AS PER NATIONAL EDUCATION POLICY (NEP) – 2020

CURRICULUM FRAMEWORK FOR
M. SC. IN MATHEMATICS AND COMPUTING

WITH EFFECT FROM THE
ACADEMIC YEAR: 2024-25

Rajiv Gandhi University
(A Central University)
RONO HILLS, DOIMUKH,
ARUNACHAL PRADESH-791112

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs): The main objectives of the Programme, M.Sc. in Mathematics and Computing, are:	
PEO1:	To deepen students' understanding of advanced mathematical concepts and theories across various branches of mathematics to enhance student's problem-solving abilities by fostering analytical and critical thinking skills
PEO2:	To allow students to specialize in specific areas of mathematics according to their interests and career goals to explore the interdisciplinary applications of mathematics in science and engineering.
PEO3:	To provide students with opportunities for professional development through seminars and workshops.
PEO4:	To cultivate an understanding of the ethical implications of mathematical research and its applications.
PEO5:	To develop students' research skills through independent research projects preparing them for further academic pursuits or careers in research and development.

PROGRAMME OBJECTIVES (POs):		
	Type of Programme Outcome (PO)	**Programme Outcome (PO) Descriptor**
PO1:	**Problem-Solving**	A graduate student should be able to demonstrate the capability to • solve problems of familiar and non-familiar contexts that are best approached with critical thinking and apply the learning to real-life situations.
PO2:	**Analytical Reasoning & Critical Thinking**	A graduate student should be able to demonstrate the capability to • apply analytical thought to a body of knowledge, including the analysis, evaluation and practices, as well as evidence, arguments, claims, beliefs, and the reliability and relevance of evidence, • identify relevant assumptions or implications; and formulate coherent arguments, • Identify logical flaws in the arguments, analyse and synthesise data from various sources, draw valid conclusions and support them with evidence and examples.
PO3:	**Creativity**	A graduate student should be able to demonstrate the capability to • create, perform, or think in different and diverse ways about the same objects or scenarios, • deal with problems and situations that do not have simple solutions, • innovate and perform tasks in a better manner, • view a problem or a situation from multiple perspectives, • think 'out of the box' and generate solutions to complex problems in unfamiliar contexts, adopt innovative, imaginative, lateral thinking, interpersonal skills and emotional intelligence.
PO4:	**Communication Skills**	The graduates should be able to demonstrate the skills that enable them to: • listen carefully, read texts and research papers analytically, and present complex information clearly and concisely to peers and the public at large, • express thoughts and ideas effectively in writing and orally and communicate with others using appropriate media, • confidently share views and express herself/himself, • construct logical arguments using correct technical language related to a field of learning, work/vocation, or an area of professional practice, convey ideas, thoughts, and arguments using respectful and sensitive language to gender and other minority groups.
PO5:	**Research-related Skills**	A graduate student should be able to demonstrate the capability to • a keen sense of observation, inquiry, and capability for asking relevant/ appropriate questions, • the ability to problematise, synthesize and articulate issues and design research proposals, • the ability to define problems, formulate appropriate and relevant research questions, formulate hypotheses, test hypotheses using quantitative and qualitative data, establish

		hypotheses, make inferences based on the analysis and interpretation of data, and predict cause-and-effect relationships, • the capacity to develop appropriate methodology and tools of data collection, • the appropriate use of statistical and other analytical tools and techniques, • the ability to plan, execute and report the results of an experiment or investigation, the ability to understand basic research ethics and skills in practising/doing ethics in the field/ in personal research work, regardless of the funding authority or field of study.
PO6:	**Coordinating / Collaborating with others**	The graduates should be able to demonstrate the ability to: • work effectively and respectfully with diverse teams, • facilitate cooperative or coordinated effort on the part of a group, • act together as a group or a team in the interests of a common cause and work efficiently as a member of a team.
PO7:	**Leadership Development**	A graduate student should be able to demonstrate the capability to • mapping out the tasks of a team or an organization and setting direction. • formulating an inspiring vision and building a team that can help achieve the vision, motivating and inspiring team members to engage with that vision. • using management skills to guide people to the right destination.
PO8:	**Digital and technological skills**	A graduate student should be able to demonstrate the capability to • use ICT in a variety of learning and work situations, • access, evaluate, and use a variety of relevant information sources, • use appropriate software for analysis of data.
PO9:	**Multicultural competence and inclusive spirit**	A graduate student should be able to demonstrate the capability to • the acquisition of knowledge of the values and beliefs of multiple cultures and a global perspective to honour diversity, • capability to effectively engage in a multicultural group/society and interact respectfully with diverse groups, • capability to lead a diverse team to accomplish common group tasks and goals. gender sensitivity and adopt gender-neutral approach, as also empathy to the less advantaged and the differently abled including those with learning disabilities.
PO10:	**Value inculcation**	The graduates should be able to demonstrate the acquisition of knowledge and attitude that are required to: • embrace and practice constitutional, humanistic, ethical, and moral values in life, including universal human values of truth, righteous conduct, peace, love, nonviolence, scientific temper, citizenship values, • formulate a position/argument about an ethical issue from multiple perspectives • practice responsible global citizenship required for responding to contemporary global challenges, enabling learners to become aware of and understand global issues and to become active promoters of more peaceful, tolerant, inclusive, secure, and sustainable societies, • identify ethical issues related to work and follow ethical practices, including avoiding unethical behavior such as fabrication, falsification or misrepresentation of data, or committing plagiarism, and adhering to intellectual property rights, • adopt objective, unbiased, and truthful actions in all aspects of work, in stil integrity, identify ethical issues related to work, and follow ethical practices.
PO11:	**Environmental awareness and action**	The graduates should be able to demonstrate the acquisition of and ability to apply the knowledge, skills, attitudes, and values required to take appropriate actions for: • recognize environmental and sustainability issues and participate in actions to promote sustainable development. • mitigating the effects of environmental degradation, climate change, and pollution, effective waste management, conservation of biological diversity, management of biological resources and biodiversity,
PO12:	**Community engagement and service**	The graduates should be able to demonstrate the capability to • participate in community-engaged services/ activities for promoting the well-being of society.

PROGRAMME SPECIFIC OBJECTIVES (PSOs): After completing the programme, the students will be:	
PSO1:	able to demonstrate a mastery of advanced mathematical concepts, theories, and techniques across various areas of mathematics, and gain proficiency in formulating, analyzing, and solving complex mathematical problems using appropriate methodologies and tools.
PSO2:	able to apply mathematical modeling techniques to real-world problems in various fields of science and engineering.
PSO3:	able to demonstrate strong critical thinking skills and the ability to critically evaluate mathematical arguments, theorems, and proofs.
PSO4:	proficient in using computational tools and software packages for mathematical analysis, simulation, and visualization which will facilitate research.

Curricular Components at Entry for a Post Graduate Programme:

(i) **Two-Year Master of Science in Mathematics:** Students entering Two-Year Master of Science in Mathematics after a Three-year UG programme have to do course work in first and second semesters. For third and fourth semesters, students can choose to do (i) only coursework in third and fourth semesters or (ii) coursework in third semester and Research in fourth semester or (iii) only research in third and fourth semesters, as per the criteria set by the Department / University.

(ii) **One-Year Master of Science in Mathematics:** Students entering One-Year Master of Science in Mathematics after a Four-Year UG programme students can choose to do (i) only coursework or (ii) coursework and Research or (iii) only research, as per the criteria set by the Department / University.

COURSE STRUCTURE FOR TWO-YEARS PG PROGRAMME IN MATHEMATICS

1st Year Curricular Component: Coursework						
Semester	**Course Code**	**Course Name**	**Credits**			
			L	**T**	**P**	**TOTAL**
I NCrF Credit Level 6.0	MAT-101- CC-5110	Number Theory	3	1	-	4
	MAT-101 - CC-5120	Advanced Real Analysis	3	1	-	4
	MAT-101 - CC-5130	Abstract Algebra	3	1	-	4
	MAT-101 - CC-5140	Mechanics	3	1	-	4
	MAT-101- RC-5110	Research Methodology /MOOC's Equivalent	3	1	-	4
II NCrF Credit Level 6.0	MAT-101 - DE-52**mn**0	Departmental Elective-1	-	-	-	4
	MAT -101–DE-52**mn**0	Departmental Elective-2	-	-	-	4
	MAT -101–DE-52**mn**0	Departmental Elective-3	-	-	-	4
	MAT-101 –DE-52**mn**0	Departmental Elective-4	-	-	-	4
	MAT -101–RC-5210	Research and Publication Ethics/ MOOC's Equivalent	-	-	-	4
Total Credits			**40**			

- **Students who exit at the end of first year shall be awarded Postgraduate Diploma in Mathematics.**
- **Students who continue for second year may choose one of the following components (Coursework, Coursework and Research, Research) for semesters III and IV.**

2nd Year Curricular Component: Coursework			
Semester	**Course Code**	**Course Name**	**Credits**
III NCrF Credit Level 6.5	MAT-101-CW -61X0	Elective-I	4
	MAT-101-CW -61X0	Elective-II	4
	MAT-101-CW -61X0	Elective-III	4
	MAT-101-CW -61X0	Elective-IV	4
	MAT-101-CW -61X0	Elective-V	4
IV NCrF Credit Level 6.5	MAT-101-CW -62X0	Elective-VI	4
	MAT-101-CW -62X0	Elective -VII	4
	MAT-101-CW -62X0	Elective -VIII	4
	MAT-101-CW -62X0	Elective -IX	4
	MAT-101-CW -62X0	Elective -X	4
Total Credits			**40**

OR

2nd Year Curricular Component: Coursework and Research			
Semester	**Course Code**	**Course Name**	**Credits**
III NCrF Credit Level 6.5	MAT—101-CW -61X0	Elective-I	4
	MAT—101-CW -61X0	Elective-II	4
	MAT—101-CW -61X0	Elective-III	4
	MAT—101-CW -61X0	Elective-IV	4
	MAT—101-CW -61X0	Elective-V	4
IV NCrF Credit Level 6.5	MAT-101-RP-6110	Research Project	20
Total Credits			**40**

OR

2nd Year Curricular Component: Research			
Semester	**Course Code**	**Course Name**	**Credits**
III & IV	MAT-101-RP-6110	Research Project	**40**

COURSE STRUCTURE FOR ONE YEAR PG PROGRAMME IN MATHEMATICS

1st Year Curricular Component: Coursework and Research			
Semester	**Course Code**	**Course Name**	**Credits**
I **NCrF Credit Level 6.5**	MAT—101-CW -61X0	Elective-I	4
	MAT—101-CW -61X0	Elective-II	4
	MAT—101-CW -61X0	Elective-III	4
	MAT—101-CW -61X0	Elective-IV	4
	MAT—101-CW -61X0	Elective-V	4
II **NCrF Credit Level 6.5**	MAT-101-RP-6110	Research Project	20
Total Credits			**40**

