonlinear ordinary and partial differential equations in fluid mechanics.</li> <li>2. Apply decomposition-based and homotopy-based approaches to obtain analytical and convergent solutions for incompressible viscous flow problems.</li> <li>3. Develop computational proficiency in implementing and comparing different semi-analytical techniques for modeling, analysis, and optimization of flow systems.</li> </ol>			
<b>Course Outcomes (COs):</b>			
<p>Upon successful completion of this course, students will be able to:</p> <p><b>CO1:</b> Apply numerical and semi-analytical methods such as SIMPLE/SIMPLER, Adomian Decomposition Method (ADM), and Variational Iteration Method (VIM) to solve ordinary and partial differential equations arising in incompressible viscous flow problems.</p> <p><b>CO2:</b> Utilize homotopy-based advanced methods—including Homotopy Perturbation Method (HPM), Homotopy Analysis Method (HAM), Optimal HAM (O-HAM), and Optimal/Modified HPM (OM-HPM)—to obtain accurate and convergent solutions for complex flow and differential equation systems.</p>			
<b>Syllabus:</b>			
<b>Course content</b>			<b>No. of Lect.</b>
<b>Primitive Variable Formulation for Incompressible Viscous Flow:</b> The Momentum equation, Pressure and Velocity Corrections, Pressure-Correction equation, Semi-Implicit Method for Pressure-Linked Equation (SIMPLE), Boundary Condition for Pressure-Correction equation, Revised-SIMPLE (SIMPLER), Numerical Examples			4
<b>Adomian Decomposition Method (ADM):</b> ADM for ODEs, Solving System of ODEs by ADM, ADM for Solving Partial Differential Equations, ADM for System of PDEs, Numerical Examples			3
<b>Variational Iteration Method (VIM):</b> Methodology, Linear Operator and Lagrange's Multiplier, Advantages and limitations, Applications to Ordinary and fractional order differential equations, Revised-VIM (R-VIM).			3
<b>Homotopy Based Advanced Semi-Analytical Methods:</b> Introduction to concept of Homotopy in topology and traditional Perturbation method. Then following advance methods are to be discussed:			10
<ol style="list-style-type: none"> <li>1. <b>Homotopy Perturbation Method (HPM)</b> : Basic Idea of HPM, Numerical Examples, Advantages and limitations</li> <li>2. <b>Homotopy Analysis Method (HAM):</b> Zeroth order Homotopy equation, Higher order deformation equation, convergence of homotopy-series solution, essence of convergence control parameter, Choice of linear operator and initial guess, Advantages and limitations</li> <li>3. <b>Optimal HAM (O-HAM):</b> Different types of residual calculating and optimal methods) and their flexibility Generalised Newtonian Iteration formula, Advantages and limitations</li> <li>4. <b>Optimal and Modified HPM (OM-HPM):</b> Introduction of convergence control parameter in the auxiliary linear operator, its methodology, its superiority over HPM, HAM and Optimal HAM.</li> </ol>			

**Further Readings:****Text Books:**

1. Subhash V Patanker, Numerical Heat Transfer and Fluid Flow, McGraw-Hill Book Company.
2. S. Chakraverty, N R Mahato, P. Karunakar, and T. D. Rao, Advanced Numerical and Semi-Analytical Methods for Differential Equations, Wiley, 2019.

**Reference Books:**

1. H.K.Versteeg and W Malalasekera-An Introduction to Computational Fluid Dynamics, Pearson 2008

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]****CO-PO-PSO Mapping (High/Medium/Low)**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	H	M	H	M	L	M	M	M	H	H	H	M
CO2	H	H	H	H	H	M	L	M	H	M	H	H	H	H

<b>Course code</b>	<b>MTM E 552C9</b>	<b>Elective III: Computational and Semi-Analytical Methods (Practical)</b>	<b>Credit 2 (0-0-4)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>

**Course Objectives:**

The main objectives of this course are:

1. Understand and implement computational methods for solving diffusion, convection, and incompressible viscous flow problems using MATLAB.
2. Apply semi-analytical approaches such as ADM, VIM, HPM, HAM, O-HAM, and OM-HPM using Mathematica to solve differential equations arising in fluid dynamics.
3. Integrate theoretical, numerical, and semi-analytical concepts to analyze and interpret fluid flow behavior with practical computational skills.

**Course Outcomes (COs):**

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

**CO1:** Implement computational fluid dynamics methods in MATLAB to solve steady and unsteady diffusion and convection problems, as well as incompressible viscous flow problems using Finite Difference, Finite Volume, and SIMPLE algorithms.

