KISS

KALINGA INSTITUTE OF SOCIAL SCIENCES

CURRICULUM AND CREDIT FRAMEWORK FOR UNDERGRADUATE PROGRAMME

BACHELOR OF SCIENCE (B.SC.) IN MATHEMATICS

(As per NEP-2020, NCrF, NHEQF)

Academic Session 2024-2025



DEPARTMENT OF MATHEMATICS

SCHOOL OF INDIGENOUS KNOWLEDGE, SCIENCE AND TECHNOLOGY

KALINGA INSTITUTE OF SOCIAL SCIENCES (KISS)

DEEMED TO BE UNIVERSITY

Higher Education Campus, KISS Campus-3, Bhubaneswar, Odisha, 751024

https://university.kiss.ac.in | https://kiss.ac.in

SL. No.		Contents	Pg. No.
I		About the Department / School and Programme	3
	i)	About the school	3-4
	ii)	About the department	5-6
	iii)	Misson and vision of School	6
II		B. Sc. in Mathematics Programme	6
III		Process of Curriculum Development	7
IV		Definitions of Components	7-8
V		NCRF-Aligned Components (National Credit Framework)	8-9
	i.	NCrF compliant Course Engagement Table	9
	ii	NCrF Categorywise Credit Distribution(UGC CCFUP Compatible)	9-10
VI		Eligibility of Admission with Number of seats	10
VII		Examination Pattern: As per NEP 2020	10
	i	Duration of the Examinations-Mid Semester & End Semester	10-11
	ii	Distribution of Marks in End Semester and Continuous Evaluation	11
	iii	Distribution of Sessional Marks: (Continuous Evaluation)	12
	iv	Examination Question Pattern of End Term Examination and Mark Distribution	12
	v	Examination Question Pattern of Mid Semester Examination and Mark distribution	12-13
	vi	Grading System	13
	vii	Formula for Conversion of grade Point of Marks	14
	viii	Hard case rule	14
VIII		Duration and Types of Courses and Process of Multiple Entry and Exit	14-15

IX		**Programme Educational Objectives (PEOS)**	**15-16**
X		**Programme Outcomes(POs)**	**16-18**
XI		**Programme specific outcomes(PSO)**	**18**
XII		**Course Structure of B.Sc Mathematics**	**18-24**
XIII		**Detailed Course content for B.Sc. Mathematics**	**22**
	i)	**Semester - I**	**24-37**
	ii)	**Semester - II**	**37-53**
	iii)	**Semester - III**	**53-64**
	iv)	**Semester - IV**	**64-73**
	iv)	**Semester - V**	**73-93**
	iv)	**Semester - VI**	**93-112**
	iv)	**Semester - VII**	**112-127**
	iv)	**Semester - VIII**	**127-144**

I. About the Department / School and Programme

i. About the School

The School of Indigenous Knowledge, Science and Technology, KISS Deemed to be University, was established in 2017-18 with a view of Indigenous scientific knowledge and technological development in a symbiotic relationship with Nature. Indigenous people have an innate understanding of natural resources available in our ecosystem which was in a supinestate over the years. In the age of globalization, the tribes who are the real custodians of indigenous knowledge are far behind in the race of technological advancement.

Gradual developments of such people in varied facets of life enable them to explore their traditional knowledge for human welfare. As the over-exploitation of natural resources threatens the ecological balance and sustainable livelihood of tribal people, it is imperative to study our time-tested indigenous knowledge and tribal technology with greater vigour.

Hence, an innovative School –School of Indigenous Knowledge, Science and Technology – has been set up to promote, preserve and protect indigenous knowledge and implement it for sustainable development.

The importance of this School is to disseminate advanced knowledge by providing instructional and research facilities in tribal medicinal systems through physiochemical analysis, geosciences and their impact on the health conditions. The importance of gemology in their culture, Sutras and sub-sutras of Vedic mathematics, a nutritional component of the food habit of tribes, intellectual property rights to preserve and conserve the biodiversity of indigenous people and advancement in technologies relating to the natural resources of the tribal areas as well as in other branches of learning as it may deem fit.

This could be possible by teaching innovative courses in Indigenous Knowledge and Intellectual Property Rights, Tribal Sports, Nutrition and Health Management, Indigenous People and the Science of Gemology and Vedic Mathematics. The courses attempt to examine indigenous knowledge and technology, blending both traditional and modern scientific methods from interdisciplinary and multidisciplinary approaches. The School of Indigenous Knowledge, Science and Technology constantly endeavors to improve the knowledge and practice content of its academic programme to match the local, regional, national and international standards.

This School has introduced four innovative interdisciplinary programmes viz. Physics, Chemistry, Mathematics and Computer Science with specialization in Indigenous Knowledge, Science and Technology in the first phase with the approval of UGC to provide impetus to research in Indigenous Knowledge, Science and Technology with multi-disciplinary education facility free of cost. Besides implementing Sustainable Development Goals of the United Nation, the school has been able to bring a bout the much needed socio-economic changes in the tribal hinter land of Odisha and its neighbouring states.

Because of the school's unique excellence to help the tribal students develop their vocational, entrepreneurial and lifeskills, it has been trying to break the vicious cycle of poverty and social isolation of tribal communities.The school also seeks to raise the consciousness of the tribal students that the people of their communities have a right to access varied indigenous resources and opportunities in order to live a self- sufficient, adequate and dignified life.

ii. About the Department

The Department of Mathematics at KISS Deemed to be University is a part of the School of Indigenous Knowledge, Science and Technology (SIKST**)**. The department is committed to providing quality education in mathematics while supporting the University's mission of empowering tribal and indigenous students through higher education, research, and innovation. KISS Deemed to be University, established in 2017 under Section 3 of the UGC Act, is the world's first university exclusively dedicated to the education of indigenous communities.

The department offers undergraduate and postgraduate programmes in Mathematics, with a curriculum designed to build strong theoretical foundations alongside practical and computational skills. The syllabus includes areas such as algebra, real and complex analysis, differential equations, linear algebra, numerical methods, vector calculus, probability, statistics, and mathematical modelling. Students are encouraged to develop analytical thinking, logical reasoning, problem-solving ability, and computational proficiency required for higher studies and professional careers.

The Department of Mathematics emphasizes innovative teaching methods, including classroom lectures, tutorials, seminars, assignments, projects, and the use of modern computational tools such as MATLAB and Python. Faculty members strive to create a student-centred learning environment that promotes conceptual understanding, critical thinking, and lifelong learning.

Research forms an integral part of the department's academic activities. Faculty members actively pursue research in various branches of pure and applied mathematics, including functional analysis, operator theory, summability theory, numerical analysis, linear algebra, and differential equations. The department encourages students to participate in seminars, workshops, conferences, and research projects to enhance their academic and research capabilities. The department also periodically reviews and updates its curriculum through its Board of Studies to align with contemporary developments in mathematics and the recommendations of the National Education Policy (NEP).

The department aims to produce competent graduates equipped with mathematical knowledge, computational skills, ethical values, and a scientific outlook. Graduates are prepared for careers

in education, research, information technology, banking, finance, data science, government services, and higher education.

In line with the vision of KISS Deemed to be University, the Department of Mathematics is dedicated to academic excellence, social responsibility, and inclusive education. Through quality teaching, meaningful research, and community engagement, it contributes to the University's goal of empowering indigenous youth and promoting sustainable national development.

iii. Vision & Mission of the School

VISION:

Be an internationally acclaimed School, recognized for excellence in teaching, research, consultancy and outreach; skill development and social entrepreneurship for tribal youth by promoting Indigenous Science and Technology

MISSION:

1. Foster all-round development of students through multi-faceted education.
2. Focus on Indigenous Science and Technology with the help of innovative courses like Vedic Mathematics, Indigenous people and the Science of Gemology, Tribal Sports, Nutrition and Health Management, Indigenous Knowledge and Intellectual Property Rights.
3. Engage with local, national and global communities to get ideas about Indigenous Science and Technological applications for contemporary needs and problems and become successful in life.
4. Manage resources for self-employment and create employment for others.

II. B.Sc.in Mathematics Programme

The B.Sc. (Hons/Hons with Research) in Mathematics with Specialization in Indigenous Knowledge, Science and Technology is a four-year undergraduate programme introduced in the Academic Session 2024–25, designed in accordance with NEP-2020 and the UGC Curriculum and Credit Framework for Undergraduate Programmes (CCFUP). The programme aims to develop human resources with strong core competence in key areas of Computer Science while integrating perspectives, case studies and applications from Indigenous Knowledge, Science and Technology.

This four-year UG programme (introduced in 2024–25) follows the multiple entry–exit structure with certificate, diploma, degree and honours with research options as per NEP-2020 and NCrF.

Across eight semesters, the curriculum includes core Mathematics courses such as calculus, real analysis, linear algebra, abstract algebra, ordinary differential equation , partial differential equation, operation research, number theory, problability, statistics, graph theory, optimization theory, numerical analysis, functional analysis, discrete mathematics, differential geometry, complex analysis, topology etc.

In line with the syllabus, students also complete minor courses, internships, and interdisciplinary/open courses offered under the MDC/SEC framework to broaden their exposure. Learning experiences are enriched through labs attached to major theory papers, mini-projects, internships, guest lectures and presentations that expose learners to current industry practices, emerging technologies and socially engaged computing. The overall design follows an outcome based approach with clearly articulated Programme Outcomes (POs) and Course Outcomes (COs), mapped across all listed courses in the structure and aligned with national qualification and credit frameworks..

III. Process of Curriculum Development

1. Formation of Syllabus Committee with domain experts.
2. Consultation with stakeholders (students, alumni, employers, community).
3. Review and approval by School faculty.
4. Vetting by Board of Studies (BoS) with external experts.
5. Final approval by Academic Council.
6. Integration of NEP-2020, CBCS, NCrF, and NHEQF guidelines.

IV. Definitions of Components

a) **Ability Enhancement Courses (AEC):** It refers to the courses enhancing competency in a Modern Indian Language (MIL) and in the English language with special emphasis on language and communication skills not literature, prose, poetry and novel etc.

b) **Academic Bank of Credits (ABC):** The ABC has been envisaged by the UGC to facilitate the academic mobility of students with the freedom to study across the HEIs in the country with an appropriate ‘credit transfer’ mechanism from one programme to another, leading to attain a Degree/Diploma/Certificate, etc.

c) **Academic Year**: Two consecutive semesters constitute one academic year.

d) **Choice Based :** The students select courses from the prescribed courses i.e., Major, Minor, Multidisciplinary, Ability Enhancement Course (AEC), Skill Enhancement Course (SEC), Value Added Course (VAC), Summer Internship/ Lab/Research.

e) **Major** is the subject of main focus.

f) **Credit Based Semester System (CBSS):** Under the CBSS, the requirement for awarding a degree/diploma/Certificate is prescribed in terms of number of credits to be earned.

g) **Credit:** A unit by which the course work is measured. One credit is equivalent to one hour of lecture or tutorials or two hours of practical work/field work per week in a semester.

h) **Minor** Course helps a student to gain a broader understanding beyond the major discipline. The subjects mentioned in the minor (in the course structure table) will be offered only if a minimum of 10 students opt for that particular subject.

i) **Multidisciplinary**: It refers to the courses that a student can opt from other disciplines in order to broaden the intellectual experience.

j) **Skills Enhancement Courses (SEC):** It refers to the courses aiming at imparting practical skills, hands-on training, soft skills, etc., to enhance the employability of students.

k) **Summer Internship/Apprenticeship/Summer Project**: It refers to experiential exposure of a student. Summer Internship of 6-8 weeks duration after the completion of the fourth semester, followed by a project report and viva-voce examination during the fifth semester has been made compulsory to enable the students to have hands on experience of real-life business situations.

l) **Research** has been provided in the Eighth semester (for students securing 7.5 CGPA or above) involving application of knowledge in exploring/critical analysis/solving issues related to a real-life situation.

m) **Value Added Courses**: It refers to the courses enabling the students to acquire and demonstrate the knowledge and understanding of contemporary society.

V. NCrF-Aligned Components (National Credit Framework)

Operational Definition of Credit (NCrF Standard)

"1 Credit = 30 Notional Learning Hours."

A standard 4-credit course = 120 Notional Learning Hours.

(i)NCrF-Compliant Course Engagement Table

Component	Operational Definition	Hours (Example for 4-credit course)
Face-to-Face Lectures	Concept delivery, interactive instruction	45
Tutorials / Labs / Field	Hands-on practice, experimentation	30
Independent Self-study	Pre-reading, journal review	20
Continuous Assessment	Assignments, quizzes, mid-term	12
Final Semester Exam Preparation	Revision, project completion	13
Total Notional Hours	**Must equal 30 hours × credits**	**120**

MOOC Courses (SWAYAM and SWAYAM Plus)

According to the UGC guidelines integrated into the new curriculum structures, Higher Education Institutions (HEIs) are permitted to allow students to take up to 40% of their total courses in a semester through the national MOOC platform, SWAYAM (or SWAYAM Plus for industry-aligned courses).

Credits earned via SWAYAM are mapped directly against the appropriate NHEQF academic level and digitally stored in the student's Academic Bank of Credits (ABC) to count toward their final degree, diploma, or certificate.

(ii)NCrF Category Wise Credit Distribution (UGC CCUFP Compatible) (for UG Programme)

Semester	Discipline Specific courses- core		Minor		MDC/IDC		AEC		SEC/ Internship/Dessertation		VAC		Grand Total Credits
	No. Of Papers	Total Credits	No. Of Papers	Total Credits	No. Of Papers	Total Credits	No. Of Papers	Total Credits	No. Of Papers	Total Credits	No. Of Papers	Total Credit	
I	1	4	1	4	1	3	1	2	1	3	4	8	20
II	1	4	1	4	1	3	1	2	1	3	2	4	20

III	2	8	1	4	1	3	1	2	1	3			20
IV	4	14	1	4			1	2					20
V	4	16	1	4					1	2			22
VI	4	16	1	4									20
VII	4	16	1	4									20
VIII	1	4	1	4					1	12			20
Total Credits for the Course		80		32		9		8		23		12	162

These exit awards correspond to progressive NHEQF / NSQF levels and are fully NCrF-compliant for credit accumulation, mobility and re-entry through the Academic Bank of Credits.

Skill Enhancement Courses (SEC), Multidisciplinary Courses (MDC), value-added courses and internships are creditised as per NCrF, recognising vocational, experiential and community-based learning alongside academic coursework. These courses are designed at appropriate NSQF levels, with clear competency descriptors and notional hours.

VI. Eligibility for Admissions with No. of Seats

As per the admission guidelines and brochure of the KISS Deemed to be University.

VII. Examination Pattern: As per NEP 2020

The medium of examination is English which will be reflected in their final grade sheet/certificate. Provided that for a language subject answers are to be in that language. Sanskrit may be written in Odia script but language has to be Sanskrit.

(i) Duration of the Examinations-Mid Semester & End Semester:

Duration of examination for all term End examination shall be for 2.5 hours and for all Mid Term examination for 1 hour irrespective of full marks in the course/subjects and irrespective of credit. The practical examinations shall be of 2 hours duration.

Each School shall have a designated faculty as Examination Coordinator to be decided by the Vice Chancellor in addition to the Controller of Examinations of the University.

Continuous Evaluation and Mid Semester Examination:
a) Mid semester examination will be of 1-hour duration for 20/10 marks (20 for subjects having no practical and 10 for subject with practical papers). There shall be no pass mark in Mid Semester examination.

b) The Mid-Semester Examination shall be conducted and valued by the Faculty who are teaching the corresponding paper. A student who fails to appear in a Mid-Semester Examination will be allowed one more chance to take the same examination before appearing the concerned term-end examination. There will be no provision to re-appear in the Mid-Semester Examination for improvement.

c) For subjects with practical there will be a Mid-Semester practical examination carrying 10 marks.

d) The University authority of the valuation zones will preserve the answer Script of the End Semester examination for 06 months from the date of publication of result for reference.

e) A student has to appear the mid semester examination positively. Absence in the mid semester examination will be considered as fail however the candidate may be allowed to appear the mid semester examination before commencement of the concerned Term-End examination under special case duly considered by the HoD (for the ***candidates who represent the University or State for Inter- University or inter-state competitions in Games and Sports or attending different recognized National level camps/any critical medical case duly certified by the designated medical officer).***

(ii) Distribution of Marks in End Semester and Continuous Evaluation:
(Irrespective of credit in a course/Paper)

Course Type	Maximum Marks	Semester-End theory Mark	Continues Evaluation Marks /Sessional	Mid Semester theory Mark	Semester-End and Practical mark	Mid Semester Practical Mark
Without Practical	**100**	**60**	**20**	**20**	**----**	**--**
With Practical	**100**	**50**	**10**	**10**	**20**	**10**
Thesis/ Dissertation/ Seminar/Field Work	**100**	**------**	**-------**	**-------**	**-------**	**-------**

The **modes of evaluation** of **Thesis/ Dissertation/ Seminar/Field Work** shall be as follows:

Literature Review
Synopsis Presentation
Field Work / Data Collection and Data Analysis
Findings and Conclusions
Presentation and Viva-Voce

(iii) Distribution of Sessional Marks:(Continuous Evaluation)

Course Type	Maximum Mark	Mid Semester	Attendance	Surprise Test/Quiz/Viva	Assignment/ Presentation
Without Practical	**40**	**20**	**Above 95%- 5 Marks** **85%-94%- 4 Marks** **75%-84%- 3 Marks**	**10**	**05**
With Practical	**30**	(Theory 10 + Practical 10)=20		**05**	**Nil**

(iv) Examination Question Pattern of End Term Examination and Mark Distribution:

The evaluation process may cover summative and formative aspects and assess understanding applications, articulation, program and course outcome.