OR

1st Year Curricular Component: Coursework			
Semester	**Course Code**	**Course Name**	**Credits**
I **NCrF Credit Level 6.5**	MAT-101-CW -61X0	Elective-I	4
	MAT-101-CW -61X0	Elective-II	4
	MAT-101-CW -61X0	Elective-III	4
	MAT-101-CW -61X0	Elective-IV	4
	MAT-101-CW -61X0	Elective-V	4
II **NCrF Credit Level 6.5**	MAT-101-CW -62X0	Elective-VI	4
	MAT-101-CW -62X0	Elective -VII	4
	MAT-101-CW -62X0	Elective -VIII	4
	MAT-101-CW -62X0	Elective -IX	4
	MAT-101-CW -62X0	Elective -X	4
Total Credits			**40**

OR

1st Year Curricular Component: Research			
Semester	**Course Code**	**Course Name**	**Credits**
I & II **NCrF Credit Level 6.5**	MAT-101-RP-6110	Research Project	**40**

ELECTIVE PAPERS

Semester	Course Code	Course Name	Credits			
			L	T	P	Total
2 Yrs. PG Programme (Sem.-II) And 1 Yr. PG Diploma	MAT -101–DE-52110	Complex Analysis	3	1	-	4
	MAT -101–DE-52120	Linear Algebra	3	1	-	4
	MAT -101–DE-52130	Differential Equations	3	1	-	4
	MAT -101–DE-52140	Numerical Methods	3	-	1	4
	MAT -101–DE-52150	Tensor Calculus	3	1	-	4
	MAT-101-DE-52160	Python	3	-	1	4
	MAT-101-DE -52170	Stochastic Processes	3	1	-	4
	MAT-101-DE -52180	Biomechanics	3	1	-	4
	MAT-101-DE -52190	Space Dynamics	3	1	-	4

Semester	Course Code	Course Name	Credits			
			L	T	P	Total
1 Yr. PG Programme (Sem.-I) OR 2 Yrs. PG Programme (Sem.-III)	MAT-101-CW -6110	Calculus of Variations and Integral Equations	3	1	-	4
	MAT-101-CW -6120	Mathematical Programming	3	-	1	4
	MAT-101-CW -6130	Continuum Mechanics	3	1	-	4
	MAT-101-CW -6140	Mathematical Statistics	3	1	-	4
	MAT-101-CW -6150	Topology	3	1	-	4
	MAT-101-CW -6160	Measure Theory	3	1	-	4
	MAT-101-CW -6170	Rings and Modules	3	1	-	4
	MAT-101-CW -6180	Fluid Mechanics-I	3	1	-	4
	MAT-101-CW -6190	Functional Analysis	3	1	-	4
1 Yr. PG (Sem.-II) OR 2 Yrs. PG (Sem.-IV)	MAT-101-CW - 6210	Fluid Mechanics-II	3	1	-	4
	MAT-101-CW - 6220	Graph Theory	3	1	-	4
	MAT-101-CW- 6230	Wavelets and Applications	3	-	1	4
	MAT-101-CW - 6240	Fuzzy Set Theory and Applications	3	1	-	4
	MAT-101-CW - 6250	Operation Research	3	1	-	4
	MAT-101-CW - 6260	Differential Geometry of Manifolds	3	1	-	4
	MAT-101-CW - 6270	Advanced Functional Analysis	3	1	-	4
	MAT-101-CW - 6280	Theory of Distribution and Sobolev Spaces	3	1	-	4
	MAT-101-CW - 6290	Computational Fluid Dynamics	3	1	-	4

MAT-101-CC-5110
NUMBER THEORY
Credit: 4 (L-3, T-1, P-0)
Total Contact Hours: 60
Theory-100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to
CO1: Understand the theory and applications of quadratic congruences.
CO2: Know about the Diophantine equations of second order and Fermat's last theorem, and applications of primitive roots in solving congruences.
CO3: Know representations of number as sum of squares and properties of Fibonacci sequence.
CO4: Understand the basics of Partition theory of numbers and related results.

Unit-I: Quadratic congruence, quadratic residue, Euler's criterion for quadratic residue, Legendre symbol and properties; quadratic reciprocity law, Jacobi symbol and properties, polynomial congruence.
(Contact Hours: 15)

Unit-II: Diophantine equations of second degree; Fermat's last theorem, primitive roots and indices, Fibonacci sequence and their properties, Benet's formula for Fibonacci numbers. **(Contact Hours: 15)**

Unit-III: Representations of integers as Sum of two squares; Difference of two squares; Sum of three squares; Sum of four squares. **(Contact Hours: 10)**

Unit-IV: Partitions of integer, graphical representation and conjugate partition, partitions into odd parts, partitions into distinct parts, partitions into even parts and their generating functions, Euler's pentagonal number theorem, Jacobi's triple product identity and applications. **(Contact Hours: 20)**

Books Recommended:

1. I. Niven, H.S. Zuckerman and H.L. Montgomery, *An Introduction to the Theory of Numbers* (6th edition), John Wiley and Sons (2003).
2. D. M. Burton, *Elementary Number Theory* (7th Edition), McGraw Hill Education (1 July 2017).
3. T. M. Apostol, *Introduction to Analytic Number Theory*, Springer International Student Edition, Narosa Publishing House, Fourth Reprint, (1993).
4. G. E. Andrews, *Number Theory*, Hindustan Publishing Corporation, New Delhi, (1992).
5. S.B. Malik, *Basic Number Theory* (Second edition), S Chand (2018).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
CO4	3	3	-	-	2		-	-	-	-	-	-	3	2	3	1	3
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-CC -5120
ADVANCED REAL ANALYSIS
Credit: 4 (L-3, T-1, P-0)
Total Contact Hours: 60
Theory: 100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to:
CO1: Understand the concept of sequence and series of functions and their convergence theory.
CO2: Understand the concept and properties of Riemann-Stieltjes (R-S) integral.
CO3: Understand fundamentals of measure theory and Lebesgue integrals.

Unit-I: Uniform convergence: sequence and series of functions, pointwise and uniform convergence, Cauchy's criterion for uniform convergence of a series, uniform convergence and continuity, integration and differentiation. Weirstrass's approximation theorem. **(Contact Hours: 15)**

Unit-II: Definition and existence of Riemann-Stieltjes (R-S) integral, properties of R-S integral, integrations and differentiations. **(Contact Hours: 15)**

Unit-III: Lebesgue exterior measure, Lebesgue measure of sets, theorems on measurable sets. Definition of measurable functions, properties of measurable functions and simple functions. **(Contact Hours: 10)**

Unit IV: Lebesgue integral of bounded function, definition and theorem involving Lebesgue integral, relationship of Lebesgue and Riemann integral. Fatou's Lemma, monotone convergence theorem, the general Lebesgue integral, Lebesgue convergence theorem. **(Contact Hours: 20)**

Books Recommended:

1. H. L. Royden and P.M. Fitzpatrick, *Real Analysis*, PHI, 5th Edition (2022).
2. W. Rudin, *Principles of Mathematical Analysis*, McGraw Hills Education, 3rd Edition, (2023).
3. P. K. Jain, V. P. Gupta and P. Jain, *Lebesgue measure and integration*, Wiley (2019).
4. T. M. Apostol, *Mathematical Analysis*, Narosa Publishing House, New Delhi (1985).
5. R. Werede and M. Spiegel, *Advanced Calculus*, McGraw Hill Education; 3rd edition (2010).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	0	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	2	2	0	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	3	2	0	1
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**2**	**2**	**0**	**1**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-DE -5130
ABSTRACT ALGEBRA
Credit: 4 (L-3, T-1, P-0)
Total Contact Hours: 60
Theory: 100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: Upon successful completion of the course, the students will be able to:
CO1: Gain knowledge on class equation, Sylow's theorems and their applications, direct product of groups, Jordan holder theorem, solvable groups, field theory, ideal of a ring, EDs, PIDs, & UFDs and relationships among them.
CO2: Identify and analyze different types of algebraic structures in the category of groups, rings, ideals and fields.
CO3: Emphasize on field structures such as algebraically closed fields, splitting fields and field extensions and to use the fundamental results in algebra.
CO4: Find out the number of subgroups, normal subgroups of a finite group and solve problems using above mentioned powerful concepts.

Unit-I: Conjugacy class, normalizer, centralizer, centre of a group, class equations, Cauchy theorem, Sylow's theorems, applications of Sylow's theorems. **(Contact Hours: 15)**

Unit-II: Direct products of finite numbers of groups, decomposable groups. normal and subnormal series of groups, composition series, Schreier's refinement theorem, Jordan holder theorem, commutators, derived subgroups, solvable groups. **(Contact Hours: 15)**

Unit-III: Ideals, principal and prime ideals. integral domain and quotients of an integral domain, divisibility in commutative rings, PID, UFD and their properties, Eisenstein's irreducibility criterion. **(Contact Hours: 15)**

Unit-IV: Field theory, extension of fields, algebraic and transcendental numbers, splitting field, existence of finite fields and Galois's group. **(Contact Hours: 15)**

Books Recommended:

1. I. N. Herstein, *Topics of Algebra*, Wiley (2006).
2. M. Artin, *Algebra*, Prentice Education India (2015).
3. D. S. Dummit and R.M. Foote, *Abstract Algebra*, John Wiley and Sons Inc. (2011).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
CO4	3	3	-	-	2		-	-	-	-	-	-	3	2	3	1	3
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-CC-5140
MECHANICS
Credit: 4 (L-3, T-1, P-0)
Total Contact Hours: 60
Theory: 100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to:
CO1: Understand the basic concepts Mechanics.
CO2: Apply the principles of mechanics for solving practical problems related to equilibrium of rigid bodies.
CO3: Apply the principles of mechanics for solving practical problems related to particle in motion.
CO4: Apply concepts of Conservation principles, Lagrange's equations and Hamilton's Equation.

Unit-I: Moments and products of inertia: Definitions, parallel axes theorem, theorem of six constants, D' Alembert's principle, momental ellipsoid, equimomental system, principal axes, moment of momentum.
(Contact Hours: 15)

Unit-II: Conservation of Momentum and Energy: Principle of conservation of linear momentum and angular momentum under finite and impulsive forces, conservation of energy, conservative forces.
(Contact Hours: 15)

Unit-III: Lagrange's Equations: Generalized coordinates, degrees of freedom, holonomic system, Lagrange's equations of motion for finite forces, conservative forces, small oscillation.
(Contact Hours: 15)

Unit-IV: Hamilton's Equations of motion: Generalized velocities, Lagrangian and generalized momentum, Hamilton's canonical equations, Hamilton's principle and principle of least action.
(Contact Hours: 15)

Books Recommended:

1. S. L. Loney, An elementary treaties on the *Dynamics of a Particle and Rigid bodies*, G.K. Publications Private Limited (2016).
2. H. Goldstein, *Classical Mechanics*, Pearson Education; 3rd edition (2011).
3. M.R. Spiegel, *Theoretical Mechanics* (Schaum's Outline Series), McGraw Hills Education (2017).
4. F. Chorlton, *Text book of Dynamics*, CBS *Publishers* & Distributors Pvt. Ltd., New Delhi (2004).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
CO4	3	3	-	-	2		-	-	-	-	-	-	3	2	3	1	3
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-RC-5110

RESEARCH METHODOLOGY

Credit: 4 (L-3, T-1, P-0)

Total Contact Hours: 60

Theory: 100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to:

CO1: Understand various elements involved in formulation of research problems.