**CO2:** Apply advanced semi-analytical methods such as ADM, VIM, HPM, HAM, O-HAM, and OM-HPM using Mathematica to obtain accurate solutions for ordinary, fractional, and partial differential equations relevant to fluid dynamics.

**Syllabus:**

In MTM304C (Computational Fluid Dynamics), the focus was primarily on introducing computational fluid dynamics methods, with some computational solution for their understanding of those methods. However, the present course goes a step further by incorporating **practical implementation of these methods along with advanced semi-analytical approaches** such as ADM, VIM, HPM, HAM, and OM-HPM. Without the integration of these practical components and semi-analytical frameworks, the knowledge from MTM304C remains incomplete. This course therefore provides the **necessary complement** to MTM304C by equipping students with both **theoretical understanding and hands-on implementation skills**, making the learning process holistic and directly applicable to complex fluid dynamics problems.

1. MATLAB-Based Numerical Code for Computational Methods: Numerical experiments for the solution of steady/unsteady one-dimensional diffusion and / or convection equations using Finite difference method (FTCS, Lax-Friedrichs, Leap Frog, Crank-Nicolson methods) and Finite volume method (Central Difference Scheme (CDS) and different upwind schemes). Numerical experiments for the solution of some problems on fluid dynamics using SIMPLE algorithm

2. MATHEMATICA-Based Code for Semi-analytical Methods: Series semi-analytical solutions of some ordinary as well as fractional differential equations using advanced semi-analytical approaches such as ADM, VIM, HPM, HAM, O-HAM and OM-HPM with the help of Mathematica software.
<b>Further Readings:</b>
<b>Text Books:</b>
1. H.K.Versteeg and W Malalasekera-An Introduction to Computational Fluid Dynamics, Pearson 2008
2. C. A. J. Fletcher, Computational Techniques for Fluid Dynamics, Vol-I, Springer, 1988.
3. S. Chakraverty, N R Mahato, P. Karunakar, and T. D. Rao, Advanced Numerical and Semi-Analytical Methods for Differential Equations, Wiley, 2019.
<b>Reference Books:</b>
1. Subhash V Patanker, Numerical Heat Transfer and Fluid Flow, McGraw-Hill Book Company
<b>Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]</b>

### CO-PO-PSO Mapping (High/Medium/Low)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	H	M	H	M	L	M	M	M	H	H	H	M
CO2	H	H	H	H	H	M	L	M	H	M	H	H	H	H

<b>Course code</b>	<b>MTM C 553X9</b>	<b>Research Project/Dissertation</b>	<b>Credit 8 (0-0-16)</b> <b>Full Marks 100</b>
<b>Core/Elective/Other</b>	<b>Core</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
<p>The main objectives of this course are:</p> <ol style="list-style-type: none"> <li>1. Identify and define research problems in mathematics and applied sciences through systematic review of existing literature and identification of knowledge gaps.</li> <li>2. Formulate mathematical models and apply appropriate analytical, numerical, or computational methods to address the selected research problems.</li> <li>3. Develop independent research skills, including data collection, analysis, validation, and critical interpretation of results.</li> <li>4. Enhance scholarly communication abilities through effective preparation of reports, presentations, and scientific publications.</li> <li>5. Demonstrate professional ethics, integrity, and responsibility in conducting and presenting mathematical research.</li> </ol>			
<b>Course Outcomes (COs):</b>			
Upon successful completion of this course, students will be able to:			
<b>CO1:</b> Identify, formulate, and analyze mathematical research problems by reviewing existing literature and recognizing gaps in knowledge.			
<b>CO2:</b> Apply appropriate mathematical tools, techniques, and methodologies to develop models, perform computations, and derive results for the chosen research problem.			
<b>CO3:</b> Critically interpret research outcomes, validate results, and assess their significance in the context of the problem and existing literature.			
<b>CO4:</b> Communicate research findings effectively through well-structured reports, presentations, and publications while adhering to academic integrity and ethical standards.			
<b>Guidelines for Postgraduate Research (8 Credits)</b>			
<b>1. Selection of Topic</b>			

The research topic must be carefully chosen so that it is relevant to the student's subject area and aligned with their academic interests. It should be practical and feasible to complete within the available time frame and resources, ensuring that the objectives can be realistically achieved. Finally, the selected topic must be reviewed and formally approved by the assigned Research Guide or Mentor to ensure its suitability and academic value.