Question Pattern		**With Practical**	**Without Practical**
Part-I –Objective	**Answer in MCQ/ in one word/in one sentence as directed**	**1x5=5**	**1x6=6**
Part-II- Very Short Type	**Answer within 50 words. Answer any 3 out of 5 questions (with practical) and Answer any 5 out of 7 question (without practical)**	**2x3=6**	**2x5=10**
Part-III- Short Type	**Answer within 250 words Answer any 3 out of 5 questions (with practical) and Answer any 4 out of 6 question (without practical)**	**5x3=15**	**5x4=20**
Part-IV- Long Type	**Answer within 800 words. Answer any 3 out of 5 questions**	**8x3=24**	**8x3=24**
Total		**50**	**60**
For Practical Paper		**One Major Experiment-10 Record- 05 Viva voce-05**	---------

(v) Examination Question Pattern of Mid Semester Examination and Mark Distribution

Question Pattern		With Practical	Without Practical
Part-I –Objective	Answer in MCQ/ in one word/in one sentence as directed	1x3=3	1x6=6
Part-II- Very Short Type	Answer within 50 words. Answer any 1out of 2 questions (with practical) and Answer any 2 out of 3 question (without practical)	2x1=2	2x2=4
Part-III- Short Type	Answer within 250 words Answer any 1 out of 2 questions (with practical) and Answer any 2 out of 3 question (without practical)	5x1=5	5x2=10
Total		10	20
For Practical Paper		One Major Experiment -5 Record-02 Viva voce-03	---------

VIII. Duration and Types of Courses and Process of Multiple Entry and Exit

NHEQF-Aligned Components (National Higher Education Qualifications Framework)

1. NHEQF Level Mapping for Multi-Entry / Multi-Exit

"This programme is structured according to the multi-entry, multi-exit parameters defined by UGC. The progressive qualification bands map directly onto the National Higher Education Qualifications Framework (NHEQF)."

Insert the following table:

Milestone / Year Completed	Exit Award	NHEQF Level	Standard Credit Range
Year 1 (Sem I–II)	UG Certificate	Level 4.5	~40 + 4 credits in work based vocational courses offered during summer term or internship / Apprenticeship in addition to 6 credits from skill-based courses earned during first and second semester.
Year 2 (Sem III–IV)	UG Diploma	Level 5.0	~80 + 4 credit in skill based vocational courses offered during first year or second year summer term
Year 3 (Sem V–VI)	UG Degree (3-Year)	Level 5.5	~120
Year 4 (Sem VII–VIII) **Year 1(Sem I-II)**	UG Honours / Honours with Research Post-Graduate Diploma	Level 6.0	~160
Year 2(Sem III-V)	Master's degree (e.g. M.A., M.Com., M.Sc., etc.)	Level 6.5	80 Credits
	Doctoral Degree	Level 8.0	Credits for coursework and, a thesis and published work

IX. Programme Educational Objectives (PEOS):

PEO1: **Employability**: Graduates will establish themselves as competent professionals in education, industry, government, finance, information technology, data analytics, and related sectors by applying mathematical knowledge, analytical reasoning, computational skills, and problem-solving abilities to address real-world challenges..

PEO2: **Entrepreneurship**: Graduates will demonstrate entrepreneurial capabilities by creating self-employment opportunities, developing innovative mathematical and

technological solutions, and contributing to sustainable livelihood generation, particularly within tribal and rural communities.

PEO3: **Research Readiness:** Graduates will pursue higher education, research, and professional development in mathematics and interdisciplinary domains, contributing to the advancement of knowledge through innovation, critical inquiry, and evidence-based problem-solving.

PEO4: **Indigenous Knowledge Integration**: Graduates will integrate mathematical concepts with indigenous knowledge systems and local practices to develop context-specific solutions, preserve cultural heritage, and contribute to the socio-economic empowerment of tribal and indigenous communities.

PEO5: **Social Responsibility**: Graduates will uphold professional ethics, social responsibility, and leadership qualities while addressing societal challenges through mathematical modelling, data-driven decision-making, and community-oriented initiatives that promote inclusive and sustainable development

X. Programme Outcomes (PO)

(Aligned with NEP-2020 Graduate Attributes; Schools may customize.)

PO1	Moral & Ethical Values	Apply ethical principles and commit to professional ethics and responsibilities and norms of the software professional practices
PO2	Disciplinary Knowledge	Acquire and apply the knowledge of mathematics and computer science to solve real life problems
PO3	Communication Skills	To develop an understanding of, and ability with the different forms of communication - writing, reading, speaking, listening- including visual and graphical, within science and beyond and the ability to apply these appropriately and effectively for different audiences.
PO4	Critical Thinking, Problem solving & analytical reasoning	Acquire an ability to think and work creatively, including the capacity for self-starting, and the ability to apply science skills to unfamiliar applications. It encompasses skills such as understanding risk management and risk-taking, “thinking outside the box”, and questioning the norm to suggest new solutions for old problems. Develop an understanding of the scientific method of evidence-based knowledge

		acquisition, deduction, inference, and induction. Including problem-solving, critical thinking & analysis and the ability to discover new knowledge.
PO5	Indian Knowledge Systems (IKS)	Mathematics will be connected with astronomy, architecture, commerce, philosophy, and education in the Indian knowledge tradition. Students will appreciate the cultural, philosophical, and scientific contributions of Indian scholars to world mathematics.
PO6	Research-Related Skills	Use application-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO7	Cooperation/Teamwork	Function effectively as an individual, and as a member or in diverse teams, and in multidisciplinary settings
PO8	Digital Literacy	Create, select, and apply appropriate techniques, resources, and modern IT tools to model complex solutions with an understanding of their limitations.
PO9	Experiential & Life – long learning	Develop the capacity to engage in reflection and learning beyond formal educational contexts that are based on the ability to make effective judgments about one's own work and to undertake self-directed, curiosity motivated, learning. The capacity to learn in, and from, new disciplines to enhance the application of scientific knowledge and skills in professional contexts.
PO10	Leadership Qualities	To acquire skills to function as a leader which includes not only subject specific skills such as laboratory skills, computing skills or quantitative data handling skills, but also more generic skills such time management, personal organization, teamwork and negotiation.
PO11	Professional & Decision-making Skills	To acquire, develop, employ, and integrate a range of technical, practical and professional skills, in appropriate and ethical ways within a professional context, autonomously and collaboratively and across a range of disciplinary and professional areas.

PO12	Environment Awareness and Sustainability	To build an awareness of the role of science within a global culture and willingness to contribute to the shaping of community views on complex issues where the methods and findings of science are relevant. This includes an understanding of how science underpins society, the applications of science in different cultures and identifying and engaging with current and future challenges.

XI. Programme specific outcomes (PSOs) :

PSO1: Students would be able to recall facts and understand the basic concepts of Mathematics like Differential equations, Real Analysis, Complex Analysis, Functional Analysis, Abstract Algebra , Linear algebra ,Operation Research and Numerical Analysis. This program also applies and explains the ideas or concepts of those basics of Indigenous knowledge and management of resources

PSO2: Apply advanced mathematical techniques and logical reasoning to analyze, model, and solve complex problems in pure and applied mathematics..

PSO3: Use mathematical software and programming tools (such as MATLAB, Python, R, or Mathematica) for numerical computation, data analysis, and simulation.

PSO4: Apply mathematical concepts to interdisciplinary areas including physics, computer science, economics, statistics, data science, and engineering.

PSO5: Demonstrate readiness for careers in academia, research, teaching, analytics, finance, or competitive examinations through strong mathematical communication and ethical practices.

. COURSE STRUCTURE FOR B.SC. IN MATHEMATICS
SEMESTER DETAILS: The Programme comprises of Eight Semesters

Department of Mathematics
School of Indigenous Knowledge, Science and Technology

SEMESTER-I(With Single Major)			
Course Category		**NAME OF THE COURSE**	**CREDITS**

	COURSE CODE		L	T	P	TOTAL
Core Course(Major)	MT10001	Calculus	3	1	0	4
Minor (Opted by other Departments)	MT12001	Algebra	3	1	0	4
Multidisciplinary(MDC) (Opted by other Departments)	MT13001	Basic of Mathematics	2	1	0	3
Ability Enhancement Course (AEC) (Choose any one)	AE14001	Modern Indian Language (Odia)	2	0	0	2
	AE14003	Modern Indian Language (Hindi)	2	0	0	2
	AE14005	Modern Indian Language (Sanskrit)	2	0	0	2
	AE14007	Modern Indian Language (Santali)	2	0	0	2
	AE14009	Alternative English	2	0	0	2
Skill Enhancement Course(SEC) (any other course from Arts or Science stream offered by University)	MT15001	Computational Mathematics	2	0	1	3
Value Added Course(VAC)	VA16201	Environment Education and Disaster Management	3	0	1	4
			Total=20 Credits			

SEMESTER-II (With Single Major)

Course Category	COURSE CODE	NAME OF THE COURSE	CREDITS			
			L	T	P	TOTAL
Core Course (Major)	MT10002	Real Analysis	3	1	0	4
Minor (Opted by other Departments)	MT12002	Introduction to Differential Equations	3	1	0	4
Multidisciplinary(MDC) (Opted by other Departments)	MT13002	Introduction to Statistics	2	1	0	3
Ability Enhancement Course (AEC) (Choose any one)	AE14002	Translation Studies (Odia)	2	0	0	2
	AE14004	Translation Studies (Hindi)	2	0	0	2
	AE14006	Translation Studies (Sanskrit)	2	0	0	2
	AE14008	Translation Studies (Santali)	2	0	0	2
	AE14010	Translation Studies (English)	2	0	0	2
Skill Enhancement Course (SEC)	CS15002	Introduction to Programming using Python	2	0	1	3
Value added courses(VAC) (Choose any two)	VA16302	Introduction to Methods of Applied Mathematics	2	0	0	2
	VA16394	Flutter Application Development	1	0	1	2

	VA16146	Indian Knowledge System	2	0	0	2
	VA16484	Community Engagement and Social Responsibility	2	0	0	2
		Total				**20Credits**

Exit Point: Undergraduate Certificate

Students exiting the programme after securing 40 credits will be awarded a UG Certificate in the relevant Discipline /Subject provided they secure 4 credits in work-based vocational courses offered during the summer term or internship / Apprenticeship in addition to 6 credits from skill-based courses earned during the first and second semester.

SEMESTER-III (With Single Major)

Course Category	COURSE CODE	NAME OF THE COURSE	CREDITS			
			L	T	P	TOTAL
Core Course (Major)	MT20001	Theory of Real Functions	3	1	0	4
	MT20003	Numerical Methods	3	0	1	4
Minor (Opted by other Departments)	MT22001	Introduction to Probability and Statistics	3	1	0	4
Multidisciplinary(MDC) (Opted by other Departments)	MT23001	Mathematics and its impact on Life	2	1	0	3
Ability Enhancement Course (AEC)	AE24001	Communicative English	2	0	0	2
Skill Enhancement Course(SEC)	CS25001	Prompt Engineering and AI Tools	2	0	1	3
		Total				**20 Credits**

SEMESTER-IV(With Single Major)

Course Category	COURSE CODE	NAME OF THE COURSE	CREDITS			
			L	T	P	TOTAL
Core Course(Major)	MT20002	Multivariate Calculus	3	0	1	4
	MT20004	Ordinary Differential Equation	3	1	0	4
	MT20006	Elements of Number Theory	3	1	0	4
Seminar	SE20082	Seminar	0	0	2	2
Minor(Opted by other Departments)	MT22002	Linear Algebra	3	1	0	4
Ability Enhancement Course (AEC)	AE24002	Professional Communication	2	0	0	2
		Total				**20 Credits**

Exit Point: Undergraduate Diploma

Students exiting the programme after securing 80 credits will be awarded a UG Diploma in the relevant Discipline /Subject

provided they secure an additional 4 credits in skill-based vocational courses offered during the first year or second year Summer term.						
SEMESTER-V(With Single Major)						
Course Category	**COURSE CODE**	**NAME OF THE COURSE**	**CREDITS**			
			L	**T**	**P**	**TOTAL**
Core Course(Major)	MT30001	Metric Spaces and Complex Analysis	3	1	0	4
	MT30003	Operations Research	3	1	0	4
	MT30005	Abstract Algebra	3	1	0	4
	MT30007	Differential Geometry	3	1	0	4
Minor(Opted by other Departments)	MT32001	Logic and Boolean Algebra	3	1	0	4
Internship	IP37081	Internship	0	0	2	2
		Total				**22 Credits**
SEMESTER-V(With Double Major)						
	MT30001	Metric Spaces and Complex Analysis	3	1	0	4
	MT30003	Operations Research	3	1	0	4
	MT30005	Abstract Algebra	3	1	0	4
	MT30007	Differential Geometry	3	1	0	4
Minor(Opted by other Departments)	MT32001	Logic and Boolean Algebra	3	1	0	4
Double Major(Opted by other Departments)	MT32003	Stochastic Calculus	3	0	1	4
	MT32005	Advanced Analysis	3	1	0	4
	MT32007	Mathematical Programming Using C	3	0	1	4
Internship	IP37081	Internship	0	0	2	2
		Total				**34 Credits**
SEMESTER-VI (With Single Major)						
Course Category	**COURSE CODE**	**NAME OF THE COURSE**	**CREDITS**			
			L	**T**	**P**	**TOTAL**
Core Course(Major)	MT30002	Probability and Statistics	3	1	0	4
	MT30004	Analytical Number Theory	3	1	0	4
	MT30006	Graph Theory	3	1	0	4
	MT30008	Optimization Techniques	3	1	0	4
Minor(Opted by other Departments)	MT32002	Numerical Analysis	3	0	1	4
		Total				**20 Credits**
SEMESTER-VI(With Double Major)						
Core Course(Major)	MT30002	Probability and Statistics	3	1	0	4
	MT30004	Analytical Number Theory	3	1	0	4
	MT30006	Graph Theory	3	1	0	4
	MT30008	Optimization Techniques	3	1	0	4
Minor(Opted by other Departments)	MT32002	Numerical Analysis	3	0	1	4

Double Major(Opted by other Departments)	MT32004	Topics in Calculus	3	1	0	4
	MT32006	Statistical Methods	3	1	0	4
	MT32008	Data Structure for problem solving	3	0	1	4
		Total				**32 Credits**
Exit Point: Bachelor's Degree with Hons.						
SEMESTER-VII(With Single Major)						
Course Category	**COURSE CODE**	**NAME OF THE COURSE**	**CREDITS**			
			L	**T**	**P**	**TOTAL**
Core Course(Major)	MT40001	Advanced Abstract Algebra	3	1	0	4
	MT40003	Advanced Real Analysis	3	1	0	4
	MT40005	Advanced Differential Equations	3	1	0	4
	IK40055	Scientific Research Methods	3	1	0	4
Minor(Opted by other Departments)	MT42001	Linear Programming	3	1	0	4
		Total				**20 Credits**
SEMESTER-VII (With Double Major)						
Core Course(Major)	MT40001	Advanced Abstract Algebra	3	1	0	4
	MT40003	Advanced Real Analysis	3	1	0	4
	MT40005	Advanced Differential Equations	3	1	0	4
	IK40055	Scientific Research Methods	3	1	0	4
Minor(Opted by other Departments)	MT42001	Linear Programming	3	1	0	4
Double Major(Opted by other Departments)	MT42003	Fuzzy Mathematics and Applications	3	1	0	4
		Total				**24 Credits**
SEMESTER-VIII(With Single Major)						
Course Category	**COURSE CODE**	**NAME OF THE COURSE**	**CREDITS**			
			L	**T**	**P**	**TOTAL**
Core Course(Major)	MT40002	Partial Differential Equations and Transforms	3	1	0	4
Minor(Opted by other Departments)	MT42002	Fundamentals of Mathematical Analysis	3	1	0	4
Dissertation	RD40082	Research and Dissertation	0	0	12	12
		If not going for Research work				
Core Course(Major)	MT40004	Complex Analysis	3	1	0	4
	MT40006	Advanced Linear Algebra	3	1	0	4
	MT40008	Functional Analysis	3	1	0	4
		Total				**20 Credits**
Grand Total with Single Major (With or without Research) 162Credits						
SEMESTER-VIII(With Double Major)						
Core Course(Major)	MT 40002	Partial Differential Equations and Transforms	3	1	0	4

Minor(Opted by other Departments)	MT 42002	Fundamentals of Mathematical Analysis	3	1	0	4
Double Major(Opted by other Departments)	MT 42004	Introduction to Probability and Stochastic Process	3	1	0	4
Dissertation	RD 40082	Research and Dissertation	0	0	12	12
	If not going for Research work					
Core Course(Major)	MT 40004	Complex Analysis	3	1	0	4
	MT 40006	Advanced Linear Algebra	3	1	0	4
	MT 40008	Functional Analysis	3	1	0	4
		Total				**24 Credits**
Grand Total with Double Major (With or without Research) 194 Credits						
Students shall choose Minor and MDC courses from other subjects offered by the University, while the Minor and MDC courses listed in this course structure are intended for students of other departments.						
Exit Point: Bachelor's Degree with Hons. and Research **Students will be awarded UG Degree (Honours) with Research in the relevant Discipline /Subject provided they secure 160 credits** **Honours students not undertaking research will do 3 courses for 12 credits in lieu of a research project / Dissertation.**						

Course Structure (Semester wise)

Semester-I(With Single Major)

Code	Course Title	Credit	L-T-P
MT10001	Calculus	4	3-1-0
MT12001	Algebra	4	3-1-0
MT13001	Basic of Mathematics	3	2-1-0
AE14001	Modern Indian Language (Odia)	2	2-0-0
AE14003	Modern Indian Language (Hindi)	2	2-0-0
AE14005	Modern Indian Language (Sanskrit)	2	2-0-0
AE14007	Modern Indian Language (Santali)	2	2-0-0
AE14009	Alternative English	2	2-0-0
MT15001	Computational Mathematics	3	2-0-1
VA16201	Environment Education and Disaster Management	4	3-1-0

Course Code: MT10001
Course Title: Calculus (Credits – 4)
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

1. Different functions like hyperbolic function, exponential function.
2. Different formulae and their applications
3. Different types of curves and tracing of curves.
4. Some important results with their applications.