CO2: Understand the importance of literature review and identifying the gaps in research problems.

CO3: Understand different aspect involved in writing research papers, research proposal for grants, and research database accounts.

Unit-I: Importance of Scientific Research: Philosophy and history of mathematics, formulation of research problem, significance of hypothesis and null hypothesis, formulation of objectives, quantitative & qualitative research, research tools–online and open access journals, primary and secondary sources, web sources, critical literature review.

(Contact Hours: 15)

Unit-II: Importance of Literature Review: Structure and components of scientific and technical report writings, survey of a research topic, needs of citations in literature reviews, uses of pictures and graphs in texts, bibliography, citation and acknowledgement in a research paper, survey article and thesis writing. **(Contact Hours: 15)**

Unit-III: Importance of Reviewing a paper: Role of a supervisor, publishing a research article, research article-review, funding agencies, writing of research proposal for financial grant, similarity in research articles, copyright issues of publishing houses, necessity of account in Orcid, Google scholar, Research gate, Scopus and Web of science.

(Contact Hours: 15)

Unit-IV: Research Paper Writing: Preparation of a research paper for publication-Title, Abstract, Importance of Keywords and AMS subject classifications, Results, Findings & Discussions. Conference presentation.

(Contact Hours: 15)

Books Recommended:

1. N. J. Higham, *Handbook of Writing for the Mathematical Sciences*, SIAM (2020).
2. D.E. Knuth, Tracy Larrabee and P. M. Roberts, *Mathematical Writing*, Mathematical Association of America (1989).
3. N. E. Steenrod, P. R. Halmos, M. M. Schiffer and J. A. Dieudonne, *How to Write Mathematics*, American Mathematical Society (1973).
4. L. C. Prerelman, *The Mayfield Technical Scientific Writing*, Tata James parade & McGraw Hills (2001).
5.C. R. Kothari and G. Garg, *Research Methodology*, New Age International Publishers (2023).
6. G. J. Alred, W. E. Oliu and C. T. Brusaw, *Handbook of Technical Writing*, Bedford/St. Martin's Press (2018).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-RC-5210

RESEARCH AND PUBLICATION ETHICS

Credit: 4 (L-3, T-0, P-1)

Total Contact Hours: 60

Theory: 100 (End Semester: 80, Internal Assessment: 20)

Practical-100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: The course will enable student to:

CO1: Understand Philosophy and Ethics of scientific research and research misconducts.

CO2: Understand the ethics involved in research publications, best practices and different conflict of interests.

CO3: Acquaint with open access journals, databases and research metrics, and use of different software for plagiarism check.

Unit I: Philosophy and Ethics: Introduction to philosophy: definition, nature and scope, concept, branches - Ethics: definition, moral philosophy, nature of moral judgments and reactions.
Scientific Conduct: Ethics with respect to science and research - Intellectual honesty and research integrity Scientific misconducts: Falsification, Fabrication and Plagiarism (FFP) - Redundant Publications: duplicate and overlapping publications, salami slicing - Selective reporting and misrepresentation of data. **(Contact Hours: 15)**

Unit II: Publication Ethics: Publication ethics: definition, introduction and importance - Best practices / standards setting initiatives and guidelines: COPE, WAME, etc. - Conflicts of interest - Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types - Violation of publication ethics, authorship and contributor ship - Identification of publication misconduct, complaints and appeals - Predatory publisher and journals. **(Contact Hours: 10)**

Unit III: Open Access Publishing: Open access publications and initiatives - SHERPA/RoMEO online resource to check publisher copyright & self-archiving policies - Software tool to identify predatory publications developed by SPPU - Journal finger / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer, Journal Suggested, etc.
Publication Misconduct:
1. Group Discussion: Subject specific ethical issues, FFP, authorship, Conflicts of interest, Complaints and appeals: examples and fraud from India and abroad.
2. Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools.
Databases and Research Metrics
1. Databases: Indexing databases, Citation databases: Web of Science, Scopus, etc.
2. Research Metrics: Impact Factor of journal as per Journal Citations Report, SNIP, SJR, IPP, Cite Score - Metrics: h-index, g index, i10 Index, altmetrics. **(Contact Hours: 20)**

Practical: Practical in consonant with Unit- III. **(Contact Hours: 15)**

Books Recommended:

1. A. Bird, *Philosophy of Science*, Routedge (2006).
2. A. Mac lntyre, *A Short History of Ethics*, Notre Dame Press (2022).
3. P. Chaddha, *Ethics in Competitive Research: Do not get scooped; do not get plagiarized*, ISBN: 9789387480865 (2018)
5. D. B. Resnik, *What is ethics in research & why is it important*. National Institute of Environmental Health Sciences, 1-10 (2011).
6. J. Becall, (2012), *Predatory publishers are corrupting open access*, Nature, 489(7415), 179-179.
7. S. K. Yadav, *Research and Publication Ethics*, Springer Cham (2023), https://doi.org/10.1007/978-3-031-26971-4

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	-	3	3	2	2	-	-	2	-	2	-	-	0	0	0	0	3
CO2	-	3	3	2	2	-	-	2	-	2	-	-	0	0	0	0	3
CO3	-	3	3	2	2	-	-	2	-	2	-	-	0	0	0	0	3
Average	**-**	**3**	**3**	**2**	**2**	**-**	**-**	**2**	**-**	**2**	**-**	**-**	**0**	**0**	**0**	**0**	**3**

High-3, Medium-2, Low-1, No Correlation-0

Departmental Elective Papers

MAT-101- DE -52110
COMPLEX ANALYSIS
Credit: 4 (L-3, T-1, P-0)
Total Contact Hours: 60
Total Marks: 100 (End Semester Theory: 80, Internal Assessment: 20)

Course Outcomes: This course will enable students to:
CO1: Understand the significance of Cauchy's integral formula of complex integration and applications.
CO2: Know different types of singular points and their applications.
CO3: Understand the theory of calculus of residues and its applications in evaluating contour integrals and expansion theorem.
CO4: Understand the concept of conformal mappings and bilinear transformations.

Unit-I: Cauchy's inequality, Liouville's theorem and applications, Gauss Mean value theorem, Maximum modulus theorem and minimum modulus principle and applications. **(Contact Hours: 15)**

Unit-II: Laurent's expansion theorem, zeros of analytic functions, singularities, poles, types and properties of singularities, singularities at infinity. rational and meromorphic function, argument principle, Rouche's theorem. **(Contact Hours: 15)**

Unit-III: Residues and their calculus, Cauchy's residue theorem, evaluation of definite integrals, special theorems used in evaluating integrals, Mittag-Leffler's expansion theorem. **(Contact Hours: 15)**

Unit-IV: Elementary Transformation: rotation, translation, stretching, inversion, Jacobian of a transformation, conformal and isogonal transformations, bilinear transformation, cross-ratio, fixed points and normal form of bilinear transformation, inverse points and critical points. Some special bilinear transformations: real axis onto itself, half plane onto unit circular disc, circular disc onto circular disc. **(Contact Hours: 15)**

Books Recommended:

1. J. W. Brown and R. V. Churchill, *Complex Variables and Applications*, Tata McGraw Hill (2021).
2. E. G. Milewski, *The Complex Variables Problem Solver*, Research and Education Association, New York (1998).
3. M.R. Spiegel, *Complex variables*, Schaum's Series, McGraw Hill Education (1917).

COs- POs/PSOs Matrix of the Course

PSOs/POs COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
CO4	3	3	-	-	2		-	-	-	-	-	-	3	2	3	1	3
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-CC-51120
LINEAR ALGEBRA
Credit: 4 (L-3, T-1, P-0)
Total Contact Hours: 60
(End Semester: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to:
CO1: Learn the connection of matrices with linear transformations, the concept of characteristic and minimal polynomials, and their properties.
CO2: Understand canonical forms for linear transformations and the underlying concepts.
CO3: Understand the theory of inner product spaces and bilinear forms.

Unit-I: Linear transformations and its matrices, determination of linear transformation for a given matrix and bases, isomorphism between algebra of linear transformations and family of matrices, characteristic and minimal polynomial, Cayley-Hamilton theorem. **(Contact Hours: 15)**

Unit-II: Canonical forms: invariant subspaces, invariant direct sum decomposition, primary decomposition theorem, cyclic subspaces, rational canonical form, Jordan canonical form. **(Contact Hours: 15)**

Unit-III: Inner product spaces, projections and its applications, orthogonal vectors and subspaces, orthogonal bases, Gram-Schmidt process, adjoint, self-adjoint, normal, and unitary operators. **(Contact Hours: 15)**

Unit-IV: Bilinear forms, the matrix of a bilinear form, Hermitian forms, orthogonality, classification of bilinear forms, real quadratic form, matrix of a quadratic form, criterion positive definiteness. **(Contact Hours: 15)**

Books Recommended:

1. K. Hoffman and R. Kunze, *Linear Algebra*, Prentice Hall of India (1996).
2. S. Lipschutz and M. Lipson, *Schaum's outline of Linear Algebra*, McGraw Hill Education (2017).
3. G. Strang, *Linear Algebra and its Applications*, Cengage Learning, India Edition (2005).
4. G. Schay, *A concise introduction to Linear Algebra*, Birkhauser Boston Inc (2012).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-DE -52130

DIFFERENTIAL EQUATIONS

Credit: 4 (L-3, T-1, P-0)

Total Contact Hours: 60

Theory: 100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to:

CO1: Understand existence and uniqueness of solution of differential equations before solving it.

CO2: Solve different types of partial differential equations.

CO3: Solve different types of boundary value problems.

Unit-I: First order ODEs: Picard's theorem, Non-Local existence theorem.

Series Solution of Second Order Linear Equations: Ordinary points, regular and singular points, Legendre, Bessel and hyper geometric differential equations and their properties. **(Contact Hours: 15)**

Unit-II: Stability: Autonomous Systems. The Phase Plane and Its Phenomena, Types of Critical Points. Stability, Critical Points and Stability for Linear Systems. **(Contact Hours: 10)**

Unit-III: Linear & non-linear partial differential equations of first order: Various forms of first order partial differential equations, Lagrange's method, method of characteristics. Use of standard forms for solution of non-linear partial differential equations. Charpit's method.

PDEs of 2nd order: Second Order Differential Equations with constant and variable coefficients, Canonical Forms. **(Contact Hours: 20)**

Unit-IV: Strum-Liouville Problems: Orthogonality of characteristic functions, Expansion of a function in Series of Orthonormal Functions.

Boundary Value Problems: Heat Equation, Wave Equation, Laplace Equation, Examples.