## **2. Role of Student**

Students must actively participate in the entire research process by identifying a clear problem, conducting a literature survey to find gaps, and preparing a structured plan with objectives, methodology, and timeline. They should collect and analyse data appropriately, then compile findings into a well-organised research report or dissertation (to be submitted for evaluation).

## **3. Role of Research Guide / Mentor**

The Research Guide or Mentor plays a crucial role in supporting the student's research journey by assisting in the selection of a suitable topic and refining the research questions. They are responsible for providing guidance in the choice of methodology, data collection techniques, and methods of analysis. The mentor also ensures that the student follows ethical practices, including avoiding plagiarism and maintaining confidentiality in handling data. In addition, the guide monitors the student's progress through regular meetings and constructive feedback, helping to keep the research work on track and of high academic quality.

## **4. Report Format**

- **Title Page** (with student name, guide name, department, date).
- **Abstract** (summary of research in 250–300 words).
- **Introduction & Objectives.**
- **Review of Literature.**
- **Research Methodology** (design, data collection, sampling, tools).
- **Analysis and Results.**
- **Discussion** (interpretation of findings).
- **Conclusion & Future Scope.**
- **References** (APA / standard style).
- **Appendices** (if any).

## **5. Ethical Considerations**

Students must maintain academic integrity by avoiding plagiarism, ensuring confidentiality and anonymity of data sources, and properly acknowledging all references and contributions. In case of publication, they should strictly follow the norms of publication ethics, upholding transparency, credibility, and honesty in presenting their research findings.

## **6. Evaluation**

The department will form an evaluation committee consisting of the research guide(s), departmental faculty members, and external subject experts. At least one external member must be part of the committee and present during the student's presentation. The committee will assess and evaluate the complete research report and presentation.

## **7. Marks distribution**

### **Total marks 100; Credits 8**

- Proposal and Abstract – 10 marks
- Literature Review – 10 marks
- Methodology & Data Collection – 10 marks
- Data Analysis & Interpretation – 10 marks
- Report Quality – 30 marks or full 70 marks
- Viva-Voce & Presentation – 30 marks

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]**

### CO-PO-PSO Mapping (High/Medium/Low)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	H	H	M	M	M	H	M	H	H	H	H
CO2	H	H	H	H	H	M	M	M	H	M	H	H	H	H
CO3	H	H	M	H	H	H	M	M	H	M	H	H	H	H
CO4	M	M	M	H	M	H	H	H	H	H	M	M	M	H

<b>Course code</b>	<b>MTM O 554X9</b>	<b>Field Visit</b>	<b>Credit 2 (0-0-4)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Other</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
<p>The main objectives of this course are:</p> <ol style="list-style-type: none"> <li>1. To expose students to real-world applications of mathematical concepts, models, and computational techniques through field or industrial experiences.</li> <li>2. To develop analytical and problem-solving abilities by observing and interpreting mathematical practices in professional or research environments.</li> <li>3. To enhance communication and documentation skills through effective report writing and presentations on field-based mathematical observations.</li> </ol>			
<b>Course Outcomes (COs):</b>			
<p>Upon successful completion of this course, students will be able to:</p> <p><b>CO1:</b> Analyze and interpret real-world applications of mathematical concepts, techniques, and computational methods observed during field visits, connecting theoretical knowledge with practical scenarios.</p> <p><b>CO2:</b> Demonstrate effective communication and documentation skills by preparing detailed reports and presentations on mathematical applications, insights, and learning outcomes from professional or research environments.</p>			
<b>Guidelines for Field Visit</b>			
<b>Objective:</b>			
<p>The field visit aims to provide students with practical exposure to real-world applications of mathematical concepts, techniques, and computational tools in industry, research institutions, laboratories, or other relevant organizations. It enhances observational, analytical, and problem-solving skills.</p>			
<b>Duration:</b>			
<p>The field visit should cover at least 1-3 full days or equivalent hours spread over multiple visits, depending on the host organization's schedule and course requirements.</p>			
<b>Preparation:</b>			
<ol style="list-style-type: none"> <li>1. Students must form groups (3–5 members per group) for better coordination and reporting.</li> <li>2. Prior to the visit, students should study the background of the organization and identify key areas where mathematics is applied.</li> <li>3. Prepare a list of questions or topics to explore during the visit.</li> </ol>			
<b>During the Visit:</b>			
<ol style="list-style-type: none"> <li>1. Students should actively observe and note mathematical applications in real-world scenarios such as data analysis, modelling, computational simulations, optimisation, operations research, or statistical applications.</li> <li>2. Interact respectfully with professionals, asking relevant questions about their work and mathematical methods used.</li> <li>3. Maintain discipline and adhere to the organization's rules and safety guidelines.</li> </ol>			
<b>Post-Visit Requirements:</b>			
<ol style="list-style-type: none"> <li>1. Each group/student must submit a field visit report including: <ul style="list-style-type: none"> <li>o Objectives of the visit</li> <li>o Overview of the organization/institution</li> <li>o Mathematical techniques, tools, or applications observed</li> <li>o Learning outcomes and reflections</li> </ul> </li> </ol>			