Course Outcomes:

After completing this course the students will be able to

CO1: Remember the concepts of different functions.

CO2: Understand parametric equations, arc length and volumes.

CO3: Apply some important rules like L-Hospital rule and Leibnitz rule.

CO4: Analyze some results on L-Hospital rule, Leibnitz rule.

CO5: Evaluate the different problems relating to different functions and triple product of functions.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	-	–	-	–	–	–	–	-	–	–	–	3	3	2	--	–
CO2	–	3	--	2	–	2	–	–	–	–	–	–	–	–	2	–	–
CO3	–	2	--	3	–	3	–	–	–	–	–	–	–	–	2	–	–
CO4	–	2	--	3	–	2	–	–	–	–	–	–	–	–	--	2	–
CO5	–	2	--	3	–	2	–	–	–	–	–	–	–	–	2	–	–

Course Contents:

UNIT-I: Differential Calculus and Curve Tracing (11 Classroom contact Hours)

Hyperbolic functions, higher order derivatives, Leibnitz rule and its applications to problem of type $e^{ax+b}\ sinx, e^{ax+b}\ cosx$, $(ax+b)^n\ sinx$,$(ax+b)^n\ sinx$ concavity and inflection points, asymptotes,

Curve tracing in Cartesian and polar coordinates

UNIT-II: Applications of Integral Calculus(12 Classroom contact Hours.)

L'Hospital's rule, applications in business, economics and life sciences. Reduction formulae, derivations and illustrations of reduction formulae of the type $\int sinnx\,dx, \int cosnx\,dx, \int tannx\,dx, \int secnx\,dx$ volumes by slicing,disks and washer's method, Volume by cylindrical Shells

UNIT-III: Parametric Curves and Analytical Geometry(11 Classroom contact Hours.)

Parametric equations, parameterzing a curve, arc length, arc length of parametric curves, area of surface of revolution. Techniques of sketching conics, reflection properties of conics, rotation of axes and second degree equations, classification into conics using the discriminant, polar equations of conics.

UNIT-IV: Vector Functions and Applications(11 Classroom contact Hours.)

Triiple product, introduction to vector functions, operations with vector-valued functions, Limits and continuity of vector functions, differentiation and integration of vector functions, tangent and normal components of acceleration, modeling ballistics .

Tutorial:-30 hours

Recommended Learning Resources

Textbooks:

1.G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.

Reference Materials & Digital Resources:

. 1. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.

2.H. Anton, I. Bivens and S. Davis, Calculus, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.

3.R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer Verlag, New York, Inc., 1989

SDG Mapping for this Course:.

SDG NO.	SDG Title	Nature of Contribution

SDG 4	Quality Education	Enhances analytical skills, logical reasoning, and higher-order thinking essential for quality higher education
SDG 9	Industry, Innovation and Infrastructure	Provides foundational knowledge for innovation-driven industries and infrastructure planning

Course Code: MT12001
Course Title: Algebra (Credits – 4)

Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

1. Define complex number and its real part and imaginary part.
2. Describe the meaning of equivalence relation, domain, range and co domain.
3. System of linear equations, echelon form and matrix equations
4. Linear transformation, inverse of a matrix , rank of a matrix.

Course Outcomes:

After completing this course the students will be able to

CO1: Remember the concepts of polar form of complex numbers, equivalence relations.

CO2: Understand composition of functions, Division algorithm.

CO3: Apply fundamental theorems and mathematical induction.

CO4: Analyze some results of system of linear equations and echelon form.

CO5: Evaluate the different problems relating to linear transformation, rank of matrix.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	-	–	-	–	–	–	–	-	–	–	–	3	2	–	--	–
CO2	–	3	--	--	2	2	–	–	–	–	–	–	–	–	2	–	–
CO3	–	2	--	--	3	3	–	–	–	–	–	–	–	–	2	–	–
CO4	–	2	--	--	3	2	–	–	–	–	–	–	–	–	--	2	–
CO5	–	2	--	--	3	2	–	–	–	–	–	–	–	–	2	–	–

Course Contents:

UNIT-I : Complex Numbers and Set Theory(11 Classroom contact Hours)

Polar representation of complex numbers, nth roots of unity, De Moivre's theorem for rational indices and its applications. Equivalence relations, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set.

UNIT-II: Number Theory and Mathematical Induction(12 Classroom contact Hours)

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

UNIT-III: Systems of Linear Equations and Linear Transformations(11 Classroom contact Hours)

Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation Ax=b, solution sets of linear systems, applications of linear systems, linear independence. Introduction to linear transformations, matrix of a linear transformation.

UNIT-IV: Matrices, Vector Spaces and Eigenvalues(11 Classroom contact Hours)

Inverse of a matrix, characterizations of invertible matrices. Subspaces of Rn, dimension of subspaces of Rn and rank of a matrix, Eigen values, Eigen Vectors and Characteristic Equation of a matrix.

Tutorial:-30 Hours

Recommended Learning Resources

Textbooks:

1. John B. Fraleigh, **A First Course in Abstract Algebra**, 7th Edition, Pearson.

2. Gilbert Strang, **Introduction to Linear Algebra**, 5th Edition, Wellesley-Cambridge Press.

Reference Materials & Digital Resources:

. 1.Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, Wiley.

2. S. Kumaresan, Linear Algebra: A Geometric Approach, PHI Learning.
3. Gareth Williams, Linear Algebra with Applications, Jones & Bartlett Learning.
4. I. N. Herstein, Topics in Algebra, 2nd Edition, Wiley.
5. Thomas Koshy, Elementary Number Theory with Applications, 2nd Edition, Academic Press.
6. Richard Johnsonbaugh, Discrete Mathematics, 8th Edition, Pearson.

SDG Mapping for this Course:.

SDG NO.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Algebra develops abstract thinking, logical reasoning, and structural understanding, which are central to quality higher education

SDG 9	Industry, Innovation and Infrastructure	Algebra forms the mathematical backbone for coding theory, cryptography, and algorithm design

Course Code: MT13001
Course Title : Basic of Mathematics
Total Credits: 03 (Credits: Theory-02, Tutorial-01)
Total Lectures: Theory- 30 and Tutorial-22

Course Objectives:

The course aims to:

1. Develop fundamental mathematical and computational skills.
2. Introduce logical reasoning and problem-solving techniques.
3. Build competency in algebraic, geometric, and statistical methods.
4. Enable students to apply mathematics to real-life and interdisciplinary problems.
5. Enhance quantitative reasoning for higher studies and professional careers.

Course Outcomes (COs):

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

CO1: Remember basic arithmetic, algebraic, and logical concepts in solving mathematical problems.

CO2: Understand functions, graphs, matrices, and coordinate geometry to model practical situations.

CO3: Analyze data using elementary statistical techniques and basic probability.

CO4: Apply mathematical reasoning and quantitative skills for multidisciplinary applications.

CO5: Evaluate the different problems relating to linear transformation, rank of matrix.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	-	_	-	_	_	_	_	-	_	_	_	3	2	_	--	_
CO2	_	3	--	--	2	2	_	_	_	_	_	_	_	_	2	_	_
CO3	_	2	--	--	3	3	_	_	_	_	_	_	_	_	2	_	_
CO4	_	2	--	--	3	2	_	_	_	_	_	_	_	_	--	2	_
CO5	_	2	--	--	3	2	_	_	_	_	_	_	_	_	2	_	_

Course Contents:

UNIT-I: Number System, Algebra and Mathematical Logic (07 Classroom contact Hours)

Real numbers and their properties , Fractions, decimals and percentages ,Ratio, proportion and variation ,Indices and logarithms ,Linear equations and quadratic equations ,Mathematical statements ,Logical connectives ,Truth tables ,Basic methods of mathematical reasoning

UNIT-II: Functions, Graphs and Coordinate Geometry (07 Classroom contact Hours)

Relations and functions ,Domain and range ,Types of functions ,Linear, quadratic and exponential functions , Graphs of elementary functions ,Cartesian coordinate system ,Straight line ,Slope and equation of a line ,Distance and midpoint formula ,Applications in real-life problems

UNIT-III: Matrices and Basic Statistics (08 Classroom contact Hours)

Introduction to matrices ,Types of matrices ,Matrix operations ,Determinants (up to order 3) Solution of simple systems of linear equations ,Collection and presentation of data ,Mean, median and mode ,Variance and standard deviation ,Graphical representation of data

UNIT-IV: Probability, Financial Mathematics and Applications (08 Classroom contact Hours)

Random experiments and events , Basic probability ,Conditional probability ,Simple counting techniques ,Simple and compound interest ,Banking mathematics ,EMI and loan calculations Mathematics in business, economics and everyday decision making

Textbooks:

1. S. R. Arora, *Mathematics for Degree Students*, S. Chand.
2. Howard Anton, *Elementary Linear Algebra*, Wiley.
3. Richard Johnsonbaugh, *Discrete Mathematics*, Pearson.
4. R. S. Aggarwal, *Quantitative Aptitude*, S. Chand.
5. Jay L. Devore, *Probability and Statistics for Engineering and the Sciences*, Cengage.

Reference Books:

1. Kenneth Rosen, *Discrete Mathematics and Its Applications*, McGraw-Hill.
2. Gilbert Strang, *Introduction to Linear Algebra*, Wellesley-Cambridge Press.
3. E. Kreyszig, *Advanced Engineering Mathematics*, Wiley.
4. H. S. Hall and S. R. Knight, *Higher Algebra*.

SDG Mapping for this Course:.

SDG NO.	SDG Title	Nature of Contribution

SDG 4	Quality Education	It develops abstract thinking, logical reasoning, and structural understanding, which are central to quality higher education
SDG 9	Industry, Innovation and Infrastructure	It forms the mathematical backbone for coding theory, cryptography, and algorithm design

Modern Indian Languages (Odia)

Level 100

Code	Course Title	Credit	L-T-P
AE14001	Modern Indian Languages (Odia)	2	2-0-0

Refer to UG syllabus of Odia Department

Modern Indian Language (Hindi)

Level 100

Code	Course Title	Credit	L-T-P
AE14003	Modern Indian Language (Hindi)	2	2-0-0

Refer to UG syllabus of Hindi Department

Modern Indian Language (Sanskrit)

Level 100

Code	Course Title	Credit	L-T-P
AE14005	Modern Indian Language (Sanskrit)	2	2-0-0

Refer to UG syllabus of Sanskrit Department

Modern Indian Language (Santali)

Level 100

Code	Course Title	Credit	L-T-P
AE14007	Modern Indian Language (Santali)	2	2-0-0

Refer to UG syllabus of Santali Department

Alternative English

Level 100

Code	Course Title	Credit	L-T-P
AE14009	Alternative English	2	2-0-0

Refer to UG syllabus of English Department

COURSE CODE-MT15001

COURSE TITLE-Computational Mathematics

Total Credits: 04 (Credits: Theory-02, Tutorial-01)

Total Lectures: Theory- 30 and Tutorial-30

Course Objectives:

Students will be able to articulate and describe:

1. Calculation of error and approximation is a necessity in all real life, industrial and scientific computing

2 Various methods of finding solution of system of linear equations

3. Finite difference operator and various numerical integration methods

4.Introduction of some mathematical softwares like matlab.

Course Outcomes:

After completing this course the students will be able to

CO1: Remember to calculate error and approximation

CO2: Understand methods of finding solution of system of linear equations

CO3: Apply the Methods based on finite difference operator and various numerical integration

CO4:Analyze the Numerical Solution of system of linear equations

CO5: Evaluate the problems based on iteration, Lagrange's interpolation

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	2	–	–	–	–	–	–	–	–	3	1	1	1	1
CO2	–	3	–	2	–	2	–	–	–	–	–	–	3	2	1	1	1
CO3	–	2	–	3	–	3	–	–	–	–	–	–	2	3	2	2	1
CO4	–	2	–	3	–	2	–	–	–	–	–	–	2	3	2	2	1
CO5	–	2	–	3	–	2	–	–	–	–	–	–	2	3	2	2	2

UNIT-I: Introduction to Computational Mathematics and Numerical Errors (08 Classroom contact Hours)

Introduction to Computational Mathematics, mathematical modelling, numerical error (floating-point representation, computer arithmetic, round-off errors, and loss of significance in numerical computations)

UNIT-II: Solution of Linear Algebraic Equations and Interpolation (07 Classroom contact Hours)

System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis. Interpolation: Lagrange and Newton's methods. Error bounds.

UNIT-III: Finite Difference Operators and Numerical Integration (08 Classroom contact Hours)

Finite difference operators. Gregory forward and backward difference interpolation. Numerical Integration: Trapezoidal rule, Simpson's rule, Simpsons 3/8th rule, Midpoint rule, Composite Trapezoidal rule, Composite Simpson's rule.

UNIT-IV: Introduction to matlab, python programming (07 Classroom contact Hours)

Practical:-30 hours

1.Introduction to MATLAB/Python environment, variables, operators, input/output 2

2 Floating-point arithmetic, round-off errors and loss of significance 2

3 Solution of linear equations using Gaussian Elimination 2

4 Solution of linear equations using Gauss-Jordan Method 2

5 Gauss-Jacobi Iterative Method and convergence study 2

6 Gauss-Seidel Iterative Method and convergence study 2

7 Lagrange Interpolation 2

8 Newton's Forward and Backward Interpolation 2

9 Finite Difference Operators and Difference Tables 2

10 Numerical Integration using Trapezoidal a

Textbooks:

1. . M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 6th Ed., New age International Publisher, India, 2007.

.**Reference Materials & Digital Resources:**

Text Book:-

1. Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007

2.C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008

3. Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed. , PHI Learning Private Limited, 2013.

4. .John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited, 2012.

5.https://onlinecourses.swayam2.ac.in/cec24_ma07/preview

. SDG Mapping for this Course

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Enhances logical reasoning, abstract thinking, and advanced mathematical skills
SDG 8	Decent Work and Economic Growth	Analytical and problem-solving skills applicable in research, data science, and technology
SDG 9	Industry, Innovation and Infrastructure	Applications of topology in networks, data structures, and algorithm design

COURSE CODE-VA16201

COURSE TITLE-ENVIRONMENT EDUCATION AND DISASTER MITIGATION

Total Credits: 04 (Credits: Theory-03, Practical-01)

Total Lectures: Theory- 45 and Practical-30

Learning Objectives: The objective is to make students aware about the environmental functions and issues.

Course Outcomes:

CO1: Students will develop a comprehensive understanding of the complex interactions between humans and the environment, tracing historical developments, analyzing contemporary challenges, and exploring sustainable solutions.

CO2: Students will be able to critically analyze the impact of human activities on natural resources, biodiversity, ecosystems, and the climate, evaluating the effectiveness of conservation efforts and mitigation strategies **CO3:** Apply the Methods based on finite difference operator and various numerical integration

CO3: Students will gain an interdisciplinary perspective by integrating knowledge from fields such as ecology, geography, sociology, economics, and policy studies to address environmental issues holistically.

CO4: Students will cultivate problem-solving skills by applying scientific principles, analytical tools, and ethical considerations to devise innovative solutions for environmental challenges at local, regional, and global scales

CO5: Students will develop the capacity for active engagement and advocacy in environmental stewardship, recognizing their role as responsible global citizens and agents of positive change in promoting sustainability and resilience

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	2	–	–	–	–	–	–	–	–	3	1	1	1	1
CO2	–	3	–	2	–	2	–	–	–	–	–	–	3	2	1	1	1
CO3	–	2	–	3	–	3	–	–	–	–	–	–	2	3	2	2	1
CO4	–	2	–	3	–	2	–	–	–	–	–	–	2	3	2	2	1
CO5	–	2	–	3	–	2	–	–	–	–	–	–	2	3	2	2	2

Course Contents:

UNIT- I: Humans and the Environment (06 Classroom contact Hours)

The man-environment interactions: Human as hunger-gatherers; Origin of agriculture; Great ancient civilizations and the environment; Industrial revolution and its impact on the environment; Population growth and natural resource exploitation; Concept of sustainable development, Sustainable Development Goals (SDGs).