(Contact Hours: 15)

Books Recommended:

1. S. L. Ross, *Differential Equations*, John Wiley & Sons, Inc. (2007).

2. W. E. Boyce and R. C. DiPrima, Elementary Differential Equations and Boundary Value Problems, John Wiley & Sons (2009).

3. I. Snedden, *Elements of partial differential equations*. Tata McGraw Hill (2006).

4. M. D. Raisinghannia, *Advanced Differential Equations*, S. Chand. & Co. Ltd. (2024).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-DE -52140

NUMERICAL METHODS

Credit: 4 (L-3, T-0, P-1)

Total Contact Hours: 60

Theory: 100(End Semester: 80, Internal Assessment: 20)

Practical: 100(End Semester: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to:

CO1: Find the root(s) of nonlinear equations up to a certain level of precision and understand the techniques of numerical interpolations.

CO2: Understand the techniques of numerical differentiation and integration.

CO3: Construct best approximation for a given set of data through curve fitting technique.

CO4: Solve differential equations using numerical methods.

Unit I: Computational errors, roots of algebraic and transcendental equations, Bisection method, Regular-Falsi method, Secant method and Newton-Raphson method. System of linear equations; Gaussian elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss-Seidel method **(Contact Hours: 12)**

Unit II: Finite differences, relation between finite differences and derivatives of functions, factorial notation. Newton's forward and backward interpolation formula, Newton's and Lagrange's divided difference formulae, Gauss's, Stirling's and Bessel's interpolation formulae. Curve fitting: Least square method, fitting of straight line, power function, polynomial functions of second and higher degrees and exponential functions.

(Contact Hours: 18)

Unit III: Numerical differentiation, numerical integration, quadrature formulas, Trapezoidal rule, Weddle's rule, Simpson's one third and three-eight rule. **(Contact Hours: 10)**

Unit IV: Eigenvalue problem: Power method, Householder method, Reduction to tridiagonal form, QR method. Numerical Solution of Differential: Euler's Method, RK method of 2^{nd} and 4^{th} orders .

(Contact Hours: 10)

Unit V: Practical in consonant with Unit I - IV. **(Contact Hours: 10)**

Books Recommended:

1. M. K. Jain, S.R.K. Iyengar and R.K. Jain, *Numerical Methods for Scientific and Engineering Computation*, New age International Publisher, India, (2022).

2. S. S. Sastry, *Introductory Methods of Numerical Analysis*, Prentice Hall of India, (2012).

3. K. E. Atkinson, *An Introduction to Numerical Analysis*, Wiley India Private Limited (2008).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
CO4	3	3	-	-	2		-	-	-	-	-	-	3	2	3	1	3
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-DE-52150
TENSOR CALCULUS
Credit: 4 (L-3, T-1, P-0)
Total Contact Hours: 60
Total Marks: 100 (Theory: 80, Internal Assessment:20)

Course Outcomes: This course will enable the students to:

CO1: Develop the idea of tensors, quotient law and algebra of tensors with respect to transformation of coordinates.

CO2: Learn the concept of covariant derivatives, Christoffel symbols and laws of transformation with applications in theoretical physics and engineering.

CO3: Learn the notion of curvilinear, spherical and cylindrical coordinate system, parallel vector field, Curvature tensor, Ricci tensor, Intrinsic differentiation, Geodesics and their applications in relativity theory.

Unit-I: Einstein Summation convention, Kronecker symbols, n-dimensional space S_n, transformation of coordinates in S_n, Invariants, Covariant and Contravariant vectors, Covariant, contravariant and mixed tensors, algebra of tensors, symmetric and skew-symmetric tensors, outer and inner multiplication, contraction of tensors, quotient law, reciprocal tensor. **(Contact Hours: 15)**

Unit-II: Riemannian Space, line element and metric tensor, inclination between two vectors, orthogonal vectors, Christoffel symbols of 1^{st} and 2^{nd} kind with their properties, laws of transformation of Christoffel symbols of 1^{st} and 2^{nd} kind. **(Contact Hours: 10)**

Unit-III: Covariant differentiation of tensors, covariant differentiation of sum, difference and product of tensors, Ricci's theorem, Gradient, divergence, curl and Laplacian, conservative vector, irrotational Vector, Riemann Christoffel curvature tensor and their properties, Ricci tensor, Intrinsic differentiation, Geodesics. **(Contact Hours: 15)**

Unit-IV: Curvilinear coordinate system in E_3: line element, length of vector, angle between two vectors in a curvilinear coordinate system, basis, reciprocal basis, covariant and contravariant vector in E_3, spherical and cylindrical coordinate systems, curves in E_3, parallel vector field along a curve in E_3, parallel vector space in Riemannian Space, parallel vector field in a surface of a Riemannian Space, Serret-Frenet formulas. **(Contact Hours: 20)**

Recommended Books:

1. David C. Kay, *Tensor Calculus*, McGraw Hill, (2011).
2. A. Lichnerowicz, *Elements of Tensor Calculus*, Dover Publications Inc. (2016).
3. U.C. Dey, A.A. Shaikh and J. Sengupta, *Tensor Calculus*, Narosa (2008).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	0	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	2	2	0	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	3	2	0	1
CO4	3	3	-	-	2		-	-	-	-	-	-	3	2	2	0	1
Average	3	3	-	-	2		-	-	-	-	-	-	3	1	2	0	1

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-DE -52160

PYTHON

Credit: 4 (L-3, T-0, P-1)

Total Contact Hours: 60

Theory: 100 (End Semester: 80, Internal Assessment: 20)
Practical: 100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to:

CO1: Understand basics of programming language Python.

CO2: Understand the complex logics that are using in Computer Science and Engineering.

CO3: Solve problems easily through python programming using functions and strings.

CO4: Apply the concept of Python in data science and AI programming.

Unit I: Introduction: History, features, installation, Debugging, Formal and Natural Languages, Difference Between Brackets, Braces, and Parentheses. Variables and Expressions, Conditional Statements**,** Looping, Control statements**.** **(Contact Hours: 10)**

Unit II: Functions: Function Calls, Type Conversion Functions, Math Functions, Composition, Adding New Functions, Definitions and Uses, Flow of Execution, Parameters and Arguments, Stack Diagrams, Fruitful Functions and Void Functions, Return Values, Incremental Development, Boolean Functions, Recursion, Leap of Faith, Checking Types. **Strings**: Traversal with a for Loop, String Slices, Searching, Looping and Counting, String Methods, in Operator, String Comparison, String Operations. **(Contact Hours: 10)**

Unit III: Lists: **v**alues and Accessing Elements, traversing a List, element deletion, Built-in List Operators, Concatenation, Repetition, Built-in List functions and methods. **Tuples:** Tuples, Accessing values, Tuple Assignment, Tuples as return values, Variable-length argument tuples, Basic operations, Concatenation, Repetition, in Operator, Iteration, Built-in Tuple Functions. **Dictionaries:** Creating a Dictionary, Accessing Values in a dictionary, Updating Dictionary, Element Deletion from Dictionary, Properties of Dictionary keys, Operations, Built-In Dictionary Functions, Built-in Dictionary Methods. **Files:** Text Files, The File Object Attributes, Directories Exceptions: Built-in, Handling and User-defined Exceptions, Exception with Arguments. File Handling: CSV, JSON, importing read/write. Exceptions handling: build in, raise errors, error handling, try-except-finally. **(Contact Hours: 13)**

Unit IV: Regular Expressions: Concept and various types of regular expressions. **Classes and Objects:** Overview of Object Oriented Programming, Class Definition, Creating Objects, Instances as Arguments, Instances as return values, Built-in Class Attributes, Inheritance, Method Overriding, Data Encapsulation, Data Hiding. **Multithreaded Programming**: Thread Module, creating a thread, synchronizing threads, multithreaded priority queue Modules: Importing module, Creating and exploring modules, Math module, Random module, Time module. Data Structure: Array, stack, queue, searching, sorting, tress. Database in Python: connectivity, SQLite, Select, update, insert, delete, filter. decorators, generators, Iterables, Map, filter. Anaconda, Numpy basics, Panda Basics. **(Contact Hours: 12)**

Unit V: Practical: Python programming in consonance with the topics covered in Units-I-IV. **(Contact Hours: 15)**

Books Recommended:

1. E. Balagurusamy, *Introduction to Problem Solving with Python*, Tata McGraw Hill (2015).
2. M. H. Goldwasser and D. Letscher, *Object-oriented Programming in Python*, Pearson Prentice Hall (2008).
3. T.A. Budd, *Exploring Python*, Tata McGraw Hill (2016).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
CO4	3	3	-	-	2		-	-	-	-	-	-	3	2	3	1	3
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-DE-52170

STOCHASTIC PROCESSES

Credit: 4 (L-3, T-1, P-0)

Total Contact Hours: 60

Theory: 100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: The course will help the students to:
CO1: Understand concepts of generating functions and their applications in combinatory and probability theory.
CO2: Understand the fundamentals of stochastic processes and classify and analyse its different types.
CO3: Apply Markov processes to model and analyze epidemic process.
CO4: Understand the concepts of renewal processes and queuing processes.

Unit-I: Generating Functions, Laplace Transformations, Stochastic Process: Introduction, specification of Stochastic Processes, Recurrent Events, Random walk models: gambler's ruin model, Markov Chain.

(Contact Hours: 12)

Unit-II: Markov Processes in continuous time: introduction, Poisson process, Simple birth process, Simple death process, the simple birth and death process. **(Contact Hours: 12)**

Unit-III: The Polya process, Brownian Motion Process. Weiner Process, Introduction to Epidemic Processes: simple epidemics, general epidemics. **(Contact Hours: 12)**

Unit-IV: Introduction to Renewal Processes, Renewal equation, Renewal theorems, Delayed and Equilibrium renewal process. Introduction to discrete Branching processes: Galton-Watson branching process. **(Contact Hours: 12)**

Unit-V: Queueing process: Basic characteristics of queueing system, different performance measures. Steady state solution of Markovian queueing models: M/M/1, M/M/C. Introduction to diffusion processes: Diffusion limit of random walk, diffusion limit to a discrete branching process. **(Contact Hours: 12)**

Books Recommended:

1. N.T.J. Bailey, *The elements of Stochastic Processes- with applications to the natural sciences*, John Wiley & Sons, New York (1990).

2. J. Medhi, *Stochastic Processes,* New Age International Private Limited (2020).

3. W. Feller, *An Introduction to Probability Theory and its Applications,* Vol. I, John Wiley, New York (1991).

4. S. M. Ross, *Stochastic Process,* Wiley, New York (2008).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
CO4	3	3	-	-	2		-	-	-	-	-	-	3	2	3	1	3
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-DE-52180

BIOMECHANICS

Credit: 4 (L-3, T-1, P-0)

Total Contact Hours: 60

Total Marks: 100 (Theory: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to:

CO1: Learn the concepts of stresses and rates of strain, Newtonian viscous fluid, heat and mass transport.
CO2: Understand of the conservations of mass, momentum, and energy and their mathematical formulation.
CO3: Identify, analyze, and solve various biomechanical problems in the human body.
CO4: Use computer calculations as a tool to carry out scientific investigations and develop new variants of the acquired methods, if required by the problem of blood flow through Artery etc.