2. Submit the report and presentation within the timeline specified by the instructor.

**Assessment:**

- Field Visit Report: 50%
- Presentation/Discussion: 30%
- Participation and Engagement during the Visit: 20%

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]**

**CO-PO-PSO Mapping (High/Medium/Low)**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	M	H	M	M	M	H	M	H	H	M	H
CO2	M	M	M	H	M	H	H	H	H	H	M	M	M	H

<b>Course code</b>	<b>MTM O 555X9</b>	<b>Internship/Industry Project/Innovative Project</b>	<b>Credit 2 (0-0-4)</b> <b>Full Marks 25</b>
<b>Learning Process</b>			
<p>The internship or industry project provides students with hands-on exposure to real-world mathematical and computational problem-solving. Each student will be associated with an industry, research institute, or academic organization where they will undertake a project involving problem identification, data collection, mathematical formulation, and computational analysis. The work will be carried out under the guidance of a faculty supervisor. Students are expected to maintain a project diary or logbook recording weekly progress, methodologies adopted, and observations made. Periodic review presentations will be conducted to assess progress and provide academic guidance. The learning process culminates in the preparation and submission of a detailed project report, followed by an oral presentation or viva voce, where the student demonstrates an understanding of the results and practical implications of the work undertaken.</p>			
<b>Evaluation Process</b>			
<p>The evaluation of the internship or project work is continuous and comprehensive, assessing both process and outcomes. Continuous assessment will carry 30% weightage and will be based on the student's regularity, initiative, technical progress, and quality of periodic review presentations as evaluated by the internal guide or review committee. The project report or dissertation will account for 30% of the total marks, focusing on organization, clarity, originality, mathematical or computational rigor, and quality of documentation. The final presentation and viva-voce examination will carry 40% weightage and will assess the student's understanding of the problem, analytical ability, interpretation of results, and communication skills. Internal and external examiners will jointly conduct the evaluation. Plagiarism checks, adherence to ethical standards, and acknowledgment of all contributors are mandatory for final acceptance of the report.</p>			

<b>Course code</b>	<b>MTM O 556A0</b>	<b>Elective-I: Intellectual Property Rights (IPR)</b>	<b>Credit 2 (1-1-0)</b> <b>Full Marks 25</b>
<b>Core/Elective/Other</b>	<b>Other</b>		<b>Compulsory</b>
<b>Course Objectives:</b>			
<p>The main objectives of this course are:</p> <ol style="list-style-type: none"> <li>1. To familiarize students with the fundamental principles, evolution, and significance of Intellectual Property Rights (IPR) in fostering innovation and protecting creative works.</li> <li>2. To develop an understanding of different forms of IPR—patents, copyrights, trademarks, industrial designs, geographical indications, and trade secrets—and their application in research and business contexts.</li> </ol>			

- To promote ethical and responsible use of intellectual property by integrating IPR awareness into research, academic writing, and entrepreneurial practices.

**Course Outcomes (COs):**

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

**CO1:** Understand the fundamental concepts, types, and importance of Intellectual Property Rights (IPR) in research, innovation, and entrepreneurship.

**CO2:** Apply IPR knowledge in practical scenarios, including patent searches, copyright issues, and ethical considerations in academic and startup environments.

**Syllabus:**

Course content	No. of Lectures
Definition, scope, and importance of IPR, Historical perspective and evolution of IPR, Role of IPR in knowledge economy and innovation, International framework: WIPO, TRIPS agreement.	4
Patents: Definition, features, patentable inventions, process of patent filing in India. Copyrights: Basics, protection, duration, fair use. Trademarks: Definition, types, and importance for businesses. Industrial Designs: Concepts and protection. Geographical Indications (GIs): Examples and relevance in India. Trade Secrets and Emerging Areas (software, digital rights).	8
IPR in research and academia: plagiarism, ethics, and authorship rights. Case studies of Indian IPR success stories (e.g., basmati rice, turmeric, pharmaceuticals). IPR and entrepreneurship/startups. National IPR Policy of India. Introduction to online resources and databases for patents and copyrights.	8

**Further Readings:**

**Text Books:**

1. Ganguli, P. (2001). *Intellectual Property Rights: Unleashing the Knowledge Economy*. McGraw Hill.
2. Pandey, N., & Dharni, K. (2014). *Intellectual Property Rights*. PHI Learning.