UNIT-II: Natural Resources and Sustainable Development (07 Classroom contact Hours)

Overview of natural resources, renewable and non-renewable resources. Biotic resources: Major type of biotic resources-forests, grassland, wetlands, wildlife. Water resources: Types of water resources-fresh water and marine; Availability and use of water resources; Environmental impact of over-exploitation, issues and challenges; Conflicts over water.Soil and mineral resources: Energy resources: Renewable and non-renewable sources of energy; Non-conventional energy sources-solar, wind, tidal, hydro, geothermal, biomass, hydrogen and fuel cells; Implications of energy use on the environment.

UNIT-III: Conservation of Biodiversity and Ecosystems (05 Classroom contact Hours)

Biodiversity as a natural resource; Biodiversity in India and the world; Biodiversity hotspots; Endangered species, Red data book. Threats to biodiversity and ecosystems: Commercial exploitation of species; Invasive species. Major conservation policies: in-situ conservation approaches; Major protected areas; National and International initiatives for biodiversity conservation; the role of traditional knowledge, community-based conservation. Land use and Land cover change: deforestation, desertification, urbanization, Loss of Biodiversity and it's impact.

UNIT- IV: Environmental Pollution (07 Classroom contact Hours)
Environmental issues at local, regional, and global levels. Air, noise, water, soil, thermal and radioactive pollution. Point sources and non-point sources of pollution.

Air pollution: Sources of air pollution; Primary and secondary pollutants; particulate matter and sulphur dioxide; Volatile Organic compounds (VOCs), Polycyclic aromatic hydrocarbons (PAHs) and Persistent organic pollutants (POPs); acid rain; smog, Ozone hole. National Ambient Air Quality Standards.

Water pollution: Sources of water pollution; River, lake and marine pollution, groundwater pollution; water quality, Water quality parameters and standards; adverse health impacts of water pollution on human and aquatic life.

Soil pollution: Soil pollutants and their sources; Solid waste and their recycling. Noise pollution: Definition of noise; Unit of measurement of noise pollution; Mineral exploitation; Environmental problems due to extraction of minerals and use; Degradation of soil quality and impact on agriculture productivity, Noise pollution; Noise standards; adverse impact of noise on human health. Thermal and Radioactive pollution: Sources and impact on human health and ecosystems.

UNIT-V : Climate Change: Impacts, Adaptation and Mitigation (06 Classroom contact Hours)
Understanding climate change, Projections of global climate change with reference to temperature, rainfall, climate variability and extreme events; Climate change projections for the Indian sub-continent.

Impacts of climate change on ocean and land systems; Sea level rise, changes in marine and costal ecosystems; Impacts on forests and natural ecosystem; Impacts on animal species, agriculture, health, urban infrastructure; Climate-resilient development; Indigenous knowledge for adaption to climate change.

Mitigation of climate change: Green House Gas (GHG) Reduction vs. sink enhancement; Concept of carbon intensity, energy intensity and carbon neutrality; Energy efficiency measures; Renewable energy sources; Carbon capture and storage.

UNIT-VI : Environmental Management (07 Classroom contact Hours)
Introduction to environmental laws and regulations: Constitutional provisions- Article 48A, Article 51A (g) and other environmental rights, Environmental legislations on the forest, wildlife and pollution control. Environmental audit and impact assessment; Waste Management- Concept of 3R (Reduce, Recycle and Recycle) and sustainability.

UNIT-VII : Environmental Treaties and Legislation (09 Classroom contact Hours)
Major International Environmental Agreements: UN Conference on Human Environment 1972, Convention on Biological Diversity (CBD); Cartagena Protocol on Biosafety; Nagoya Protocol on Access and Benefit-sharing ; Convention on International Trade in Endangered Species of Wild Flora and Fauna(CITES); Ramsar Convention on Wetlands of International Importance; United Nations Convention to Combat Desertification (UNCCD); Vienna Convention for the Protection of the Ozone Layer; Montreal Protocol on Substances that Deplete the Ozone Layer and the Kigali Amendment; Basel Convention on the Control of Trans boundary Movements of Hazardous Wastes and their Disposal; Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade; Stockholm Convention on Persistent Organic Pollutants; Minamata

Convention on Mercury; United Nations Framework Convention on Climate Change (UNFCCC); Kyoto Protocol; Paris Agreement; India's status as a party to major conventions

Major Indian Environmental Legislations: The Wild Life (Protection) Act, 1972; The Water (Prevention and Control of Pollution) Act, 1974; The Forest (Conservation) Act, 1980; The Air(Prevention and Control of Pollution) Act, 1981 The Environment (Protection) Act, 1986; The Biological Diversity Act, 2002; The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006; Noise Pollution (Regulation and Control) Rules, 2000; Industry-specific environmental standards; Waste management rules, National Green Tribunal.

Major International organizations and initiatives: United Nations Environment Programme(UNEP), International Union for Conservation of Nature (IUCN), World Commission on Environment and Development (WCED), United Nations Educational, Scientific and Cultural Organization (UNESCO), Intergovernmental Panel on Climate Change (IPCC), and Man and the Biosphere(MAB) programme.

UNIT-VIII: Disaster Management(30 hour Practical)

Concept of Hazards, Disasters, Natural and man made hazards, Types of hazards, Concept of disaster management, Vulnerability and risk. Nature and characteristics of hazards: Flood, Cyclone, Drought, and Earthquake. Man made hazards – Industrial and Fire.

Disaster management cycle, Pre disaster management, during disaster management, Post Disaster review and management, Preventing, mitigation, preparedness, Adaptation. Disaster Management Plan at National Level, State Level, District Level and Community Level.

Recommended Learning Resources

Text book:

1.Singh, J.S., Singh, S.P. and Gupta, S.R. 2014. *Ecology, Environmental Science and Conservation*. S. Chand Publishing, New Delhi.

Reference book:

1. Das, M.C. Text Book of Ecology, Tata Mc Grew Hills, New Delhi
2. Central Pollution Control Board Web page for various pollution standards. https://cpcb.nic.in/standards/
3. Chiras, D. D and Regan olds, J.P. (2010) . Natural Resource Conservation: Management for a Sustainable Future. 10th edition, Upper Saddle River, N.J. Benjamin/Cummins/Person.
4. Fisher, Michael H. (2018) An Environmental History of India-Form Earliest Times to the Twenty-First Century, Cambridge University Press.
5. Harris, France (2012) Global Environmental Issues, 2nd Edition. Wiley-Blackwell.
6. John W. Twidell and Anthony D. (2015). Renewable Energy Sources, 3rd Edition, Weir Publisher (ELBS)

7. Kanchi Kohli and Manju Menon (2021) Development of Environment Laws in India, Cambridge University Press.

8. Krishnamurthy, K.V.(2003) Textbook of Biodiversity, Science Publishers, Plymouth, UK

9. Ministry of Environment, Forest and Climate Change (2019) A Handbook on International Environment Conventions & Programmes.
https://moef.govt.in/wp-content/uploads/2020/02/convention-V-16-CURVE-web.pdf

10. Rajagopalan, R. (2011). Environmental Studies: From Crisis to Cure. India: Oxford University Press.

11. Annual Reports of Ministry of Env., Forests and Climate Change, Govt of India, New Delhi

Note: Latest edition of the text books should be used.

SDG Mapping for this Course

SDG No.	SDG Title	Nature of Contribution
SDG 3	Good Health and Well-being	Safety, health impacts of disasters and pollution
SDG 11	Sustainable Cities and Communities	Resilient infrastructure, disaster-risk reduction strategies
SDG 13	Climate Action	Climate literacy, adaptation and mitigation concepts
SDG 15	Life on Land	Biodiversity, forests, indigenous ecological knowledge

SEMESTER II(With Single Major)			
Code	**Course Title**	**Credit**	**L-T-P**
MT10002	Real Analysis	4	3-1-0
MT12002	Introduction to Differential Equations	4	3-1-0
MT13002	Introduction to Statistics	3	2-1-0
AE14002	Translation Studies (Odia)	2	2-0-0
AE14004	Translation Studies (Hindi)	2	2-0-0
AE14006	Translation Studies (Sanskrit)	2	2-0-0
AE14008	Translation Studies (Santali)	2	2-0-0
AE14010	Translation Studies (English)	2	2-0-0
CS15002	Introduction to Programming using Python	3	
VA16302	Introduction to Methods of Applied Mathematics	2	2-0-0
VA16394	Flutter Application Development	2	1-0-1
VA16146	Indian Knowledge System	2	2-0-0
VA16484	Community Engagement and Social Responsibility	2	2-0-0

COURSE CODE-MT10002

COURSE TITLE- REAL ANALYSIS

Total Credits: 04 (Credits: Theory-03, Tutorial-01)

Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

Students will be able to articulate and describe:

1 . concepts of field , count ability and unaccountability.
2. Supremum, infimum, bounded sets
3. convergence and divergence
4. infinite series and different tests

Course Outcomes:

After completing this course the students will be able to

CO1: Remember the concepts of field, countable set

CO2: Understand supremum and infimum

CO3: Apply some important results of divergence

CO4: Analyze Some results on infinite series

CO5: Evaluate the different problems relating to ratio test and comparison test

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	2	–	–	–	–	–	–	–	–	3	2	–	--	–
CO2	–	3	–	2	–	–	–	–	–	–	–	–	–	–	2	–	–
CO3	–	2	–	3	–	2	–	2	–	–	–	–	–	–	2	–	2
CO4	–	2	–	3	–	–	–	–	–	–	–	–	–	–	--	2	–
CO5	–	2	–	3	–	–	–	–	–	–	–	–	–	–	2	–	–

COURSE CONTENTS:

UNIT-I: Algebraic and Order Properties of the Real Number System (11 Classroom contact Hours)

Review of Algebraic and Order Properties of R, neighborhood of a point in R, Idea of countable sets, uncountable sets and uncountability of R. Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets.

UNIT-II: Completeness of $\mathbb{R}$ and Topological Properties of Sets(12 Classroom contact Hours)

Suprema and Infima, The Completeness Property of R, The Archimedean Property, Density of Rational (and Irrational) numbers in R, Intervals. Limit points of a set, Isolated points, Illustrations of Bolzano-Weierstrass theorem for sets.

UNIT-III: Sequences and Their Convergence(11 Classroom contact Hours)

Sequences, Bounded sequence, Convergent sequence, Limit of a sequence. Limit Theorems, Monotone Sequences, Monotone Convergence Theorem. Subsequences, Divergence Criteria, Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for Sequences. Cauchy sequence, Cauchy's Convergence Criterion.

UNIT-IV: Infinite Series and Tests for Convergence(11 Classroom contact Hours)

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

Tutorial:-30 Hours

Recommended Learning Resources

Text book:

1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.

Reference books:

1. Gerald G. Bilodeau , Paul R. Thie, G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones & Bartlett, 2010. 3. Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, Elementary Real Analysis, Prentice Hall, 2001.

2. S.K. Berberian, A First Course in Real Analysis, Springer Verlag, New York, 1994.

3. https://onlinecourses.swayam2.ac.in/cec24_ma11/preview

SDG Mapping for this Course

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strengthens rigorous mathematical reasoning, analytical thinking, and foundational knowledge
SDG 8	Decent Work and Economic Growth	Development of logical and analytical skills applicable in research, education, analytics, and technical fieldengineering roles
SDG 9	Industry, Innovation and Infrastructure	Mathematical foundations supporting advanced modeling, algorithms, and technological innovation

Course Code: MT12002
Course Title: Introduction to Differential Equations
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

Students will be able to articulate and describe ddifferential Equations, order and degree, first and second second Order differential Equations, solution of differential equations, first order partial Differential Equations

Course Outcomes:

After completing this course the students will be able to

CO1: Remember the concepts, nature and significance of Differential equations

CO2: Understand Parameters defining ordinary differential equations and its solutions

CO3: Apply existence and uniqueness of solutions of differential equation

CO4: Analyze the system of differential equations.

CO5: Evaluate the problems based on first order partial differential equations

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	–	2	2	–	–	–	–	–	–	–	3	1	1	1	1
CO2	2	3	–	3	3	--	–	–	–	–	–	–	3	2	1	1	1
CO3	–	2	–	3	3	2	–	–	–	–	–	–	2	3	2	2	1
CO4	–	2	–	2	--	--	2	–	–	2	–	–	2	3	2	2	1
CO5	–	2	–	2	2	--	–	–	–	–	–	2	2	3	2	2	2

Course Duration: 45 hours

Course Syllabus:

UNIT- I: **First-Order Ordinary Differential Equations (12 Classroom contact Hours)**

Introduction and types of differential equations, Solutions of a differential equation. First order and first degree ordinary differential eqation, Variable separable equations and equations reducible to this form, Exact differential equations and integrating factors, Linear equation and Bernoulli equations, special integrating factors and transformations.,

UNIT- II: **Second-Order Linear Differential Equations (11 Classroom contact Hours)**

Second order Linear Differential Equations*:*-General solution, Using a known solution to find the other, Homogeneous equations with constant coefficients, , Method of variation of parameters, Power series solution and special functions.

UNIT-III: **Higher-Order Differential Equations and Existence–Uniqueness Theorems (11 Classroom contact Hours)**

General solution of homogeneous equation of second order Wronskian, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation.Existence and Uniqueness of Solutions*:* Successive approximations, Picard's Theorem, Non Uniqueness of solutions, Continuation and dependence on initial conditions, Existence of solutions in the large, Existence and uniqueness of solution of systems.

UNIT-- IV: Introduction to Partial Differential Equations (11 Classroom contact Hours)
Introduction to Partial differential equation, Classification of first order Partial differential equations, Semi-linear and quasi-linear equations, Pfaffian differential equations, Lagrange's method, Compatible systems, Charpit's method, Jacobi's method, Linear Second order partial Differential Equations

Recommended Learning Resources

Textbooks:

1.G. F. Simmons, Differential Equations with Applications, McGraw Hill International Edition, 1991.
2. S. G. Deo and V. Raghavendra, Ordinary Differential Equations and stability theory, TATA McGraw Hill Ltd, 1980. Chapter 2 (Quick Review) 4,5,6,7.

Reference Materials & Digital Resources:

1. G. Birkhoff and G. C. Rota-Ordinary Differential Equations-John Wiley and Sons, N.Y., 1989.
2. Coddington and Levinson, Theory of Ordinary Differential Equations, Krieger Pub Co (June 1984)
3. Tyn-Myint-U Ordinary Differential Equations, Elsevier North-Holland, 1987.
4. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
5. https://onlinecourses.swayam2.ac.in/cec24_ma09/preview.

SDG Mapping for this Course

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Mathematical modelling competence
SDG 13	Climate Action	Basis for climate / environment differential models
SDG 3	Good Health and Well-being	Epidemic and growth models

Course Code: MT13001
Course Title : Introduction to Statistics

Total Credits: 03 (Credits: Theory-02, Tutorial-01)
Total Lectures: Theory- 30 and Tutorial-30

Course Objectives

The course aims to:

1. Introduce the fundamental concepts and applications of Statistics.
2. Develop skills in organizing, presenting, and interpreting data.
3. Familiarize students with measures of central tendency and dispersion.
4. Introduce elementary probability and common statistical distributions.
5. Enable students to apply statistical methods for solving problems in science, commerce, social sciences, and everyday life.

Course Outcomes (COs)

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

CO1: Remember the basic concepts, scope, and applications of statistics and organize data effectively.

CO2: Understand, compute and interpret measures of central tendency and dispersion.

CO3: Apply elementary probability concepts and probability distributions to practical situations.

CO4: Analyze relationships between variables using correlation and regression and interpret statistical findings.

CO5: Evaluate relationships between variables using correlation and regression and interpret statistical findings.

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	–	2	2	–	–	–	–	–	–	–	3	1	1	1	1
CO2	2	3	–	3	3	--	–	–	–	–	–	–	3	2	1	1	1
CO3	–	2	–	3	3	2	–	–	–	–	–	–	2	3	2	2	1
CO4	–	2	–	2	--	--	2	–	–	2	–	–	2	3	2	2	1
CO5	–	2	–	2	2	--	–	–	–	–	–	2	2	3	2	2	2

UNIT-I: Introduction to Statistics and Data Presentation (07 Classroom contact Hours Hours)

Meaning, nature and scope of Statistics , Types of data ,Collection of data: Primary and Secondary , Classification and tabulation of data ,Frequency distributions ,Diagrammatic and graphical representation ,Bar diagrams ,Pie charts ,Histogram ,Frequency polygon ,Ogive

UNIT-II: Measures of Central Tendency and Dispersion (08 Classroom contact Hours)

Arithmetic Mean , Median ,Mode ,Geometric Mean (basic idea) ,Harmonic Mean (basic idea) ,Quartiles and Percentiles ,Measures of Dispersion ,Range ,Quartile Deviation ,Mean Deviation Variance ,Standard Deviation ,Coefficient of Variation

UNIT-III: Probability and Probability Distributions (07 Classroom contact Hours Hours)

Random experiment, Sample space , Events ,Classical and axiomatic definition of probability, Addition and multiplication laws ,Conditional probability ,Bayes' theorem (applications),Random variable ,Probability mass and density functions ,Binomial and Normal distributions (elementary treatment)

UNIT-IV: Correlation, Regression and Applications (08 Classroom contact Hours)

Scatter diagram ,Karl Pearson's coefficient of correlation ,Spearman's rank correlation ,Simple linear regression ,Regression lines ,Interpretation of regression coefficients ,Introduction to statistical software (MS Excel/R/Open-source tools) ,Applications of statistics in economics, commerce, biology, agriculture, social sciences, and public policy

Recommended Textbooks

1. S.C. Gupta and V.K. Kapoor, *Fundamentals of Applied Statistics*.
2. S.P. Gupta, *Statistical Methods*.
3. Sheldon M. Ross, *Introductory Statistics*.
4. Richard A. Johnson, *Miller and Freund's Probability and Statistics for Engineers*.