Unit-I: Biomechanics, Method of approach, Tools of investigation, Stresses and rates of strain, Constitutive equations, Newtonian viscous fluid, Hookean elastic solid, Visco elasticity, biological transport process, Basic momentum, Heat and mass transport concepts. **(Contact Hours: 12)**

Unit-II: Conservation laws; mass conservation, Momentum conservation, Energy conservation.
(Contact Hours: 12)

Unit-III: Biofluid dynamics concept, Transport phenomena and the cardiovascular system.
(Contact Hours: 12)

Unit-IV: Biofluid mechanics of organ systems, The lungs, The Kidneys and the lever.
(Contact Hours: 12)

Unit-V: Micro-circulation, Pressure distribution in micro vessels, Pressure in the interstitial space, Velocity distribution in micro vessels, The velocity-Hemotocrit relationship, mechanics of flow at very low Reynold numbers.
(Contact Hours: 12)

Books Recommended:

1.Y. C. Fung, *Biomechanics, Mechanical Properties of living tissues*, Springer-Verlag, New York Inc. (2010).
2.C. Kleinstreuer, *Biofluid Dynamics: Principles and Selected Applications*, CRC Press (2016).

3. S.A. Levin, *Frontier in Mathematical Biology*, Springer-Verlag Berlin and Heidelberg GmbH & Co. (2012).
4. L. M. Ricciardi, *Biomathematics and Related Computational Problems*, Kluwer Academic Publishers (1988).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
CO4	3	3	-	-	2		-	-	-	-	-	-	3	2	3	1	3
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-DE-52190

SPACE DYNAMICS

Credit: 4 (L-3, T-1, P-0)

Total Contact Hours: 60

Total Marks: 100 (Theory: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to understand:

CO1: The center of mass and the center of gravity of two rigid bodies problem, location of two bodies in space and time and solution of Kepler's equation.

CO2: The dynamics of more than two bodies such as restricted three body problem and n-body problem and their stability.

CO3: About the equation of motion under perturbative force, the results of the perturbed elements, secular and periodic perturbations.

CO4: The knowledge of orbit perturbations and missile trajectories.

CO5: The idea of flight mechanics and rocket technology.

Unit-I: Basic formulae of a spherical triangle - the two-body problem: the motion of the Centre of mass, the relative motion. Kepler's equation. Solution by Hamilton Jacobi theory. Determination of Orbits: Laplace and Gauss Methods. **(Contact Hours: 12)**

Unit-II: The three-body problem: general three body problem, restricted three body problem, Jacobi integral, curves of zero velocity, stationary solutions and their stability. The n-body problem: the motion of the Centre of Mass, classical integrals. **(Contact Hours: 12)**

Unit-III: Perturbation: Equation of motion under perturbative force and the results of the perturbed elements, osculating orbit, perturbing forces, secular and periodic perturbations. **(Contact Hours: 12)**

Unit-IV: Flight Mechanics: rocket performance in Vacuum, vertically ascending paths, gravity twin trajectories, multi-stage rocket in a vacuum, definitions pertinent to single stage rocket, performance limitations of single stage rockets, definitions pertinent to multi-stage rockets, analysis of multi-stage rockets neglecting gravity, analysis of multi-stage rockets including gravity. **(Contact Hours: 12)**

Unit-V: Rocket performance with Aerodynamic forces, short-range non-lifting missiles, ascent of a sounding rocket, some approximate performance of rocket powered aircraft. **(Contact Hours: 12)**

Books Recommended:

1. J.M.A. Dandy, *Fundamentals of Celestial Mechanics*, The Macmillan Company (1962).
2. E. Finlay Freudlich, *Celestial Mechanics*, The Macmillan Company (1958).
3. R. Deutsch, *Orbital Dynamics of Space Vehicles*, Literary Licensing, LLC (2012).
4. T. E. Sterne, *An Introduction of Celestial Mechanics*, Literary Licensing, LLC (2011).
5. A. Miele, *Flight Mechanics Vol-I: Theory of Flight Paths*, Addition Wiley Publishing Company INC (1962).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
CO4	3	3	-	-	2		-	-	-	-	-	-	3	2	3	1	3
CO5	3	3	-	-	2		-	-	-	-	-	-	3	2	3	1	3
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.6**	**2**	**1**	**1.8**

High-3, Medium-2, Low-1, No Correlation-0

Course Work Elective Papers

1 Yr. PG (Sem.–I) or 2 Yrs. PG (Sem.–III)

MAT-101-CW-6110

CALCULUS OF VARIATIONS AND INTEGRAL EQUATIONS

Credit: 4 (L-3, T-1, P-0)

Total Contact Hours: 60

Theory: 100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to:

CO1: Solve different problems in mathematics and physics using the variation technique.

CO2: Understand the concept of variational problems and their applications.

CO3: Understand relationship between differential equations and integral equations, and their solving techniques.

Unit-I: Variation Problems with fixed boundaries: Variation of a functional, Admissible function, Euler-Lagrange equation, Necessary and sufficient conditions for extremum, Variational problems, Parametric and Isoperimetric problems and applications. **(Contact Hours: 15)**

Unit-II: Variation Problems with moving boundaries: Necessary and sufficient condition for extremum, variational problem for functional dependent on one or two functions, one-sided variations, Field of extremals, Jacobi conditions, Weirstrass function, Legendre condition, Canonical Equations and Variational principles, Poisson Bracket.

(Contact Hours: 15)

Unit-III: Fredholm Equation: Reduction of boundary value problem of an ordinary differential equation to an integral equation. Equation of the first, second and third kind, Solution by the method of successive approximation, Resolvent kernel and seperable kernels, Singular Integral Equations. **(Contact Hours: 15)**

Unit-IV: Volterra Equation: Equations of the first and second kind, Solution by the method of iterated kernel, existence and uniqueness of solution, Integral equations with Resolvent and Symmetric Kernels, Properties of eigenvalues and eigenfunctions for symmetric kernels. Applications of integral equations and Green's function to ordinary differential equations. **(Contact Hours: 15)**

Books Recommended:

1. I. M. Gelfand and S. V. Fomin, *Calculus of Variations,* Dover Publications (2000).
2. M. D. Raisinghania, *Integral Equations,* S. Chand and Co. (2016).
3. A.S. Gupta, *Calculus of Variation. Prentice Hall of India* (1996).
4. R. P. Kanwal, *Linear Integral Equations (Theory and Technique),* Springer-Verlag New York Inc (2014).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-CW-6120

MATHEMATICAL PROGRAMMING

Credit: 4 (L-3, T-0, P-1)

Total Contact Hours: 60

Theory: 100 (End Semester: 80, Internal Assessment: 20)

Practical: 100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to:

CO1: Solve optimization problems using Revised simplex method and duality simplex method.

CO2: Solve transportation problems and assignment problems.

CO3: Understand game theory and inventory control methods.

CO4: Formulate and solve different problems related to real life situations.

Unit-I: Revised simplex method, Duality, Fundamental theorem of duality, Dual simplex method, comparison of solution of primal and its dual. **(Contact Hours: 15)**

Unit-II: Transportation problems, North–West corner rule, Vogel's approximation method, Optimality test, Assignment problems. . **(Contact Hours: 10)**

Unit-III: Game theory: Two Person Zero Sum Game, Max-mini and Minimax Principles, Mix Strategies, Graphical and General Solutions of Games. . **(Contact Hours: 10)**

Unit-IV: Inventory Control: Deterministic inventory problems with no shortages, Deterministic inventory problems with shortages, EOQ problems with price breaks, Multi-item Deterministic problems. **(Contact Hours: 10)**

Unit-V: Practical: Computer programming (using MATLAB/MATHEMATICA) in consonance with Units-I-IV. **(Contact Hours: 15)**

Books Recommended:

1. F. S. Hillier, G.J. Lieberma, B Nag and P. Basu, *Introduction to Operation Research*, McGraw Hill (2021).
2. K. Swarup, P.K. Gupta and M. Mohan, *Operation Research*, S. Chand & Son. (2019)
3. K. V. Mittal and C. Mohan, *Optimization methods in Operations Research and System Analysis*, New Age International Publications, (2020).
4. A. T. Hamdy, *Operations Research: An Introduction*, McMillan Publishing Company, (2019).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
CO4	3	3	-	-	2		-	-	-	-	-	-	3	2	3	1	3
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-CW-6130

CONTINUUM MECHANICS

Credit: 4 (L-3, T-1, P-0)

Total Contact Hours: 60

Theory: 100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to:
CO1: Learn about a wide variety of advanced courses in solid and fluid mechanics.
CO2: Understand the concept of basics of continuum mechanics.
CO3: Understand the fundamental laws of motion and flows.
CO4: Apply the concept of continuum mechanics in solving problem.

Unit-I: Analysis of stress: The continuum concept, Homogeneity, Isotropy, Mass Density, Force and moment of equilibrium, Stress transformation laws, Stress quadric of Cauchy, Principal stresses, stress invariants, Stress ellipsoid. **(Contact Hours: 10)**

Unit-II: Deformation and Strain: Continuum Configuration, Deformation and flow concepts, Lagrangian and Eulerian descriptions, Deformation and displacement gradients, Deformation tensors, Finite strain tensors, Small deformation theory, Relative displacement, Linear rotation tensor, Rotation vector, Stretch ratio, Finite strain interpretation, Principal strains, Strain invariants, Cubical Dilatation. **(Contact Hours: 10)**

Unit-III: Motions and Flow: Material derivative, Velocity, Acceleration, Instantaneous velocity, field, Path lines and stream lines steady motion, Rate of deformation tensor, Velocity tensors and their physical interpretation. **(Contact Hours: 10)**

Unit-IV: Fundamental laws of Continuum Mechanics: Conservation of mass, Continuity equation, Linear momentum principle, Equation of motion, Equilibrium equations, Moment of momentum principle, Conservation of energy, Energy Equation. **(Contact Hours: 20)**

Unit-V: Linear Elasticity: Generalized Hook's law, Strain energy function, Isotropy, Anisotropy, Elastic symmetry, Isotropic media, Elastic constants, Navier-Cauchy equations and Beltrami -Michel equations. **(Contact Hours: 10)**

Books Recommended:

1. G. E. Mase, *Continuum Mechanics-Schaum's outlines series*, Tata McGraw-Hill (2020).
2. R. Chatterjee, *Mathematical theory of Continuum Mechanics*, Narosa Publishing House, New Delhi (2015).
3. D.S. Chandrasekharariah and L. Debnath, *Continuum Mechanics*, Elsevier (2014).
4. A. J. M. Spencer, *Continuum Mechanics,* Dover Publications Inc (2004).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
CO4	3	3	-	-	2		-	-	-	-	-	-	3	2	3	1	3
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-CW-6140
MATHEMATICAL STATISTICS
Credit: 4 (L-3, T-1, P-0)
Total Contact Hours: 60
Theory: 100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to:
CO1: Gain knowledge on various components of statistical analysis such as distributions, expectations, correlations, sampling theory and so on.
CO2: Acquire proficiency in concepts and principles of statistical computing.
CO3: Classify different types of distribution using row, primary and secondary data.
CO4: Acquaint with advancement in statistical theory and applications in real life situations.