**References Books:**

1. WIPO (2020). *Understanding Industrial Property*. World Intellectual Property Organization.
2. Cornish, W., Llewelyn, D., & Aplin, T. (2019). *Intellectual Property: Patents, Copyright, Trade Marks and Allied Rights*. Sweet & Maxwell.
3. National IPR Policy 2016, Government of India.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]**

**CO-PO-PSO Mapping (High/Medium/Low)**

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	M	L	L	M	L	L	M	L	L	H	L	L	M
CO2	H	H	M	M	H	L	L	L	M	L	H	M	M	L

Course code	MTM O 556B0	Skill-Enhanced Course on LaTeX	Credit 2 (1-1-0) Full Marks 25
Core/Elective/Other		Other	Compulsory
Course Objectives:			

The main objectives of this course are:

1. To introduce students to the fundamentals of LaTeX for preparing professional mathematical, scientific, and technical documents.
2. To enable students to apply advanced LaTeX tools for formatting reports, research papers, and presentations with proper referencing and visual elements.

**Course Outcomes (COs):**

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

**CO1:** Create and format professional documents in LaTeX, including mathematical equations, tables, figures, and bibliographies.

**CO2:** Develop research reports and academic presentations using advanced LaTeX features and the beamer class.

**Syllabus:**

Course content	No. of Lectures
<p><b>Introduction to LaTeX</b> History, importance, and applications of LaTeX in scientific and mathematical writing. Installation of LaTeX distributions (TeX Live, MikTeX) and editors (Overleaf, TeXstudio). Overview of document structure: preamble, body, and document classes (article, report, book).</p>	3
<p><b>Basic Document Preparation</b> Creating a simple document, title, author, date, sections, subsections, paragraphs, line breaks, and indentation. Compiling LaTeX documents into PDF and common compilation errors. Introduction to environments (itemize, enumerate, description).</p>	3
<p><b>Mathematical Typesetting</b> Inline and display math modes, superscripts and subscripts, Greek letters, operators, fractions, roots, summation, integrals, limits. Using align, equation, gather environments. Matrices, multi-line equations, and common math symbols.</p>	4
<p><b>Tables and Figures</b> Creating and formatting tables using tabular and tabularx environments. Adding captions, labels, and referencing. Importing figures using graphicx package, figure placement options, captions, labels, and cross-references.</p>	3
<p><b>Document Structuring and Referencing</b> Sections, subsections, table of contents, lists of figures and tables. Labels and cross-references. Creating bibliographies using thebibliography environment. Introduction to BibTeX and natbib for reference management.</p>	3
<p><b>Advanced LaTeX Features</b> Custom commands, packages, page layout settings, headers and footers. Using geometry, fancyhdr, hyperref packages. Footnotes, margin notes, and including code snippets.</p>	2
<p><b>Presentations and Project Documents</b> Introduction to beamer class for presentations. Creating slides, frames, themes, overlays, and animations. Structuring research/project reports with proper formatting, chapters, sections, and appendices.</p>	2
<p><b>Project Work and Practical Applications</b> Hands-on preparation of a complete scientific document with title page, abstract, sections, tables, figures, equations, and bibliography. Individual or group project submission.</p>	2

**Further Readings:**

**Textbooks:**

1. Leslie Lamport, *LaTeX: A Document Preparation System* (2nd Edition), Addison-Wesley, 1994.
2. Helmut Kopka and Patrick W. Daly, *A Guide to LaTeX* (4th Edition), Springer, 2003.

**Reference Books:**

1. Tobias Oetiker, et al., *The Not So Short Introduction to LaTeX2e*, 2017. (Free PDF)
2. Frank Mittelbach and Michel Goossens, *The LaTeX Companion* (2nd Edition), Addison-Wesley, 2004.

**Related Online Contents [MOOC, SWAYAM, NPTEL, other Websites]**

**CO-PO-PSO Mapping (High/Medium/Low)**

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
CO1	H	M	L	L	H	M	L	L	M	L	H	M	L	M
CO2	M	M	H	M	H	M	H	M	H	M	M	H	M	H