Reference Books

1. Freund, J.E., *Mathematical Statistics*.
2. Walpole, Myers, Myers and Ye, *Probability and Statistics for Engineers and Scientists*.
3. Croxton and Cowden, *Applied General Statistics*.
4. Montgomery and Runger, *Applied Statistics and Probability for Engineers*.

SDG Mapping for this Course

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Promotes quality education through statistical literacy. Develops analytical and quantitative skills for employability.
SDG 8	Decent Work and Economic Growth	Small business skills, local value chains
SDG 9	Industry, Innovation and Infrastructure	Supports scientific reasoning, innovation, and evidence-based decision making.
SDG 11	Sustainable Cities and Communities	Enables data-driven analysis for health, sustainable cities, and partnerships.

Translation Studies (Odia)

Level 100

Code	Course Title	Credit	L-T-P
AE14002	Translation Studies (Odia)	2	2-0-0

Refer to UG syllabus of Odia Department

Translation Studies (Hindi)

Code	Course Title	Credit	L-T-P
AE14004	Translation Studies (Hindi)	2	2-0-0

Refer to UG syllabus of Hindi Department

Translation Studies (Sanskrit)

Code	Course Title	Credit	L-T-P
AE14006	Translation Studies (Sanskrit)	2	2-0-0

Refer to UG syllabus of Sanskrit Department

Translation Studies (Santali)

Code	Course Title	Credit	L-T-P
AE14008	Translation Studies (Santali)	2	2-0-0

Refer to UG syllabus of Santali Department

Translation Studies (English)

Code	Course Title	Credit	L-T-P
AE14010	Translation Studies (English)	2	2-0-0

Refer to UG syllabus of Santali Department

Course Code: CS15002
Course Title: Introduction to Programming using Python
Total Credits: 03 (Credits: Theory-02, Practical-01)
Total Lectures: Theory- 30 and Practical-22

Course Objective:

1. To provide students with a foundational understanding of Python programming, enabling them to **develop** problem-solving skills, **enhance** critical thinking, and **apply** analytical reasoning.
2. The course aims to **foster** research-related skills, **encourage** cooperative teamwork, and **cultivate** leadership readiness, while promoting digital literacy, multicultural competence, and effective communication skills.
3. It also seeks to instill environmental awareness, sustainability, and the principles of autonomy, responsibility, accountability, and self-directed lifelong learning.

Course Outcomes:

CO1:. **Remember** programming concepts and results effectively, both orally and in writing, enhancing **communication skills**.

CO2: Understand research and **utilize** Python libraries to **create** innovative solutions, showcasing **research-related skills**.

CO3: Apply in teams to **design** and **execute** Python projects, reflecting **cooperative teamwork** and **leadership readiness**.

CO4: Analyze and solve complex problems using Python programming, demonstrating critical thinking and analytical reasoning.

CO5: Evaluate by developing Python applications that contribute to sustainability, and **engage** in **self-directed learning** to adapt to new programming paradigms

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	–	–	–	–	–	–	–	–	–	–	–	2	3	3	2	2
CO2	_	3	–	3	3	--	–	–	–	–	–	–	3	2	1	1	1
CO3	–	--	–	3	–	–	–	–	–	–	–	–	2	3	2	2	1
CO4	–	–	2	–	--	--	–	–	–	–	–	–	2	3	2	2	1
CO5	–	–	3	–	2	--	–	–	–	–	–	–	2	3	2	2	2

Course Duration: 30 hours

Course Syllabus:

Unit 1: Introduction to Python (05 Classroom contact Hours)

Python history and applications, Setting up the Python environment, Basic syntax, variables, and data types

Unit 2: Control Structures and Functions (06 Classroom contact Hours)

Conditional statements and loops, Writing and calling functions, Understanding scope and namespaces

Unit 3: Data Structures (05 Classroom contact Hours)

Lists, tuples, sets, and dictionaries, Comprehensions and iterations, Manipulating data structures

Unit 4: Modules and File Handling (07 Classroom contact Hours)

Importing modules and exploring the standard library, Reading from and writing to files, Exception handling and debugging

Unit 5: Object-Oriented Programming (07 Classroom contact Hours)

Classes and objects, Inheritance and polymorphism, Special methods and data encapsulation

List of 20 Exercises:

1. Write a Python script to display "Hello, World!"
2. Create a program that calculates the factorial of a number
3. Develop a Python program to sort a list of elements
4. Implement a Python function to check if a number is prime
5. Write a Python class representing a bank account
6. Develop a command-line application to manage a to-do list
7. Create a Python script that handles file I/O operations
8. Implement error handling in a Python program
9. Develop a Python program using list comprehensions
10. Write a Python program that uses dictionaries to store student grades
11. Create a Python module for mathematical operations
12. Implement a text-based game using Python
13. Develop a Python program that uses command-line arguments
14. Write a Python script to parse and process CSV files
15. Create a simple web scraper using Python
16. Develop a Python program that uses regular expressions
17. Implement a basic calculator using Python's math module
18. Write a Python program to visualize data using matplotlib
19. Create a Python class hierarchy representing geometric shapes
20. Develop a Python program that interacts with an external API

Textbook:

1. "Python Crash Course" by Eric Matthes

Reference Books:

1. "Automate the Boring Stuff with Python" by Al Sweigart
2. "Learning Python" by Mark Lutz

SWAYAM Courses

- The Joy of Computing using Python - https://onlinecourses.nptel.ac.in/noc24_cs113/preview
- Scientific Computing using Python - https://onlinecourses.nptel.ac.in/noc24_ph36/preview

SDG Mapping for this Course

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Widely used, modern programming foundation
SDG 8	Decent Work and Economic Growth	Python skills for data / software / AI jobs
SDG 9	Industry, Innovation and Infrastructure	Rapid prototyping and analytics for innovation
SDG 13	Climate Action	Potential to work with climate / environment datasets

COURSE CODE-VA16302

COURSE TITLE- Introduction to methods of Applied Mathematics

Total Credits: 02 (Credits: Theory-02, Tutorial-00)

Total Lectures: Theory- 30 and Tutorial-00

Course Objectives:

Students will be able to articulate and describe: To introduce fundamental mathematical tools used in real-world problem solving and develop analytical and quantitative thinking skills

Course Outcomes:

Course Outcomes:

CO1:. Remember the concepts, and basic ideas

CO2: Formulate simple mathematical models.

CO3: Apply mathematical techniques to practical problems.

CO4: Solve basic differential equations and matrix problems.

CO5: Use mathematical tools in applied domains

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	–	2	–	–	–	–	–	–	–	–	1	1	_	2	2
CO2	2	3	–	3	3	--	–	–	–	–	–	–	3	2	1	1	1
CO3		2	–	3	3	2	–	–	–	–	–	–	2	3	2	2	1
CO4	–	3	2	–	--	--	2	–	–	2	–	–	2	3	2	2	1
CO5	–	2	_	2	2	--	–	–	–	–	–	2	2	3	2	2	2

UNIT-I Mathematical Modeling (05 Classroom contact Hours)

Meaning and importance of applied mathematics, Mathematical modeling: formulation and validation, Linear and nonlinear models, Applications in population growth, finance, and science

UNIT-II Linear Algebra Techniques (05 Classroom contact Hours)

Systems of linear equations, Matrix operations and inverse of a matrix, Determinants and applications, Introduction to eigenvalues and eigenvectors, Applications in engineering and data analysis

UNIT-III Calculus for Applications (05 Classroom contact Hours)

Functions and limits, Differentiation and its applications, Maxima and minima, Optimization problems in economics and science

UNIT-IV Differential Equations (04 Classroom contact Hours)

Formation of differential equations, First-order differential equations, Applications: growth and decay, Newton's law of cooling, Introduction to second-order differential equations

UNIT V: Basics of Probability and Statistics (04 Classroom contact Hours)

Elementary probability concepts, Random variables and distributions, Mean, variance, and standard deviation, Correlation and regression, Applications in real-life data analysis

Tutorial:-30 hours

Textbook:

1."Kreyszig, E. – *Advanced Engineering Mathematics*

Reference Books:

2. Stewart, J. – *Calculus* "Learning Python" by Mark Lutz
3. Edwards & Penney – *Differential Equations and Linear Algebra*
4. Gupta, S.C. & Kapoor, V.K. – *Fundamentals of Mathematical Statistics*

COURSE CODE-VA16394

COURSE TITLE:- Flutter Application Development

Total Credits: 02 (Credits: Theory-01, Practical-01)

Total Lectures: Theory- 15 and Practical -30

Course Objective:

1. To empower students with the skills to design, develop, and deploy cross-platform mobile applications using Flutter.
2. Fostering critical thinking, problem-solving, and digital literacy aligned with current industry standards.

Course Outcomes:

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

CO 1 : Remember Flutter development principles to create innovative solutions for real-world mobile application challenges.
CO 2: Understand and optimize Flutter applications by applying analytical reasoning to enhance performance and user experience.

CO 3: Apply and integrate the latest Flutter development trends and plugins to extend app functionality and maintain relevance in a rapidly evolving digital landscape.

CO 4 : Analyze in diverse teams to manage Flutter projects, demonstrating leadership and effective communication throughout the development lifecycle.

CO5 : Evaluate and disseminate comprehensive documentation for Flutter applications, demonstrating clear communication of technical concepts to varied audiences

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	–	–	–	–	–	–	–	–	–	–	–	1	1	–	2	2
CO2	–	3	–	3	3	--	–	–	–	–	–	–	1	2	1	1	1
CO3	–	–	–	3	–	3	–	–	–	–	–	–	1	2	2	2	1
CO4	–	–	2	–	--	--	3	–	–	–	–	–	1	2	2	2	1
CO5	–	–	3	–	–	--	–	3	–	–	–	–	1	2	2	2	2

Course Duration: 12Hours

Course Syllabus:

Unit 1: Introduction to Flutter and Dart (04 Classroom contact Hours)

Flutter architecture, Dart programming language, Setting up the development environment Basic widgets , Layout design

Unit 2: State Management and Navigation (04 Classroom contact Hours)

Stateful vs. stateless widgets, State management techniques, Navigation and routing,Data passing between screens.

Unit 3: Advanced Flutter Concepts (04 Classroom contact Hours)
Asynchronous programming in Dart, Advanced UI components, third-party integrations, Package management, Deployment strategies.

Exercises:

1. Set up a Flutter development environment and create a “Hello World” application.
2. Design a login screen with form validation.
3. Implement a to-do list application with state management.
4. Create a multi-page application with bottom navigation.
5. Integrate a REST API to fetch and display data in a Flutter app.

(15 more exercises covering the units)

Recommended Learning Resources

Textbook:

1. “Beginning Flutter: A Hands-On Guide to App Development” by Marco L. Napoli

Reference Books:

1. “Flutter for Beginners: An introductory guide to building cross-platform mobile applications with Flutter and Dart 2” by Alessandro Biessek
2. “Flutter Recipes: Mobile Development Solutions for iOS and Android” by Fu Cheng

SDG (Flutter)

Aspect	Notes
Professional Ethics	App permissions, data privacy, dark patterns
Gender	Inclusive UX personas, accessibility
Human Values	Apps for community benefit (health, education, local info)
Environment & Sustainability	Apps that support SDGs (e.g., disaster alerts, agri advisory)
Key SDGs	SDG 4, 8, 9, 11, 13

COURSE CODE-VA16484

COURSE TITLE- Community Engagement and Social Responsibility

Total Credits: 02 (Credits: Theory-01, Practical-01)

Total Lectures: Theory- 12 and Practical -08

Level 100

Course Objectives

The course aims to:

1. Introduce students to the concepts, ethics, and practices of community engagement.

2. Develop an understanding of rural society, community development, and local governance.
3.Familiarize students with rural development programmes, self-help groups, and government initiatives.

4.Promote social responsibility through community participation and field-based learning.
5.Enhance students' ability to apply community engagement principles in addressing local developmental issues.

Course Outcomes (COs)

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

CO1: Explain the concepts, principles, ethics, and significance of community engagement and social responsibility.

CO2: Describe the structure and functioning of rural communities, local governance institutions, and community development processes.

CO3: Examine the role of Self-Help Groups (SHGs), rural institutions, community networks, and government schemes in promoting inclusive and sustainable development.

CO4: Demonstrate the ability to engage with communities through field-based activities, surveys, and participatory learning approaches.

CO5: Evaluate community issues and development programmes, and prepare evidence-based field reports with appropriate ethical considerations.

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	1	2	1	1	–	2	–	2	2	1	2	2	1	1	2	1
CO2	2	1	3	3	3	1	3	2	3	3	3	2	1	3	3	2	3
CO3	2	–	2	2	2	–	3	–	2	2	1	3	1	2	2	2	2
CO4	3	1	2	2	2	2	2	1	3	2	2	2	2	2	2	3	3
CO5	2	1	2	3	3	–	3	2	2	3	3	3	–	2	2	2	3

Unit I: Foundations of Community Engagement and Community Development (8 classroom contact Hours)

Concept, Ethics and Spectrum of Community Engagement; Local Community, Rural Culture and Practice of Community Engagement; Stages, Components and Principles of Community Development; Utility of Public Resources; Contributions of Self-Help Groups (SHGs); Rural Development Programmes and Rural Institutions.

Unit II: Community Participation, Governance and Social Responsibility (7 classroom contact Hours)

Local Administration and Community Involvement; Social Contribution through Community Networking; Major Government Schemes for Community Development; Programmes of Community Engagement and Their Evaluation; Community Engaged Research and Research Ethics; Rural Distress, Rural Poverty, Impact of COVID-19 on Migrant Labourers, and Disaster Mitigation.

Practical – Community Engagement and Field-Based Learning (15 Practical Hours)

1. Field Visit to a village, urban local community, Panchayati Raj Institution (PRI), or Self-Help Group (SHG).

2. Community Resource Mapping and identification of local development resources.
3. Survey on community development issues and awareness of government welfare schemes.
4. Observation of community participation and local governance practices.
5. Participation in community awareness programmes on health, sanitation, education, environment, or disaster preparedness.
6. Preparation and Presentation of a field report based on observations and community engagement activities.

Books and References: -

1.Principles of Community Engagement, 2nd Edition, NIH Publication No. 11-7782, Printed June 2011.

2. https://youtu.be/-SQK9RGBt7o

3.https://www.uvm.edu/sites/default/files/community_engagement_handout.pdf (Community Engagement)

4.https://www.atsdr.cdc.gov/communityengagement/pce_concepts.html (Perspectives of Community)

5.https://egyankosh.ac.in/bitstream/123456789/59002/1/Unit1.pdf (community concepts)

SDG Mapping for this Course

SDG No.	SDG Title	Nature of Contribution
SDG 3	Good Health and Well-being	Promotes community health support through volunteerism, disaster response, and emergency relief activities
SDG 4	Quality Education	Develops critical thinking, decision-making skills, leadership qualities, and values-based learning through experiential education
SDG 5	Gender Equality	Encourages inclusive participation of all genders in volunteer work and leadership roles in community service
SDG 10	Reduced Inequalities	Promotes equitable participation in social service activities and reduces social and cultural barriers in community engagement

SDG 11	Sustainable Cities and Communities	Encourages community-based volunteerism, disaster preparedness, and building resilient and sustainable communities
SDG 16	Peace, Justice and Strong Institutions	Builds ethical values, responsible citizenship, leadership, and peaceful community engagement through volunteer activities

SEMESTER III			
Code	**Course Title**	**Credit**	**L-T-P**
MT20001	Theory of Real Functions	4	3-1-0
MT20003	Numerical Methods	4	3-0-1
MT22001	Introduction to Probability and Statistics	4	3-1-0
MT23001	Mathematics and its impact on Life	3	2-1-0
AE24001	Communicative English	2	2-0-0
CS25001	Prompt Engineering and AI Tools	3	2-0-1

Course Code: MT20001
Course Title: Theory of Real Functions
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

Students will be able to articulate and describe:

1 .Mean value theorems and infinite series
2. Reimann Integration
3.Different types of Improper integrals
4. Power series and series of functions

Course Outcomes:

Course Outcomes:

After completing this course the students will be able to:

CO1: Remember the concepts, nature and significance of infinite series

CO2: Understand Parameters of Reimann Integration of a function

CO3: Apply some importantance of Improper integrals of a function

CO4: Analyze Some results on Mean value theorems

CO5: Evaluate the different problems relating to series of functions

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	1	–	–	–	–	–	–	–	–	2	1	1	2	2
CO2	–	3	–	2	–	--	–	–	–	–	–	–	2	2	1	1	1
CO3	–	2	–	3	–	–	–	–	–	–	–	–	3	2	2	2	1
CO4	–	2	–	3	–	--	–	–	–	–	–	–	2	3	2	2	1
CO5	–	2	–	3	–	--	–		–	–	–	–	3	3	3	2	2

UNIT-I Mean Value Theorems, Taylor's Theorem, and Applications(12 Classroom contact Hours)

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

UNIT-II Riemann Integration and Fundamental Theorems of Calculus(11 Classroom contact Hours)

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

UNIT-III Improper Integrals and Convergence of Sequences of Functions(11 Classroom contact Hours hours)

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

UNIT-IV Series of Functions and Power Series(11 Classroom contact Hours)

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

Tutorial:-30 hours

Recommended Learning Resources

Textbook:

1. ". Das and S. Pattanayak, Fundamentals of mathematics analysis, TMH Publishing Co

Reference Books:

1.S. C. Mallik and S. Arora, Mathematical analysis, New Age publications

2. R. Bartle and D.R. Sherbert, Introduction to Real Analysis, John Wiley and Sons, 2003.

SDG Mapping for this Course

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strengthens rigorous mathematical reasoning, analytical thinking, and foundational knowledge
SDG 9	Industry, Innovation and Infrastructure	Mathematical foundations supporting modeling, algorithms, and technological innovation

COURSE CODE-MT20003

COURSE TITLE- Numerical Methods

Total Credits: 04 (Credits: Theory-03, Practical-01)

Total Lectures: Theory- 45 and Practical -30

Course Objectives:

Students will be able to articulate and describe:

1. Calculation of error and approximation is a necessity in all real life, industrial and scientific computing
2 Various methods of finding solution of different type of problems such as locating roots of equations
3. Solution of nonlinear equations, systems of linear equations, ,
4. Evaluate approximate Eigen values by using different methods.