Unit-I: Mathematical expectations, Chebyshev's inequality, weak law of large numbers, Bernoulli's theorem, central limit theorem and their applications. **(Contact Hours: 10)**

Unit-II: Negative binomial distribution, hypergeometric distribution, exponential distribution, Gamma and Beta distributions and their properties including limiting cases. **(Contact Hours: 15)**

Unit-III: Correlations, coefficients of correlations and properties, Cauchy-Schwarz's inequality and limits of correlation coefficient, correlation of ranks and Spearman's rank correlation coefficient. Regression, regression curves, coefficients of regressions, non-linear regression and correlation ratio. Multiple and partial correlation and regression. **(Contact Hours: 20)**

Unit-IV: Sampling distribution and test of significance: Sampling distributions; mean and standard error, level of significance, confidence intervals, test of significance, test using Fisher's Z- transformation, t, χ^2 and F – distributions. **(Contact Hours: 20)**

Books Recommended:

1. S. C. Gupta and V. K. Kapoor, *Fundamentals of Mathematical Statistics*, S. Chand & Sons (2020).
2. M. Spiegel , J. Schiller , R. A. Srinivasan and D. Goswami, *Probability and Statistics*, McGraw Hill education; 3rd edition (2017).
3. R. V. Hogg, J. W. McKean and A.T. Craig, *Introduction to Mathematical Statistics*, Pearson Education, Asia, (2007).
4. O.P. Gupta and V. Sharma, *Mathematical Statistics*, Kedar Nath Ram Nath (2021).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
CO4	3	3	-	-	2		-	-	-	-	-	-	3	2	3	1	3
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-CW-6150
TOPOLOGY
Credit: 4 (L-3, T-1, P-0)
Total Contact Hours: 60
Theory: 100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: After completion of the course, the students will be able to:
CO1: Achieve fundamental knowledge on topological spaces, compactness, separation axioms and connectedness.
CO2: Classify different types of abstract spaces like Hausdorff, regular, normal, completely regular/normal spaces and various types of T_i (i=0,1,2,3,4,5) spaces.
CO3: Gain the ability to understand any topic related to topology and geometry.
CO4: Visualize various concepts of topological spaces which can be applied in various fields of analysis and develop skill in pursuing research.

Course Learning Outcomes: The course will enable students to visualize various concepts of abstract topological spaces which can be applied in various fields of analysis.

Unit-I: Definition of topological space, neighbourhood, interior point, interior, closure and closure point, limit point, derived sets, bases, sub bases, first and second countable space, relative topology, continuity, uniform continuity with examples, weak topology, quotient space and product space. **(Contact Hours: 15)**

Unit-II: Compactness, basic properties of compactness, Tychconoff's theorem, locally compact space, Lindelof space, sequentially and countably compact, Lebesgue covering lemma, Ascoli's theorem.

(Contact Hours: 15)

Unit-III: Separations axioms, T_0, T_1-space, Hausdroff space, regular space, normal space, completely regular space, Urysohn's lemma, Tietze extension theorem, Urysohn's metrization's theorem.

(Contact Hours: 15)

Unit-IV: Connectedness, totally disconnected, locally connected components, locally and path connectedness.

(Contact Hours: 15)

Books Recommended:

1. J. R. Munkres, *Topology,* Pearson Education (2021).
2. G. F. Simmons, *Introduction to Topology and Modern Analysis*, Krieger Publishing Company (2003).
3. S. W. Davis, *Topology,* Tata McGraw-Hill (2006).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
CO4	3	3	-	-	2		-	-	-	-	-	-	3	2	3	1	3
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-CW-6160
MEASURE THEORY
Credit: 4 (L-3, T-1, P-0)
Total Contact Hours: 60
Total Marks: 100 (Theory: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to:
CO1: Understand the basic concepts of measureable sets and functions, and Fundamental theorem of calculus for the Lebesgue integrals.
CO2: Understand theory of Lebesgue integration and applications.
CO3: Understand the concepts of signed measure and product measure with important theorems.
CO4: Learn the probability theory in terms of measure theory.

Unit-I: Basics of measurable sets, measurable functions. Lebesgue integrable functions; Fundamental theorem of calculus for the Lebesgue integrals; Absolutely continuous functions, differentiability of monotones functions,
(Contact Hours: 15)

Unit-II: Signed measures, Hahn and Jordan Decompositions, absolute continuity, Radon Nikodyn theorem, derivatives of signed measures. L_p – spaces and their dual. **(Contact Hours: 15)**

Unit-III: Product measures, construction, Fubini's theorem and its applications. Finite and infinite dimensional product spaces. Locally compact spaces, regular measures. Haar measure. **(Contact Hours: 15)**

UNIT-IV: Measurable space, measure space, finite and sigma-finite measures, Axiomatic definition of Probability, definition of Random Variable, Measure induced by a measurable function, definition of Probability distribution and distribution function, properties of distribution function and classification of distributions, Expectation as Lebesgue integrals. **(Contact Hours: 15)**

Books Recommended:

1.P.R. Halmos, *Measure Theory*, Springer (2013).

2.D.L. Cohn, *Measure Theory*, Springer Science & Business Media (2013).

3.G. De Barra, *Measure Theory and Integration*, New Age International (2022).

4. H.L. Royden, *Real Analysis*, PHI (2015).

5. I. K. Rana, *An introduction to Measure and Integration*, Narosa publishing House (2007).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2	-	-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2	-	-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2	-	-	-	-	-	-	-	3	2	1	1	1
CO4	3	3	-	-	2	3	-	-	-	-	-	-	3	2	1	1	1
Average	**3**	**3**	**-**	**-**	**2**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-CW-6170
RINGS AND MODULES
Credit: 4 (L-3, T-1, P-0)
Total Contact Hours: 60
Theory: 100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: This course will enable students to:

CO1: Demonstrate a comprehensive understanding of fundamental concepts of in ring theory.

CO2: Understand modules their properties and interconnections.

CO3: Apply Noetherian and Artinian properties in rings and modules.

CO4: Solve problems and analyze advanced algebraic structures in rings and modules.

Unit-I: Preliminaries on rings and ideals; Primeness; Local and Semi Local Rings; Nil Radical and Jacobson Radical. **(Contact Hours: 12)**

Unit-II: Modules (Definition and Examples), Direct Sums, Free Modules. **(Contact Hours: 12)**

Unit-III: Quotient Modules, Homomorphisms, Simple Modules, Modules over PID's. **(Contact Hours: 12)**

Unit-IV: Finitely Generated Modules; Exact Sequences; Chain Conditions; Ascending Chain Conditions on Modules; Maximal Condition; Noetherian Modules/Ring; Descending Chain Condition; Minimal Condition, Artinian Modules/Ring; their properties. **(Contact Hours: 12)**

Unit-V: Essential Extensions; Injective Hulls; Semisimple Modules; The Singular Submodules. **(Contact Hours: 12)**

Books Recommended:

1.M.F. Atiyah and I.G. Macdonald, *Introduction to Commutative Algebra*, Sarat Book House (2007).
2.C. Musili, *Introduction to Rings and Modules*, Narosa Publishing House, New Delhi (1999).

3.K.R. Goodearl, *Ring Theory: Nonsingular Rings and Modules*, CRC Press (1976).

4. S. Lang, *Algebra*, Springer (2005).

5. A.W. Chatters and C.R. Hajarnavis, *An Introduction Course in Commutative Algebra*, Oxford University Press (1998).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
CO4	3	3	-	-	2		-	-	-	-	-	-	3	2	3	1	3
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-CW-6180
FLUID MECHANICS – I
Credit: 4 (L-3, T-1, P-0)
Total Contact Hours: 60
Theory: 100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to
CO1: Understand various topics in fluid mechanics.
CO2: Construct the techniques to predict physical parameters that influence the flow of fluid mechanics.
CO3: Impart knowledge of the fluid mechanics to real world problems.
CO4: Understand the knowledge of vortex motion and their applications to naturally occurring vortices.

Unit-I: Different kinds of fluids: Material, local and convective derivatives, Equation of Continuity, Rotational and Irrotational motion, Stream and Path lines, Velocity Potential, Boundary surfaces. **(Contact Hours: 15)**

Unit-II: Equation of motion of inviscid fluids: Euler's equation of motion, Bernoulli's equation, Conservative field of forces, Helmholtz equation. **(Contact Hours: 15)**

Unit-III: Motion in two dimension: Stream function, Complex potential, Source, Sink, Doublet, Complex potential and images with respect to straight line and Circle, Blasius theorem **(Contact Hours: 15)**

Unit-IV: Vortex motion: Vorticity vector, vortex line, Vortex tube, Properties of vortex, Strength of the vortex, Rectilinear Vortices, Velocity components, Centre of vortices, Vortex doublet. **(Contact Hours: 15)**

Books Recommended:

1. M. D. Raisinghania, *Fluid Dynamics*, S. Chand and Co. Ltd. (2003)

2. S. W. Yuan, *Foundation to Fluid Mechanics*, Prentice-Hall, Englewood Cliffs, NJ (1967).

3. J. L. Bansal, *Viscous Fluid Dynamics*, Oxford and IBH Publishing Co. (2022).

4. G. K. Batchelor, *An Introduction to Fluid Dynamics*, Cambridge University Press (2000).

5. F. Chorlton, *Textbook of Fluid Dynamics*, G. K. Publishers (2012).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
CO4	3	3	-	-	2		-	-	-	-	-	-	3	2	3	1	3
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-CW-6190
FUNCTIONAL ANALYSIS
Credit: 4 (L-3, T-1, P-0)
Contact Hours: 60
Theory: 100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: This course will enable students to:
CO1: Understand basic concepts of Banach space and fundamental theorems associated with it.
CO2: Understand the theory of Hilbert space.
CO3: Learn various operators defined on Banach and Hilbert spaces.
CO4: Acquaint with the spectral theory of operators.