Course Outcomes:

After completing this course the students will be able to:

CO1: Remember the Iteration methods based on first degree equations

CO2: Understand the Lagrange and Newton interpolations, Finite differences

CO3: Apply the Methods based on Interpolation, Methods based on Finite Differentials

CO4:Analyze the Numerical Solution of system of linear equations

CO5: Evaluate the problems based on iteration, Lagrange's interpolation, and numerical solutions of linear differential equations.

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	1	–	–	–	–	–	–	–	–	3	1	1	1	2
CO2	–	3	–	2	–	--	–	–	–	–	–	–	3	2	1	2	2
CO3	–	2	–	3	–	2	–	1	–	–	–	–	2	3	2	2	2
CO4	–	2	–	3	–	2	–	1	–	–	–	–	2	3	2	3	2
CO5	–	2	–	3	–	2	–	1	–	–	–	–	2	3	3	3	3

UNIT-I: Errors, Algorithms, and Numerical Solution of Nonlinear Equations(12 Classroom contact Hours)

Algorithms, Convergence, Errors: Relative, Absolute, Round off, Truncation. Transcendental and Polynomial equations: Bisection method, Newton's method, Secant method. Rate of convergence of these methods.

UNIT-II: Numerical Solution of Linear Systems and Interpolation(11 Classroom contact Hours)

System of linear algebraic equations: Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis. Interpolation: Lagrange and Newton's methods. Error bounds.

UNIT-III: Finite Difference Operators and Basic Numerical Integration(11 Classroom contact Hours)

Finite difference operators. Gregory forward and backward difference interpolation. Numerical Integration: Trapezoidal rule, Simpson's rule, Simpsons 3/8th rule.

UNIT-IV: Advanced Numerical Integration Techniques(11 Classroom contact Hours)

Numerical Integration : Midpoint rule, Composite Trapezoidal rule, Composite Simpson's rule.

List of Practicals (using any software)(Flow chart) (30 Hours)

(i) Calculate the sum 1/1 + 1/2 + 1/3 + 1/4 + ----------+ 1/ N.
(ii) To find the absolute value of an integer.
(iii) Enter 100 integers into an array and sort them in an ascending order.

(iv) Bisection Method.

V) Newton Raphson Method.

(vi) Secant Method.

(vii) Regulai Falsi Method.

(viii) LU decomposition Method.

(ix) Gauss-Jacobi Method.

(x) SOR Method or Gauss-Siedel Method

(xi) Lagrange Interpolation or Newton Interpolation.

(xii) Simpson's rule.

Recommended Learning Resources

Textbook:

1.B.P. Acharya, Numerical Analysis

Reference Books:

1. Brian Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.

2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 6th Ed., New age International Publisher, India, 2007.

3. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, India, 2008

4. Uri M. Ascher and Chen Greif, A First Course in Numerical Methods, 7th Ed. , PHI Learning Private Limited, 2013.

5. John H. Mathews and Kurtis D. Fink, Numerical Methods using Matlab, 4th Ed., PHI Learning Private Limited, 2012.

6.https://onlinecourses.swayam2.ac.in/cec24_ma07/preview

SDG Mapping for this Course

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Algorithm development, numerical problem-solving, use of software tools
SDG 7	Affordable and Clean Energy	Numerical modeling of energy systems
SDG 9	Industry, Innovation and Infrastructure	Supports engineering analysis and innovation
SDG 12	Responsible Consumption and Production	Optimization of resources

Course Code: MT22001
Course Title: Introduction to Probability & Statistics

Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

Students will be able to articulate and describe:

1 . Analysis of the outcome a random experiment and numerical probability

2. Sample space, Probability axioms, Conditional probability,

3. Poisson theorem, Interchangeable events and their limiting properties

4. Convergence of a sequence of random variables

Course Outcomes:

After completing this course the students will be able to:

CO1: Remember the Algebra of sets, Fields and Sigma fields

CO2: Understand the Conditional probability and probability distribution

CO3: Apply the Poisson theorem, Interchangeable events and their limiting properties

CO4: Analyze the Convergence of a sequence of random variables

CO5: Evaluate the problems based on statistics, regression and correlation.

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	–	2	5	–	–	–	–	–	–	–	–	3	1	1	1	2
CO2	–	3	–	2	–	--	–	–	–	–	–	–	3	2	1	2	2
CO3	–	3	–	2	–	–	–	–	–	–	–	–	2	3	2	2	2
CO4	–	2	–	–	–	–	–	–	–	–	–	–	2	3	2	3	2
CO5	–	2	–	–	–	–	–	–	–	–	–	–	2	3	3	3	3

Core Syllabus:

UNIT-I: Probability Theory and Random Variables (11 Classroom contact Hours)

Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function

UNIT-II: Probability Distributions and Joint Distributions (12 Classroom contact Hours)

Discrete distributions: uniform, binomial, Poisson, geometric, negative binomial, continuous distributions: uniform, normal, exponential. Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions

UNIT-III: Bivariate Random Variables and Correlation(11 Classroom contact Hours)

Expectation of function of two random variables, conditional expectations, independent random variables, bivariate normal distribution, correlation coefficient, joint moment generating function (jmgf) and calculation of covariance (from jmgf)

UNIT-IV: Regression, Limit Theorems, and Markov Chains(11 Classroom contact Hours)

linear regression for two variables. Chebyshev's inequality, statement and interpretation of (weak) law of large numbers and strong law of large numbers, Central Limit theorem for independent and identically distributed random variables with finite variance, Markov Chains, Chapman-Kolmogorov equations, classification of states.

Tutorial:-30 Hours

Recommended Learning Resources

Textbook:

1. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia, 2007.

Reference Books:

1. Irwin Miller and Marylees Miller, John E. Freund, Mathematical Statistics with Applications, 7th Ed., Pearson Education, Asia, 2006.

2. Sheldon Ross, Introduction to Probability Models, 9th Ed., Academic Press, Indian Reprint, 2007.

3. Alexander M. Mood, Franklin A. Graybill and Duane C. Boes, Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw- Hill, Reprint 2007

4..https://onlinecourses.nptel.ac.in/noc24_ma39/preview

SDG:

SDG	Title	Contribution
3	Good Health & Well-being	Biostatistics, risk and uncertainty
4	Quality Education	Statistical and probabilistic literacy
9	Industry, Innovation & Infra	Analytics skills for data-driven innovation
10	Reduced Inequalities	Tools to measure inequality and social gaps
13	Climate Action	Probabilistic and statistical climate modelling

Course Code: MT23001
Course Title: Mathematics and its Impact on Life
Total Credits: 03 (Credits: Theory-02, Tutorial-01)
Total Lectures: Theory- 30 and Tutorial-30

Course Objectives:

Students will be able to articulate and describe

1 .Different types of sets.
2. Sub set, Super set, power set and operations of set.
3. Equation and its types and relation between roots.
4. Matrix and types of matrices and their operation

Course Outcomes:

After completing this course the students will be able to

CO1: Remember the concepts of set and complex number.

CO2: Understand the operations on sets

CO3: Apply different types of equations and their roots.

CO4: Analyze matrices, their inverse and cofactors.

CO5: Evaluate the different problems relating set theory, complex numbers, matrices

CO-PO-PSO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	–	2	2	–	–	–	–	–	–	–	–	3	1	1	1	2
CO2	–	3	–	2	--	--	–	–	–	–	–	–	3	2	1	2	2
CO3	–	3	–	2	–	–	–	–	–	–	–	–	2	3	2	2	2
CO4	–	2	–	–	–	–	–	–	–	–	–	–	2	3	2	3	2
CO5	–	2	–	–	–	–	–	–	–	–	–	–	2	3	3	3	3

Course Contents:

UNIT-I: Set Theory (07 Classroom contact Hours)

Set Theory: Introduction to sets and their representations. The empty set, finite and infinite sets, equal sets, subsets, power set, and Universal set. Venn Diagrams, operations on sets, complement of a set, problems on union and intersection of sets.

UNIT-II: Complex Numbers and Theory of Equations(08 Classroom contact Hours)

Complex Numbers Polar representation of complex numbers. De Moivre's theorem (without proof) for rational indices and their applications. Introduction and definition of equation. Types of equations. Relation between roots and coefficients.

UNIT-III: Theory of Equations and Matrices(07 Classroom contact Hours)

Descartes' rule of signs. Linear and quadratic equations and their solution. Nature of the roots of quadratic equations. Definition of a Matrix. Types of Matrices. Elementary operations on Matrices. Determinant of a square matrix (up to third order).

UNIT-IV: Determinants, Inverse of Matrices, and System of Linear Equations(08 Classroom contact Hours)

Properties of determinants. Cofactors and minor of a determinant Transpose and Adjoint of a matrix. Symmetric and Skew Symmetric Matrices .Inverse of a matrix. Solution of system of linear equations(up to third order) using matrix inversion method and Cramer's Rule.

Tutorial:-22 hours

Recommended Learning Resources

Textbook:

1. A.Kumar, S.Kumaresan, B.K.Sarma ,A Foundation Course in Mathematics, Narosa Publishing House.

Reference Books:

1. A.Kumar, S.Kumaresan, B.K.Sarma ,A Foundation Course in Mathematics, Narosa Publishing House.
2. Bernard and Child: Higher Algebra, Arihant Publications.
3. Stewart, D.Tall,The Foundations of Mathematics. Oxford University Press.
4. M.K.Sen, S.Ghoshand P.Mukhopadhyay, Topics in Abstract Algebra, University Press.
5. K.B.Dutta, Matrix and Linear Algebra, Prentice-Hall of India Pvt. Ltd.

SDG:

SDG	Title	Contribution
3	Good Health & Well-being	Mathematics supports health-related decision making

4	Quality Education	Mathematics builds logical thinking and lifelong learning skills
9	Industry, Innovation & Infra	Analytics skills for data-driven innovation
10	Reduced Inequalities	Data analysis supports fair policy decisions
13	Climate Action	Mathematical tools aid climate understanding

Communicative English

Level 200

Code	Course Title	Credit	L-T-P
AE24001	Communicative English	2	2-0-0

Refer to UG syllabus of English Department

Course Code: CS25001
Course Title: Prompt Engineering and AI Tools
Total Credits: 03 (Credits: Theory-02, Practical-01)
Total Lectures: Theory- 34 and Practical -22

Course Objective:

1. To equip students with the skills to **design**, **develop**, and **optimize** prompts for AI tools, enabling them to **solve complex problems** and **apply critical thinking**.
2. The course will **enhance analytical reasoning**, **research-related skills**, and **digital literacy**, while promoting **cooperative teamwork**, **leadership readiness**, **multicultural competence**, and **effective communication skills**.
3. It also aims to in stil **environmental awareness**, **sustainability**, and the principles of **autonomy**, **responsibility**, **accountability**, and **self-directed lifelong learning**.

Course Outcomes:

After completing this course the students will be able to

CO1: Remember effective prompts for various AI applications, demonstrating **complex problem-solving and critical thinking.**.

CO2: Understand the performance of AI tools in response to different prompts, showcasing **analytical reasoning** and **research-related skills**.

CO3: Analyze in diverse teams to **create** innovative AI solutions, reflecting **cooperative teamwork** and **leadership readiness**.

CO4: Apply the intricacies of prompt engineering effectively, both orally and in writing, enhancing **communication skills**.

CO5: **Evaluate** AI tools that are **inclusive**, **sustainable**, and **environmentally aware**, promoting **autonomy** and **self-directed learning**

Course Duration: 34 hours

Course Syllabus:

Unit 1: Introduction to Prompt Engineering (7 Classroom contact Hours)

Fundamentals of AI and machine learning, The role of prompts in AI interactions, Basic techniques for prompt engineering

Unit 2: Advanced Prompt Design (7 Classroom contact Hours)

Designing prompts for complex tasks, Optimization strategies for prompt effectiveness, Case studies of successful prompt engineering

Unit 3: AI Tools and Technologies (7 Classroom contact Hours)

Overview of current AI tools and platforms, Integration of AI tools with prompt engineering, Ethical considerations in AI tool deployment

Unit 4: Prompt Engineering for Language Models (7 Classroom contact Hours)

Techniques for natural language processing (NLP), Crafting prompts for language generation and understanding, Evaluating language model responses

Unit 5: Capstone Projects and Future Directions (6 Classroom contact Hours)

Hands-on projects with real-world AI applications, Emerging trends in prompt engineering and AI tools, Future challenges and opportunities in the field

List of 20 Exercises(22 hours)

1. Create a basic prompt for a chatbot interaction
2. Optimize a prompt for better user engagement
3. Analyze the effectiveness of prompts in a given scenario
4. Design a prompt for a language translation task
5. Evaluate the response quality of different AI models
6. Develop a prompt for an image recognition task
7. Integrate an AI tool with a custom prompt system
8. Craft prompts for sentiment analysis
9. Implement a prompt-based recommendation system
10. Create a series of prompts for a storytelling AI
11. Optimize prompts for diverse cultural contexts
12. Design a user study to test prompt clarity
13. Develop a prompt for an environmental sustainability app
14. Analyze the bias in AI responses to prompts
15. Create a prompt for a self-learning AI application
16. Develop a prompt for a problem-solving AI
17. Craft a prompt for a creative writing AI tool
18. Evaluate the ethical implications of prompt engineering
19. Design a prompt for an AI-based educational tool
20. Create a capstone project proposal for a novel AI application

Textbook:

1. "Prompt Engineering for Generative AI" by James Phoenix, Mike Taylor O'Reilly Media, Inc.

Reference Books:

1. Kore, Akshay. Designing Human-Centric AI Experiences. Jan. 2022, https://doi.org/10.1007/978-1-4842-8088-1.
2. "Natural Language Processing in Action" by Lane, Howard, and Hapke

SDG Mapping for this Course

SDG No.	SDG Title	Nature of Contribution
SDG 4	Quality Education	AI-supported learning and content creation
SDG 8	Decent Work and Economic Growth	Future-ready skills in AI-augmented workplaces
SDG 9	Industry, Innovation and Infrastructure	Applied generative AI for innovation
SDG 12	Responsible Consumption and Production	Responsible, ethical AI tool usage
SDG 16	Peace, Justice and Strong Institutions	Critical literacy around AI, misinformation

SEMESTER – IV

Paper Code	Paper Name	Credits	L-T-P
MT20002	Multivariate Calculus	4	3-1-0
MT20004	Ordinary Differential Equation	4	3-1-0
MT20006	Elements of Number Theory	4	3-1-0
SE20082	Seminar	2	2-0-0
MT22002	Linear Algebra	4	3-1-0
AE24002	Professional Communication	2	2-0-0

COURSE CODE-MT20002

COURSE TITLE- Multivariate Calculus

Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

Students will be able to articulate and describe:

1 . The concept of continuity of a function

2. Gradient, divergence and double integration

3. Concept of double integral, triple integral

4. Green's theorem and stokes theorem.

Course Outcomes:

After completing this course the students will be able to:

CO1: Remember the concept of Vector Spaces, Subspaces

CO2: Understand the concept of partial differentiation

CO3: Apply the sufficient condition of differentiability

CO4: Analyze the directional derivatives of function

CO-5: Evaluate the problems relating to double integrals, surface integrals.

CO-PO-PSO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	–	3	–	1	–	–	–	–	–	–	–	–	3	1	1	1	2
CO2	–	3	–	2	–	--	–	–	–	–	–	–	3	2	1	2	2
CO3	–	3	–	3	–	2	–	–	–	–	–	–	2	3	2	2	2
CO4	–	3	–	3	–	2	–	–	–	–	–	–	2	3	2	3	2
CO5	–	3	–	3	–	2	–	–	–	–	–	–	2	3	3	3	3

Course Contents:

UNIT-I: Functions of Several Variables and Partial Differentiation(12 Classroom contact Hours)

Functions of several variables, limit and continuity of functions of two variables, Partial differentiation, total differentiability and differentiability, sufficient condition for differentiability. Chain rule for one and two independent parameters, directional derivatives,

UNIT-II: Multiple Integrals and Vector Fields (11 Classroom contact Hours)

The gradient, maximal and normal property of the gradient, tangent planes, Extrema of functions of two variables, method of Lagrange multipliers, constrained optimization

problems, Definition of vector field, divergence and curl Double integration over rectangular region, double integration over non-rectangular region,

UNIT-III: Triple Integrals, Coordinate Transformations, and Line Integrals (11 Classroom contact Hours)

Double integrals in polar co-ordinates, Triple integrals, Triple integral over a parallelepiped and solid regions. Volume by triple integrals, cylindrical and spherical co-ordinates. Change of variables in double integrals and triple integrals. Line integrals, Applications of line integral Mass and Work.

UNIT-IV: Vector Integral Theorem (11 Classroom contact Hours)

Fundamental theorem for line integrals, conservative vector fields, independence of path Green's theorem, surface integrals, integrals over parametrically defined surfaces. Stoke's theorem, The Divergence theorem.

Tutorial:-30 hours

Recommended Learning Resources

Textbook:

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005

Reference Books:

1. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), Delhi, 2007.
2. E. Marsden, A.J. Tromba and A. Weinstein, Basic Multivariable Calculus, Springer (SIE), Indian reprint, 2005.
3. James Stewart, Multivariable Calculus, Concepts and Contexts, 2nd Ed., Brooks /Cole, Thomson Learning, USA, 2001.

SDG Mapping

SDG	Title	Contribution
4	Quality Education	Develops analytical, logical, and problem-solving skills
7	Affordable and Clean Energy	Used in energy flow and optimization
9	Industry, Innovation and Infrastructure	Foundation for engineering and technological innovation
12	Responsible Consumption and Production	Resource optimization

Course Code: MT20004

Course Title: Ordinary Differential Equation
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

Students will be able to articulate and describe

1 . Differential Equations, order and degree
2. First and second second Order differential Equations
3. Solution of differential equations
4. System of Linear Differential Equations

Course Outcomes:

After completing this course the students will be able to

CO1: Remember the concepts, nature and significance of Differential equations

CO2: Understand Parameters defining ordinary differential equations and its solutions

CO3: Apply existence and uniqueness of solutions of differential equation

CO4: Analyze the system of differential equations.

CO5: Evaluate the problems based on ordinary differential equations.

CO-PO-PSO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	–	3	–	1	–	–	–	–	2	–	–	–	3	1	1	1	2
CO2	–	3	–	2	--	--	–	–	2	–	–	–	3	2	1	2	2
CO3	–	3	–	3	–	–	–	–	2	–	–	–	2	3	2	2	2
CO4	–	3	–	3	–	–	–	–	2	–	–	–	2	3	2	3	2
CO5	–	3	–	3	–	–	–	–	2	–	–	–	2	3	3	3	3

Course Inputs:

UNIT-I : **First-Order and Second-Order Differential Equations (12 Classroom contact Hours)**

Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Variable separable equations and equations reducible to this form, Exact differential equations and integrating factors, Linear equation and Bernoulli equations, special integrating factors and transformations.Second order Linear Differential Equations:- General solution, Using a known solution to find the other,

Homogeneous equations with constant coefficients, Inverse operator method, Method of variation of parameters, Power series solution and special functions.

UNIT-II: **Mathematical Modelling, Oscillation Theory and Boundary Value Problems (11 Classroom contact Hours)**

Introduction to compartmental model, exponential decay model, lake pollution model (case study of Lake Burley Griffin), drug assimilation into the blood (case of a single cold pill, case of a course of cold pills), exponential growth of population, limited growth of population, limited growth with harvesting.Oscillations of second Order Equations*:* Fundamental Results, Sturm's Comparison theorem, Hille- wintner theorem, Oscillations of $x''+a(t)x=0$. Boundary Value Problems*:* Introduction, Strum Liouville Problem, Green's functions, Picard's theorem.

UNIT-III: **Higher-Order Differential Equations, Existence and Uniqueness of Solutions (11 Classroom contact Hours)**

General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation.Existence and Uniqueness of Solutions*:* Successive approximations, Picard's Theorem, Non Uniqueness of solutions, Continuation and dependence on initial conditions, Existence of solutions in the large, Existence and uniqueness of solution of systems.

UNIT-IV: Methods of Solution, Dynamical Systems and Systems of Differential Equations (11 Classroom contact Hours)

Method of undetermined coefficients, Method of variation of parameters. Equilibrium points, Interpretation of the phase plane, predatory-prey model and its analysis, epidemic model of influenza and its analysis, battle model and its analysis System of Linear Differential Equations*:* System of first order equations, Existence and Uniqueness theorems, Fundamental Matrix, Homogeneous and Non Homogeneous linear systems with constant Co-efficient, linear system with periodic Co-efficient.

Tutorial:-30 hours

Recommended Learning Resources

Textbook:

1. G. F. Simmons, Differential Equations with Applications, McGraw Hill International Edition, 1991.

Reference Books:

1. S. G. Deo and V. Raghavendra, Ordinary Differential Equations and stability theory, TATA Mc Graw Hill Ltd, 1980. Chapter 2 (Quick Review) 4,5,6,7.

2. G. Birkhoff and G. C. Rota-Ordinary Differential Equations-John Wiley and Sons, N.Y., 1989.
3. Coddington and Levinson, Theory of Ordinary Differential Equations, Krieger Pub Co (June 1984)
4. Tyn-Myint-U Ordinary Differential Equations, Elsevier North-Holland, 1987.
5. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004

6..https://onlinecourses.swayam2.ac.in/cec24_ma09/preview

SDG Mapping

SDG	Title	Contribution
4	Quality Education	Strengthens mathematical foundation essential for engineering, science, and research.
8	Decent Work and Economic Growth	Financial growth/decay models, market demand modeling using differential equations.
9	Industry, Innovation and Infrastructure	Engineering system modeling, control systems, and industrial process analysis using ODEs.
3	Good Health and Well-being	Modelling spread of diseases (epidemics), drug dosage, and biomedical systems using ODEs

COURSE CODE-MT20006
COURSE TITLE-ELEMENTS OF NUMBER THEORY
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:
Students will be able to articulate and describe:
1. The basics of Number Theory, Arithmetic Function,
2. Basic concepts of Distribution of Prime Number, Euler's phi-function
3.Understanding Brief sketch of an elementary proof of the prime number theorem
4. The Chinese remainder theorem and linear congruences.

Course Outcomes:

After completing this course the students will be able to:

CO1: Remember the definition of Linear Diophantine equation , prime counting function,
CO2: Understand the Averages of arithmetical functions
CO3: Apply the Brief sketch of an elementary proof of the prime number theorem,
CO4:Analyze the greatest integer function, Euler's phi-function, Euler's theorem,

CO5: Evaluate the problems relating to arithmetical functions and Euler's phi-function

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	1	–	–	–	–	1	–	–	–	3	1	1	1	2
CO2	–	3	–	2	--	--	–	–	1	–	–	–	3	2	1	2	2
CO3	–	3	–	3	–	–	–	–	1	–	–	–	2	3	2	2	2
CO4	–	3	–	3	–	–	–	–	1	–	–	–	2	3	2	3	2
CO5	–	3	–	3	–	–	–	–	1	–	–	–	2	3	3	3	3

Course Inputs:.

UNIT-I: Prime Numbers, Congruence's and Classical Number Theory (12 Classroom contact Hours)

Linear Diophantine equation , prime counting function, Statement of prime number theorem, Goldbach conjecture, linear congruence's, complete set of residues, Chinese Remainder theorem, Fermat's Little theorem, Wilson's theorem.

UNIT-II: Arithmetic Functions and Möbius Inversion (11 Classroom contact Hours)

Number theoretic functions, s um and number of divisors, totally multiplicative functions, definition and properties of the Dirichlet product, the Mobius Inversion formula,

Unit-III: Euler's Phi Function, Residue Systems and Primitive Roots (11 Classroom contact Hours)

The greatest integer function, Euler's phi-function, Euler's theorem, reduced set of residues, some properties of Euler's phi-function. Order of an integer modulo n, primitive roots for primes

Unit-IV: Quadratic Residues, Cryptography and Diophantine Equations (11 Classroom contact Hours)

Composite numbers having primitive roots, Euler's criterion, the Legendre symbol and its properties, quadratic reciprocity, quadratic congruence's with composite moduli. Public key encryption, RSA encryption and decryption, the equation $x^2 + y^2 = z^2$, Fermat's Last theorem.
Tutorial:-30 hours

Recommended Learning Resources

Textbook:

1. Introduction to Analytic Number Theory, T. M. Apostol, Springer-Verlag, New York, 1976.

Reference Books:

1. Elements of Number Theory: Exploring the Anatomy of Integers, Jean-Marie De Koninck, Florian Luca, American Mathematical Society, 2012

2. A Primer of Analytic Number Theory: From Pythagoras to Riemann, Jeffrey Stopple, Cambridge University Press, 2003.

SDG Mapping

SDG	Title	Contribution
4	Quality Education	Develops **logical reasoning, analytical thinking, and proof skills**
9	Industry, Innovation and Infrastructure	Prime numbers and Euler's theorem are foundational for **digital infrastructure and secure communication systems**.
10	Reduced Inequalities	Universal access to mathematical knowledge promotes **equitable education**.
16	Peace, Justice and Strong Institutions	Cryptographic applications strengthen **secure governance, digital identity, and transparent institutions**

COURSE CODE-MT22002

COURSE TITLE-LINEAR ALGEBRA

Total Credits: 04 (Credits: Theory-03, Tutorial-01)

Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

Students will be able to articulate and describe:

1 . The concept of Vector Spaces, Subspaces

2. Solution of System of Linear equations

3. Concept of Eigen values and Eigen vectors

4. Different canonical forms with examples

Course Outcomes:

After completing this course the students will be able to:

CO1: Remember the concept of Vector Spaces, Subspaces

CO2: Understand the System of Linear equations, Characteristic roots

CO3: Apply the Diagonal forms, triangular forms, Jordan form, Quadratic form

CO4: Analyze the Euclidean space, unitary space

CO-5: Evaluate the roots and of the system of linear equations

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	–	2	–	–	–	–	–	–	–	–	3	1	1	1	2
CO2	3	3	–	2	–	--	–	–	–	–	–	–	3	2	1	2	2
CO3	2	3	–	2	–	–	–	–	–	2	–	–	2	3	2	2	2
CO4	2	2	–	2	–	2	2	–	–	–	2	–	2	3	2	3	2
CO5	2	2	–	2	–	2	2	–	–	–	–	2	2	3	3	3	3

Core Syllabus:

Unit - I : **Vector Spaces, Linear Transformations and Matrix Algebra (12 Classroom contact Hours)**

Vector Spaces, Subspaces, Linear independence, bases, Dimension, Projection, Quotient spaces, Isomorphism of vector spaces, Algebra of matrices, Rank and Inverse of matrix, The Algebra of Linear transformation, Kernel, range, matrix representation of a linear transformation, Change of bases.

Unit -II: Linear Systems, Eigen values, Modules and Canonical Forms (11 Classroom contact Hours)

System of Linear equations, Characteristic roots and Vectors, eigen values, eigen vectors, Cayley- Hamillton theorem, Annihilator, Modules, finitely generated module. Canonical forms .Canonical Forms: Diagonal forms, triangular forms, Jordan form, Quadratic form, Inner Product spaces.

Unit-III: Jordan Canonical Form, Rational Canonical Form and Inner Product Spaces(11 Classroom contact Hours)

Canonical forms .Canonical Forms: Diagonal forms, triangular forms, Jordan form, Quadratic form, Inner Product spaces, Nilpotent transforms, Index of nilpotent, A decomposition of V. Jordan form, Rational canonical form.

Unit-IV: **Euclidean and Unitary Spaces, Orthogonality and Linear Operators (11 Classroom contact Hours)**

Euclidean space, unitary space, Cauchy –Schwartz inequality, orthogonal set, Orthogonal complement, orthogonal projection ,Bessel's inequality, Linear functional and adjoints, Linear operators, Unitary operator and Normal operators

Tutorial:-30 Hours

Recommended Learning Resources

Textbook:

1. A. Ramachandra Rao and P. Bhimsankaram. Linear Algebra, Hindustan Book Agency; 2nd Revised Edition (15 May 2000)

Reference Books:

1. S. Kumaresan-Linear Algebra, Prentice Hall India Learning Private Limited; New title Edition (2000).
2. P.P. Halmos - Finite Dimensional Vector Spaces, Springer; 1st ed. 1958. Corr. 2nd printing 1993 edition (August 20, 1993)
3. I. N. Herstein - Topics in Algebra , John Wiley and Sons; 2nd Revised edition Edition, 1975.
4. J. B. Farleigh-A first Course in Algebra, Pearson, 7th Ed., 2013.
5. J. Gallian - Contemporary Abstract algebra, Brooks/Cole Pub Co; 8 edition (13 July 2012).

SDG Mapping

SDG	Title	Contribution
4	Quality Education	Abstract thinking and modeling capacity
9	Industry, Innovation and Infrastructure	Mathematical base for advanced CS/AI
13	Climate Action	Tools for modeling complex environmental systems

Professional Communication

Level 200

Code	Course Title	Credit	L-T-P
AE24002	Professional Communication	2	2-0-0

Refer to UG syllabus of English Department

SEMESTER –V (With Single Major)

Paper Code	Paper Name	Credits	L-T-P
MT30001	Metric Spaces and Complex Analysis	4	3-1-0
MT30003	Operations Research	4	3-1-0
MT30005	Abstract Algebra	4	3-1-0
MT30007	Differential Geometry	4	3-1-0
MT32001	Logic and Boolean Algebra	4	3-1-0
IP37081	Internship	2	0-0-2

Course Code: MT30001
Course Title: Metric Space and Complex Analysis
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

Students will be able to articulate and describe:

1. Meaning of Metric Space.
2. Different types of Metric Spaces.
3. Understand the meaning of mappings.
4. Meaning of Complex numbers and the properties of Analytic function
5. Understand complex integration and its properties.

Course Outcomes:

After completing this course the students will be able to:

CO1: Remember the definition of metric space and complex number.

CO2: Understand the Concept Of complex integration.

CO3: Apply Cauchy's integral theorem.

CO4:Analyze the use of Cauchy's theorem.

CO-5: Evaluate the problems relating to metric space and complex integration

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	1	–	–	–	–	1	–	–	–	3	1	1	1	2
CO2	–	3	–	2	--	--	–	–	1	–	–	–	3	2	1	2	2
CO3	–	3	–	3	–	–	–	–	1	–	–	–	2	3	2	2	2
CO4	–	3	–	3	–	–	–	–	1	–	–	–	2	3	2	3	2
CO5	–	3	–	3	–	–	–	–	1	–	–	–	2	3	3	3	3

Course Contents:

UNIT-I Metric Spaces and Topological Properties (12 Classroom contact Hours)

Definition and examples. Sequences in metric spaces, Cauchy sequences. Complete Metric Spaces. Open and closed balls, neighborhood, open set, interior of a set. Limit point of a set, closed set, diameter of a set, Cantor's theorem. Subspaces, dense sets, separable spaces.

UNIT-II Continuity, Fixed Point Theorems and Connectedness (11 Classroom contact Hours)

Continuous mappings, sequential criterion and other characterizations of continuity. Uniform continuity. Homeomorphism, Contraction mappings, Banach Fixed point Theorem, Connectedness, connected subsets of R. Limits, Limits involving the point at infinity, continuity.

UNIT-III Complex Functions and Analyticity (11 Classroom contact Hours)
Properties of complex numbers, regions in the complex plane, functions of complex variable, mappings. Derivatives, differentiation formulas, Cauchy-Riemann equations, sufficient conditions for differentiability. Analytic functions, examples of analytic functions, exponential function, Logarithmic function, trigonometric function, derivatives of functions,

UNIT-IV Complex Integration, Series Expansions and Fundamental Theorems (11 Classroom contact Hours)
Definite integrals of functions. Contours, Contour integrals and its examples, upper bounds for moduli of contour integrals. Cauchy Goursat theorem, Cauchy integral formula. Liouville's theorem and the fundamental theorem of algebra. Convergence of sequences and series, Taylor series and its examples. Laurent series and its examples, absolute and uniform convergence of power series.

Tutorial:30 hours

Recommended Learning Resources

Textbook:

1 G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 2004.

Reference Books:

1.Satish Shirali and Harikishan L. Vasudeva, Metric Spaces, Springer Verlag, London, 2006.

2. S. Kumaresan, Topology of Metric Spaces, 2nd Ed., Narosa Publishing House, 2011.

3. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, 8th Ed., McGraw – Hill International Edition, 2009.

4. Joseph Bak and Donald J. Newman, Complex Analysis, 2nd Ed., Undergraduate Texts in Mathematics, Springer-Verlag New York, Inc., NewYork, 1997.

SDG Mapping

SDG	Title	Contribution
4	Quality Education	Core software development competence
8	Decent Work and Economic Growth	Employability in Java-based ecosystems
9	Industry, Innovation and Infra	Foundation for enterprise applications

Course Code: MT30003
Course Title: Operations Research
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:
Students will be able to articulate and describe:

1 .To solve the industrial problems to students with various methods of solving Linear Programming Problems
2. Dual simplex method with justifications and its applications
3. Sensitivity Analysis, variation in cost and requirement vectors
4. Game Theory, Two persons zero sum game

Course Outcomes:

After completing this course the students will be able to:

CO1: Remember the Mathematical formulation of LPP and methods of solving with examples

CO2: Understand the Dual simplex method and method of solving the dual problems.

CO3: Apply the Basics of Sensitivity Analysis

CO4: Analyze the Game theory with examples

CO5: Evaluate the Dynamic Programming problems and the related examples .