Unit-I: Normed linear spaces, Banach spaces and examples. Quotient space. Continuous functions and bounded linear operators. Finite dimensional normed linear spaces. Equivalent norms. Riesz Lemma **(Contact Hours: 15)**

Unit-II: Fundamental Theorems: Hahn-Banach theorem, Open mapping theorem, Closed graph theorem, Uniform boundedness theorem, Adjoint operator. Weak and Weak*- convergence in Banach spaces. **(Contact Hours: 15)**

Unit-III: Hilbert space and basic properties. Schwarz inequality. Orthogonality, Orthonormality, Orthogonal complements. Bessel's inequality. Conjugate space. Riesz representation theorem**.** **(Contact Hours: 15)**

Unit-IV: Eigenvalue, Eigenvectors, Spectrum, spectral radius, resolvent, finite dimensional spectral theorem, adjoint and self-adjoint operators, positive, normal, unitary operators, and their spectral properties. **(Contact Hours: 15)**

Books Recommended:

1. E. Kreyszig, *Introductory Functional Analysis with applications*, John Wiley & Sons, (2007).

2. G.F. Simmons, *Introduction to Topology and Modern Analysis*, Krieger Publishing Company (2003).

3. D. Somasundaram, *A First Course in Functional Analysis*, Alpha Science International Ltd (2006)

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
CO4	3	3	-	-	2		-	-	-	-	-	-	3	2	3	1	3
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

Course Work Elective Papers

1 Yr. PG (Sem.–II) or 2 Yrs. PG (Sem.–IV)

MAT-101-CW-6210
FLUID MECHANICS - II
Credit: 4 (L-3, T-1, P-0)
Total Contact Hours: 60
Total Marks: 100 (Theory: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to:
CO1: Identify and analyze various types of fluid flows.
CO2: Understand the importance of non-dimensional parameters and their importance to analyze the behavior of the flow.
CO3: Determine the exact solution of the Navier-Strokes equations under certain conditions.
CO4: Analysis of viscous flows in simple geometries and boundary layer flows by using the Navier-Stokes equation.
CO5: Apply for research in fluid dynamics as well as interdisciplinary area mostly related to Physics and Biology.

Unit-I: Viscosity: Newton's law of viscosity, Navier-Stokes equations of motion, energy equation for viscous fluid, and energy dissipation due to viscosity. **(Contact Hours: 15)**

Unit-II: Dimensional analysis: Buckingham π-theorem, and its applications, non-dimensional parameters and their importance. **(Contact Hours: 15)**

Unit-III: Exact solution of Navier-Strokes Equation: Steady laminar flow between plates, plane Poiseuille flow, Hagen-Poiseuille flow, pulsatile flow between parallel surfaces, unsteady motion of flat plate. **(Contact Hours: 15)**

Unit-IV: Boundary Layer Theory: Prandtl's boundary layer theory and its importance, boundary layer thickness, displacement thickness, momentum thickness, energy thickness, drag and lift, boundary layer equations in two dimensional flows, the Blasius solution. **(Contact Hours: 15)**

Books Recommended:

1. H. Schilchting, *Boundary Layer Theory*, McGraw Hill Book Co., New York (2014).
2. L. M. M. Thomson, *Theoretical Hydrodynamics*, Dover Publication (2013).
3. A. Schilchting and K. Gersten, *Boundary Layer Theory*, Springer (2016).
4. J. L. Bansal, *Viscous Fluid Dynamics*, Oxford and IBH Publishing (2022).
5. F. Chorlton, *Textbook of Fluid Dynamics,* G. K. Publishers (2012).
6. M. D. Raisinghania: *Fluid Dynamics*, S. Chand and Co. Ltd. (2003).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
CO4	3	3	-	-	2		-	-	-	-	-	-	3	2	3	1	3
CO5																	
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

MAT-101-CW-6220
GRAPH THEORY
Credit: 4 (L-3, T-1, P-0)
Total Contact Hours: 60

Theory: 100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to:

CO1: Gain foundational knowledge for graph theory.

CO2: Understand the concept of Eulerian and Hamiltonian graphs and their applications.

CO3: Learn applications of graph theory to various areas of applied sciences.

Unit-I: Graphs, Vertex and Degree, Sub graphs, Walks, paths and circuits, Digraphs, Connected graphs, Paths connected, disconnected graphs and components; Vertex Degrees and graphic sequences, Bipartite graphs, Operations on graphs. **(Contact Hours: 15)**

Unit-II: Cut points, bridges and blocks, block graphs and cut point graphs, trees, binary trees spanning trees, weighted graphs, spanning trees in a weighted graph. **(Contact Hours: 15)**

Unit-III: Eulerian and Hamiltonian graphs, Line graphs. Factorizations: 1– Factorizations, 2 – Factorization, Covering and critical points. **(Contact Hours: 15)**

Unit-IV: Planner graphs, outer planer graphs, Euler's polyhedron formula, Kuratowski's theorem, the chromatic number. five color theorem, four color conjecture. matrix representation of graphs: adjacency matrix, incidence matrix, circuit matrix. fundamental circuit matrix and rank. **(Contact Hours: 15)**

Books Recommended:

1. N. Deo, *Graph Theory with applications to Engineering and Computer Science*; Dover Publication Inc. (2016).
2. F. Harary: *Graph Theory*; CRC Press (2019).
3. D.B. West: *Introduction to Graph Theory*, Pearson Education India (2015).
4. V. K. Balakrishnan, *Graph Theory*, McGraw Hill (2020).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

MAT-101-CW-6230

WAVELETS AND APPLICATIONS

Credit: 4 (L-3, T-0, P-1)

Total Contact Hours: 60

Theory: 100 (End Semester: 80, Internal Assessment: 20)

Practical: 100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to:

CO1: Understand the Fourier transform with its basic properties and important theorems.

CO2: Acquaint with a remarkable tool for smoothing noisy signals.

CO3: Apply the wavelet tools in compression on data streams and images in the field of signal processing.

CO4: Solve differential equation and integral equations using wavelets.

CO5: Understand the concept of multiresolution analysis and construction of wavelets.

Unit-I: Fourier Analysis: Fourier transforms in $L^1(\mathbb{R})$, Basic properties of Fourier transforms, Fourier transforms in $L^2(\mathbb{R})$, Poisson's Summation formula, The Shannon sampling theorem and Gibbs's phenomenon, Heisenberg's uncertainty principle. **(Contact Hours: 11)**

Unit-II: Definition and examples of wavelets, Continuous wavelet transforms, Basic Properties of Wavelet transforms, continuous wavelet transform and Holder continuity. The Discrete wavelet transforms Frames and Frame Operators, Orthonormal Wavelets. **(Contact Hours: 12)**

Unit-III: Multiresolution Analysis: Definition of Multiresolution Analysis and Examples, Properties of scaling functions and Orthonormal wavelet Bases. (**Contact Hours: 12)**

Unit-IV: Construction of wavelets, cardinal B-splines, Franklin wavelet, Battle- Lemarie wavelet, Daubechies' wavelets. **(Contact Hours: 10)**

Unit-V: Practical: Problems solving through MatLab Wavelet Toolbox in consonance with the materials covered in these units. (**Contact Hours: 15**)

Books Recommended:

1.L. Debnath, *Wavelet Transforms and Their Applications*, Birkhauser (2014).

2.D. F. Walnut, *An Introduction to Wavelet Analysis*, Springer Verlag New York Inc. (2013).

3.P. Wojtaszczyk, *A Mathematical Introduction to Wavelet*, CRC Press (1997).

4.C.K. Chui, *An Introduction to Wavelets*, Academic Press (2014).

5.A. Boggess, and F. J. Narcowich, *A First Course in Wavelets with Fourier Analysis*, Wiley (2009).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
CO4	3	3	-	-	2		-	-	-	-	-	-	3	2	3	1	3
CO5																	
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-CW-6240

FUZZY SET THEORY AND APPLICATIONS

Credit: 4 (L-3, T-1, P-0)

Contact Hours: 60

Theory: 100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to:

CO1: Grasp the basic theories of fuzzy sets and fuzzy logics.

CO2: Understand the advantages of fuzzy logic to that of classical logic.

CO3: Learn the applications of fuzzy logic in decision making and automation problems.

Unit-I: Fuzzy Sets: Basic definitions, α- level sets, Basic operations on Fuzzy sets, Types of fuzzy sets, Extension principle for fuzzy sets, $t-$ norms; $t-$ conorms, Fuzzy numbers, Arithmetic with Fuzzy numbers. **(Contact Hours: 15)**

Unit-II: Fuzzy relations: Basic properties of fuzzy relations, compositions of Fuzzy relations, relational join, Fuzzy graphs, Fuzzy Equivalence relation, Fuzzy compatibility relation, Fuzzy pre- order relation, Fuzzy order relation, Fuzzy matrix. **(Contact Hours: 15)**

Unit-III: An overview of classical logic, Multivalued logics, Linguistic variables, Linguistic modifiers, Truth, Propositions of fuzzy logic, Fuzzy quantifiers. Approximate reasoning, Fuzzy implications. **(Contact Hours: 15)**

Unit-IV: Fuzzy decision making: individual decision making, multi person decision making and multi criteria decision making, Fuzzy ranking methods, Fuzzy controllers, Defuzzification. **(Contact Hours: 15)**

Books Recommended:

1. G. J. Klir and B. Yuan, *Fuzzy Sets and Fuzzy Logic Theory and Applications, PHI (2015).*
2. H. J. Zimmermann, *Fuzzy Set Theory and its Applications*, Springer (2006).
3. G. Bojadzieve and M. Bozadzieve, *Fuzzy Sets, Fuzzy Logic Applications:* World Scientific Publishing Co (1996).
4. H. T. Nguyen, N.R. Prasad, C.L. Walker and E.A. Walker, *A First Crouse in Fuzzy and Neural Controls,* Champan and Hall/ CRC Press, Taylor and Francis Group (2003).
5. J. Harris, *Fuzzy Logic Application in Engineering Science*, Springer (2006).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-CW-6250

OPERATION RESEARCH

Credit: 4 (L-3, T-1, P-0)

Total Contact Hours: 60

Total Marks: 100 (Theory: 80, Internal Assessment: 20)

Course Outcomes: After successfully completing the course, the students will enable to

CO1: Solve nonlinear programming problems using appropriate techniques and optimization solvers, interpret the results obtained.

CO2: Know when simulation and dynamic programming can be applied in real world problems.

CO3: Choose the appropriate queuing model for a given practical application.

CO4: Plan, schedule and control the given project by PERT/CPM.

CO5: Understand the various techniques of operations research; use operations research to solve various transportation problems.

Unit-I: Non-linear Programming: General Non-Linear Programming Problem, Constrained Optimization with Equality Constraints, Constrained Optimization with Inequality Constraints, Kuhn-Tucker Conditions for General NLPP with m(<n) Constraints, Quadratic Programming, Wolfe's Modified Simplex Method, Beale's Method.

(Contact Hours: 15)

Unit-II: Dynamic Programming: The recursive Equation Approach, Characteristics of Dynamic Programming, Dynamic Programming Algorithm, Solution of Discrete D.P.P., Solution of L.P.P. by Dynamic Programming.

(Contact Hours: 15)

Unit-III: Queueing Theory: Queueing System, Elements of Queueing System, Operating Characteristics of Queueing System, Probability Distributions in Queueing System, Classification of Queueing Models, (M/M/1, ∞/FIFO), (M/M/1, C/FIFO), (M/M/N, ∞/FIFO) (M/M/1, GD/FIFO), Definition of Transient and Steady States, Poisson Queueing System.

(Contact Hours: 15)

Unit-IV: Network Scheduling by PERT/CPM: Network and Basic Components, Logical Sequencing, Rules of Network Construction, Critical Path Analysis, Probability Considerations in PERT, Distinction between PERT and CPM. **(Contact Hours: 15)**

Books Recommended:

1. K. Swarup, P. K. Gupta and M. Mohan, *Operations Research,* Sultan Chand & Sons (2019).
2. Hamdy A. Taha, *Operations Research: An Introduction*, 10th edition, Pearson (2019).
3. F. S. Hillier, G.J. Lieberman, B Nag and P. Basu, *Introduction to Operation Research*, McGraw Hill. International (2017).
4. N. S. Kambo, *Mathematical Programming Techniques*, East West Press (2008).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
CO4	3	3	-	-	2		-	-	-	-	-	-	3	2	3	1	3
CO5																	
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-CW -6260

DIFFERENTIAL GEOMETRY OF MANIFOLDS

Credit: 4 (L-3, T-1, P-0)

Contact Hours: 60

Theory: 100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to:

CO1: Acquaint with basic elements of differential geometry of manifold.

CO2: Gain knowledge to do calculus and geometry.

CO3: Gain skills which are necessary to study physical systems that involve functions on curved spaces, properties and analysis on curves, surfaces, and higher dimensional spaces using tools from calculus and linear algebra.

CO4: Pursue research in the field of mechanics, relativity, electromagnetism, string theory, etc.

Unit-I: Manifolds: Topological manifolds, differentiable manifolds, smooth maps between two manifolds, functions of class C^r, diffeomorphism, tangent vector, tangent space, derivative of a smooth map between two manifolds, vector fields, f-related vector fields on differentiable manifold, integral curves of vector field, flows and local flows. **(Contact Hours: 15)**

Unit-II: Tensor algebra, Exterior algebra, differential forms, exterior derivative, Lie algebra of a Lie group, homomorphism and isomorphism of Lie group, one parameter subgroup, Lie transformation groups, Lie derivative, Parallel Whitney weak embedding theorem, statement of Whitney embedding theorem, Morse's theorem and Morse function. **(Contact Hours:15)**

Unit-III: Riemannian geometry: Covariant derivative, affine connection and existence theorem, torsion and symmetric connection, Riemannian metric, Riemannian connection, existence theorem of Riemannian connection, Riemannian curvature, sectional curvature, transformations on Riemannian Manifold. **(Contact Hours: 15)**

Unit-IV: Ricci tensor, scalar curvature, Schur's theorem, submanifold of a Riemannian Manifold, induced connections, Second fundamental form of a Riemannian submanifold, Gauss equation, Ricci equation, Coddazi equation, Mean curvature. **(Contact Hours: 15)**

Books Recommended:

1. S. Levett, *Differential Geometry of Manifolds*, Chapman and Hall/CRC (2023).
2. U. C. De and A.A. Shaikh, *Differential Geometry of Manifolds*, Narosa Publishing House (2007).
3. William M. Boothby, *An Introduction to Differentiable Manifolds and Riemannian Geometry*, Academic Press Inc. Ltd. (2002).
4. A. Mukherjee, *Topics in Differential Topology*, Hindustan Book Agency (2005).
5. S. Kumeresan, *A Course in Differential Geometry and Lie Groups*, Hindustan Book Agencies (2002).
6. S. Gallot, D. Hulin and J. Lafontaine, *Riemannian Geometry*, Springer Verlag (2004).
7. A.A. Kosinski, *Differentiable Manifolds*, Dover Publication Inc. (2003).

POs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-CW-6270

ADVANCED FUNCTIONAL ANALYSIS

Credit: 4 (L-3, T-1, P-0)

Total Contact Hours: 60

Theory: 100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: This course will enable students to:

CO1: Understand the foundational concepts of topological vector space.

CO2: Identify the concepts of Hilbert spaces and properties of different operators defined on it.

CO3: Understand important related to spectral properties of different operators.

Unit-I: Topological vector space, separation properties, boundedness and continuity, seminorms and local convexity, Quotient spaces. Weak topology of a topological vector space, weak*-topology of a dual space, Banach-Alaoglu theorem, Krein-Milman theorem, Milman theorem. **(Contact Hours: 15)**

Unit-II: Uniform, strong and weak convergences. Compact linear operators on normed linear spaces; the separability of the Range and spectral properties of a compact operator; operator equations involving compact operators. **(Contact Hours: 10)**

Unit-III: Bounded operators on Hilbert spaces; spectral properties of bounded self-adjoint linear operators; positive operators and their square root; projection operators; spectral representation of a bounded self-adjoint linear operator, closed linear operators; closable operators and their closures; spectral representation of unitary and self-adjoint linear operators; multiplication operator and differentiation operator. **(Contact Hours: 20)**

Unit-IV: Spectral measure; spectral theorem for bounded normal operators. Functional calculus and spectral mapping theorem for analytic functions; Riesz decomposition theorem. Numerical range of an operator; spectral radius; subnormal and hyponormal operators; partial isometries; polar decomposition. **(Contact Hours: 15)**

Books Recommended:

1. E. Kreyszig, *Introductory Functional Analysis with applications*, John Wiley & Sons, (2007).
2. W. Rudin, *Functional Analysis*, McGraw Hill Education (2017).
3. P. R. Halmos, *Introduction to Hilbert spaces and theory of spectral multiplicity*, Dover Publication Inc. (2018).
4. G. Bachman and L. Narici, *Functional Analysis*, Dover Publication Inc. (2003).
5. J. B. Conway, *A course in Functional Analysis*, Springer Verlag, New York (1997).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-CW-6280

THEORY OF DISTRIBUTION AND SOBOLEV SPACES

Credit: 4 (L-3, T-1, P-0)

Contact Hours: 60

Theory: 100 (End Semester: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to:

CO1: Understand the concept of test functions and distributions.

CO2: Grasps the definitions and properties of Sobolev space.

CO3: Apply distributions in locally convex space and manifolds.

CO4: Utilize various techniques from non-linear analysis in mathematical problems and proving theorems.

Unit-I: Test Function and distribution: Definition, operations with distributions, convolution of distributions, Fourier transform of tempered distributions. **(Contact Hours: 12)**

Unit-II: Sobolev spaces: Definition and properties, extension theorem, imbedding and completeness theorem, fractional order Sobolev spaces, trace theory. **(Contact Hours: 12)**

Unit-III: Distributions in Locally convex spaces and distributions on Manifolds. (**Contact Hours: 12)**

Unit-IV: Application to Elliptic Problems: Weak solution of elliptic boundary value problem (BVP), regularity of weak solutions, maximum principle, eigenvalue problems, fixed point theorems and their application in semilinear elliptic BVP. **(Contact Hours: 12)**

Unit-V: Some techniques from nonlinear analysis: Banach, Brouwer, Schauder and Schaeffer fixed point theorems, The Galerkin methods, Monotone Iterations, Variational Methods, Pohozaev's Identity. **(Contact Hours: 12)**

Books Recommended:

1. S. Kesavan, *Topics in Functional Analysis and Applications*, New Academic Science (2020).
2.R. S. Pathak, *A Course in Distribution Theory and Applications*, Narosa Publications (2001).
3. J.T. Oden and J. N. Reddy, *An Introduction to Mathematical Theory of Finite Elements*, Courier Corporation (2011).
4. E. H. Lieb and M. Loss, *Analysis*, American Mathematical Society (2001).
5. R. Strihartz, *A guide to Distribution Theory and Fourier Transforms*, World Scientific Publishing Co.(2003).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
CO4	3	3	-	-	2		-	-	-	-	-	-	3	2	3	1	3
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0

MAT-101-CW-6290

COMPUTATIONAL FLUID DYNAMICS

Credit: 4 (L-3, T-1, P-0)

Total Contact Hours: 60

Total Marks: 100 (Theory: 80, Internal Assessment: 20)

Course Outcomes: The course will enable students to:

CO1: Understand the concepts of incompressible and compressible flows, finite difference and finite volume method, explicit and implicit methods and so on.

CO2: Recognize the basic principles of fluid mechanics and use the appropriate model equations to investigate the flow.

CO3: Demonstrate an ability to describe various flow features in terms of appropriate fluid mechanical principles and force balances.

CO4: Develop numerical models of fluid flow to tackle various problems that arises in different branches of engineering sciences.

Unit-I: Introduction: Brief introduction of boundary layer flow, incompressible and compressible flows, finite difference and finite volume method, example of parabolic and hyperbolic systems and time discretization technique, explicit and implicit methods, upwind and central difference schemes, stability, dissipation and dispersion errors. **(Contact Hours: 15)**

Unit-II: Solution of Simultaneous Equations: point iterative/block iterative methods, Gauss-Seidel iteration (concept of central coefficient and residue, SOR), different acceleration techniques. Approximate solution of differential equations through variational formulation, Boundary conditions in the variational form: Primary and secondary variables, Essential and natural boundary conditions, Properties of variational form. **(Contact Hours: 15)**

Unit-III: Fundamentals of Discretization: Preprocessing, Solution, Postprocessing, Finite Element Method, Finite difference method, well posed boundary value problem, Possible types of boundary conditions, Conservativeness, Boundedness, Transportiveness, Illustrative examples: 1-D steady state heat conduction without and with constant source term. **(Contact Hours: 15)**

Unit-IV: Finite Volume Method: Some Conceptual Basics and Illustrations through 1-D Steady State Diffusion Problems: Physical consistency, Overall balance, FV Discretization of a 1-D steady state diffusion type problem, Four basic rules for FV Discretization of 1-D steady state diffusion type problem, Source term linearization, Implementation of boundary conditions, implicit, fully explicit and Crank-Nicholson schemes. **(Contact Hours: 15)**

Books Recommended:

1.H. K. Versteeg and W. Malalasekera, *An introduction to Computational Fluid Dynamics*, PHI (2007).

2. T. K. Sengupta, *Computational Fluid Dynamics*, University Press (2004).

3. C. Hirch, *Numerical Computation of Internal and External Flows,* Butterworth-Heinemann (2007).

4. S. V. Patankar, *Numerical Heat Transfer and Fluid Flow, Hemisphere Series on Computational Methods in Mechanics and Thermal Science*, Routledge (2011).

5. P. S. Ghoshdastidar, *Computer Simulation of Flow and Heat Transfer*, Cengage India Private Limited (2017).

COs- POs/PSOs Matrix of the Course

PSOs/POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	-	-	2		-	-	-	-	-	-	3	1	2	1	1
CO2	3	3	-	-	2		-	-	-	-	-	-	3	1	1	1	1
CO3	3	3	-	-	2		-	-	-	-	-	-	3	2	1	1	1
CO4	3	3	-	-	2		-	-	-	-	-	-	3	2	3	1	3
Average	**3**	**3**	**-**	**-**	**2**		**-**	**-**	**-**	**-**	**-**	**-**	**3**	**1.5**	**1.8**	**1**	**1.5**

High-3, Medium-2, Low-1, No Correlation-0