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	1	–	–	–	–	1	–	–	–	3	1	1	1	2
CO2	–	3	–	2	–	--	–	–	1	–	–	–	3	2	1	2	2
CO3	–	3	–	3	–	–	–	–	1	–	–	–	2	3	2	2	2
CO4	–	3	–	3	–	–	–	–	1	–	–	–	2	3	2	3	2
CO5	–	3	–	3	–	–	–	–	1	–	–	–	2	3	3	3	3

Course Inputs:

Unit-I: Linear Programming Problem and Simplex Methods (12 Classroom contact Hours)
Introduction to LPP, Mathematical formulation, Standard form and canonical form, Graphical solution, Simplex Method including Big-M and two phase method, Degeneracy and Revised simplex method.

Unit-II: Duality, Dual Simplex Method and Sensitivity Analysis (11 Classroom contact Hours)
Dual simplex method with justifications, Duality in Linear Programming, Duality Theorems, Fundamental Theorem of Duality, Introduction to Sensitivity Analysis, v ariation in cost and requirement vectors, coefficient matrix and applications,

Unit-III: Parametric Programming and Game Theory (11 Classroom contact Hours)
Parametric Programming Problems. Game Theory, Two persons zero sum game, Maxmin Minimax principle, Mixed strategy, Graphical solutions, Dominance Property, Arithmetic Method and general solution.

Unit-IV: Transportation, Assignment and Dynamic Programming (11 Classroom contact Hours)

Transportation and Assignment algorithms, Dynamic Programming: Principle of optimality, Reliability of system series, height of projectile, cargo-loading problem, inventory problem.

Tutorial:-30 hours

Recommended Learning Resources

Textbook:

1 G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill, 2004.

Reference Books:

1. N. S. Kambo (1991) : Mathematical Programming Tech., Affiliated East- West press.
2. G. Hadley (1987): Linear Programming
3. H. A. Taha (l992) :.Operations Research, 5th Ed. (McMillan)
4. P. Rama Murty, Operations Research, New Age International, 2nd Edition (2007).
5. F. S. Hillier, G. J. Lieberman, Introduction to Operations Research, McGraw-Hill International, 9th Edition.
6. K. Swarup, Operations Research, Sultan Chand & Sons, 12th Edition.
7.https://onlinecourses.swayam2.ac.in/cec24_ma05/preview

SDG Mapping

SDG	Title	Contribution
4	Quality Education	Develops **analytical thinking, modeling, and decision-making skills**
8	Decent Work and Economic Growth	OR techniques improve **productivity, efficiency, and profitability**
9	Industry, Innovation and Infra	Supports **optimization of industrial systems**, supply chains, and infrastructure planning.
12	Responsible Consumption/Production	Minimizes **waste, cost, and resource usage** through optimal planning and scheduling.

Course Code: MT30005
Course Title: Abstract Algebra
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

Students will be able to articulate and describe:

1. .Different algebraic structures like Groups, Subgroups, and special types of groups.
2. . Algebraic structures like ring, types of rings with their properties
3. . Algebraic structures like field and its properties

4. . Some important results with their applications.

.**Course Outcomes**:

After completing this course the students will be able to:

CO1: Remember the concepts, nature and significance of different algebraic structures

CO2: Understand Parameters defining group, ring and field theory

CO3: Apply some important results like Sylow's Theorems

CO4: Analyze Some results on roots of polynomials

CO5: Evaluate the different problems relating to the theorems.

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	1	–	–	–	–	1	–	–	–	3	1	1	1	2
CO2	–	3	–	2	–	--	–	–	1	–	–	–	3	2	1	2	2
CO3	–	3	–	3	–	–	–	–	1	–	–	–	2	3	2	2	2
CO4	–	3	–	3	–	–	–	–	1	–	–	–	2	3	2	3	2
CO5	–	3	–	3	–	–	–	–	1	–	–	–	2	3	3	3	3

Course Inputs:

Unit - I : Group Theory: Basic Concepts and Group Homeomorphisms(12 Classroom contact Hours)

Groups, Subgroups, Permutation group, Dihedral group, Cayley's Theorem, Direct product of groups, cyclic group, Normal subgroup, Quotient group, Homomorphism, Isomorphism.

Unit-II : Advanced Group Theory and Sylow Theorems(11 Classroom contact Hours)

Finitely generated Abelian group, free abelian groups, Commutator group, and Simple group, Series of groups, Group action on a set, Sylow's theorems and applications.

Unit - III : Ring Theory and Polynomial Rings(11 Classroom contact Hours)

Ring, Integral domain, Characteristic of an Integral domain, Homomorphism, Isomorphism, Ideals, Maximal ideal, Prime ideal, Quotient rings. Euclidean rings, Gaussian integers, Polynomial rings, Principal ideal domain, unique factorization domain,

Unit - IV: Module Theory and Introduction to Galois Theory(11 Classroom contact Hours)

Modules, Sub modules, Quotient modules, Direct Sums. The elements of Galois Theory, Solvability by Radicals, Galois groups over the Rationals .Extension of Fields, Transcendence of e, Roots of polynomials, construction with straightedge & compass, more about roots.

Tutorial:-30 hours

Recommended Learning Resources

Textbook:

1.Topics in Algebra, I.N. Herstein, Wiley India Pvt. Ltd, 2nd Edition, 2006..

Reference Books:

1.Contemporary Abstract Algebra, Joseph A. Gillian, Cengage Learning, 9th Edition, 2017.
2.Topics in Algebra, S. Nanda, Allied Publishers, New Delhi.
3.A First Course on Abstract Algebra, John B. Fraleigh, 7th Edition, 2008.
4. https://swayam.gov.in/explorer?searchText=ABSTRACT+ALGEBRA

SDG Mapping

SDG	Title	Contribution
4	Quality Education	Develops **analytical thinking, abstract reasoning, and logical problem-solving**.
9	Industry, Innovation and Infrastructure	Algebraic structures form the mathematical foundation for **innovations in secure communications, error-correcting codes, and computational systems**.
10	Reduced Inequalities	Promotes **equitable access to mathematical reasoning and problem-solving skills**.
16	Peace, Justice, and Strong Institutions	pplication of abstract algebra in cryptography and secure digital systems supports **fair and transparent systems**, contributing to strong institutions.

Course Code-MT30007
Course Title-Differential Geometry (Credits-4)
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

Students will be able to articulate and describe:

1. The basics of calculus in Rn, local theory of curves and surfaces
2. Basic concepts of Differential manifolds, Sub manifolds

3. Understanding Dual space, tensor of type (r.s), Operations with tensors
4. Riemann Curvature tensor and properties

Course Outcomes:

After completing this course the students will be able to:

CO1: Remember the definition of calculus in Rn, local theory of curves and surfaces
CO2: Understand the concepts of Differential manifolds, Sub manifolds
CO3: Apply the Dual space, tensor of type (r.s), Operations with tensors
CO4:Analyze the Riemann Curvature tensor and its properties

CO5: Evaluate the problems based on dual space and differential manifolds

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	1	–	–	–	–	1	–	–	–	3	1	1	1	2
CO2	–	3	–	2	--	--	–	–	1	–	–	–	3	2	1	2	2
CO3	–	3	–	3	–	–	–	–	1	–	–	–	2	3	2	2	2
CO4	–	3	–	3	–	–	–	–	1	–	–	–	2	3	2	3	2
CO5	–	3	–	3	–	–	–	–	1	–	–	–	2	3	3	3	3

Course Inputs:

Unit-I : Differential Geometry of Curves and Surfaces(12 Classroom contact Hours)
Theory of Space Curves: Space curves, Planer curves, Curvature, torsion and Serret-Frenet formulae. Osculating circles, Osculating circles and spheres. Existence of space curves. Evolutes and involutes of curves. Theory of Surfaces: Parametric curves onsurfaces. Review of calculus in Rn , Inverse and implicit function theorem, Rank theorem. Review of local theory of curves and surfaces, Serret Frenet formula, First fundamental forms, second fundamental form, Normal curvature, Geodesic curvature, Gauss formula, , Weingarten map, principal curvatures, Gaussian curvature, mean curvature , motivation of global theory, Gauss Bonnet formulae.

Unit-II : **Surface Theory, Manifolds and Lie Groups(11 Classroom contact Hours)**
Direction coefficients. First and second Fundamental forms. Principal and Gaussian curvatures. Lines of curvature, Euler's theorem. Rodrigue's formula, Conjugate and Asymptotic lines. Developables: Developable associated with space curves and curveson Introduction to Manifolds, Differential manifolds, Examples, Sub manifolds, Tangent vector and tangent space at a point of the manifold, cotangent spaces, vector fields, Lie bracket, Lie algebra, Definition and example of Lie groups, Integration on manifolds, Stoke's theorem

Unit-III : **Geodesics, Tensor Algebra and Differential Forms(11 Classroom contact Hours)**

Minimal surfaces. Geodesics: Canonical geodesic equations. Nature of geodesics on a surface of revolution. Clairaut's theorem. Normal property of geodesics. Torsion of a geodesic. Geodesic curvature. Gauss-Bonnet theorem. Surfaces of constant curvature. Conformal mapping. Geodesic mapping. Tissot's theorem. Tensors: Summation convention and indicial notation,Multi linear Algebra: Dual space, tensor of type(r.s), Operations with tensors, contractions, quotient law of tensors, metric tensor, associated tensors, symmetric and Anti symmetric tensors, Exterior forms, Wedge product , Exterior Algebra, Exterior derivative, Exact forms, Closed forms.

Unit-IV : **Riemannian Geometry and Tensor Analysis(11 Classroom contact Hours)**

Coordinate transformation and Jacobian, Contra-variant and Covariant vectors, Tensors of different type, Algebra of tensors and contraction, Metric tensor and 3-index Christoffel symbols, Parallel propagation of vectors, Covariant and intrinsic derivatives, Curvature tensor and its properties, Curl, Divergence and Laplacian operators in tensor form, Physical components Affine connection of manifolds, parallel transport, Intrinsic derivative, covariant derivative, curvature tensor, Riemannian metric, Riemannian manifold, Fundamental theorem of Riemannian Geometry, Levi Civita Connection, Riemann Curvature tensor and properties, Bianchi identities, Scalar curvature, applications to relativity.

Tutorial:-30 hours

Recommended Learning Resources

Textbook:

.1. T.J. Willmore, An Introduction to Differential Geometry, Dover Publications, 2012.

Reference Books:

1 . B. O'Neill, Elementary Differential Geometry, 2nd Ed., Academic Press, 2006.

2. C.E. Weatherburn, Differential Geometry of Three Dimensions, Cambridge University Press 2003.

3. D.J. Struik, Lectures on Classical Differential Geometry, Dover Publications, 1988.

4. S. Lang, Fundamentals of Differential Geometry, Springer, 1999.

5. B. Spain, Tensor Calculus: A Concise Course, Dover Publications, 2003

SDG Mapping

SDG	Title	Contribution
4	Quality Education	Develops **critical thinking, abstract reasoning, and advanced problem-solving skills**

8	Decent Work and Economic Growth	Supports careers in **data science, computer graphics, robotics, physics, and engineering**.
9	Industry, Innovation and Infra	Differential geometry underpins **modeling in computer graphics, structural engineering, robotics, and navigation systems**, promoting innovation.

Course Code: MT32001
Course Title: Logic and Boolean Algebra
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

Students will be able to articulate and describe

1. Statement, Negation, Conjuction, Disjunction, Implication and Double implication.
2. Logical equivalences, quantifiers, lattices
3. Boolean algebra, different methods
4. Some important results with their applications.

Course Outcomes:

After completing this course the students will be able to

CO1: Remember the concepts of Statement, Negation, Conjuction Disjunction, Implication and Double implication.

CO2: Understand Logical equivalences, quantifiers, lattices

CO3: Apply some important results on Boolean algebra, different methods

CO-4: AnalyzeSome results on roots Negation, Conjuction , Implication and Double implication.

CO-5: Evaluate the different problems relating to Logic and Boolean algebra.

CO-PO-PSO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	2	–	2	2	–	–	–	–	–	–	1	3	1	1	1	2
CO2	3	3	–	3	2	--	–	–	–	–	–	1	3	2	1	2	2
CO3	3	3	–	3	2	2	–	–	–	1	–	2	2	3	2	2	2
CO4	3	3	–	3	2	2	–	–	–	2	–	2	2	3	2	3	2

CO5	3	3	–	3	2	2	–	–	–	3	–	2	2	3	3	3	3

Course Syllabus:

UNIT-I: Propositional Logic and Logical Connectives(12 Classroom contact Hours)

Introduction, propositions, truth table, negation, conjunction and disjunction.Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators.

UNIT-II: Logical Equivalence, Predicates and Quantifiers(11 Classroom contact Hours)

Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.

UNIT-III: Partially Ordered Sets and Lattice Theory(11 Classroom contact Hours)

Definition, examples and basic properties of ordered sets, maps between ordered sets, duality principle, lattices as ordered sets, lattices as algebraic structures, sub lattices, products and homomorphisms.

UNIT-IV: Boolean Algebra and Switching Circuits(11 Classroom contact Hours)

Definition, examples and properties of modular and distributive lattices, Boolean algebras, Boolean polynomials, minimal forms of Boolean polynomials, Quinn-McCluskey method, Karnaugh diagrams, switching circuits and applications of switching circuits.

Tutorial:-30 hours

Recommended Learning Resources

Textbook:

1. BA.Davey and H.A.Priestley, Introduction to Lattices and Order, Cambridge University Press, Cambridge, 1990.

Reference Books:

1.EdgarG.Goodaire and Michael M.Parmenter, Discrete Mathematics with Graph Theory, (2nd Ed.), Pearson Education (Singapore) P.Ltd., Indian Reprint 2003.

2. Rudolf Lid land Günter Pilz, Applied Abstract Algebra,2ndEd.,UndergraduateTextsin Mathematics, Springer (SIE), Indian reprint, 2004.

3. H.R. Lewis,C.H. Papadimitriou,C.Papadimitriou,Elements of the Theory of Computation, 2nd Ed., Prentice-Hall, NJ, 1997.

SDG Mapping

SDG	Title	Contribution
4	Quality Education	Logical and computational thinking
9	Industry, Innovation & Infra	Digital logic foundation for computing/engineering

16	Peace, Justice & Institutions	Sound logical reasoning in civic/ethical discourse

Course Code: IP37081

Course Title: Internship

Code	Course Title	Credit	L-T-P
IP37081	Internship	2	0-0-2

Course Objectives:

The internship provides students with practical exposure to professional work environments by applying academic knowledge to real-world problems. It develops technical competence, problem-solving ability, communication, teamwork, ethical practices, and project management skills while fostering industry readiness, professional responsibility, lifelong learning, and experiential understanding of organizational practices.

Course Outcomes:

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

- **CO1 (Knowledge/Remember):** Recall and describe the organizational structure, professional practices, workplace ethics, safety regulations, and operational procedures followed in the internship organization.
- **CO2 (Understanding):** Explain and interpret industry requirements, project workflows, organizational processes, professional responsibilities, and the application of theoretical concepts in real-world environments.
- **CO3 (Application):** Apply domain knowledge, technical skills, modern tools, and problem-solving techniques to complete assigned tasks and projects effectively in a professional setting.
- **CO4 (Analysis):** Analyze real-world problems, evaluate alternative solutions, interpret project outcomes, and recommend appropriate improvements based on technical and organizational requirements.
- **CO5 (Synthesis/Evaluation):** Demonstrate professional competence by planning, executing, documenting, and presenting internship work while exhibiting effective communication, teamwork, ethical conduct, project management, and lifelong learning skills.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	
CO1	2	1	-	-	1	-	2	3	1	2	-	-	2	1	-	-	-	
CO2	2	2	1	1	2	2	2	3	2	2	2	2	2	2	1	-	-	
CO3	2	3	3	2	–	2	2	2	3	2	3	2	2	3	2	2	2	
CO4	2	3	2	–	–	3	2	2	2	3	3	2	3	2	2	2	2	
CO5	2	3	3	–	3	3	3	3	3	3	3	3	3	3	3	3	3	

Course Duration: 38 hours

Total Practical / Lab Experiments:[38 Lab Contact Hours]

1. **Internship Orientation and Workplace Induction**
   - Introduction to the organization
   - Workplace policies, ethics, and safety guidelines
   - Understanding organizational structure and work culture
2. **Technical Skill Development**
   - Training on organization-specific software, tools, or technologies
   - Familiarization with development environments, databases, cloud platforms, or hardware (as applicable)
3. **Assignment and Task Execution**
   - Participation in project-related activities
   - Requirement analysis and task planning
   - Problem identification and solution implementation
   - Testing and validation of assigned work
4. **Documentation and Reporting**
   - Maintenance of daily work diary/logbook
   - Weekly progress reports
   - Preparation of technical documentation
5. **Professional Skills Development**
   - Team collaboration
   - Technical communication
   - Time management

- Professional ethics and workplace responsibility

6. **Project Demonstration**
   - Presentation of completed work
   - Demonstration of developed solution or assigned tasks
   - Interaction with industry/faculty mentor
7. **Internship Report and Viva Voce**
   - Submission of internship report
   - Seminar presentation
   - Viva voce examination

Suggested Assessment Scheme

Component	**Weightage (%)**
Industry/Supervisor Evaluation	30
Faculty Mentor Evaluation	20
Daily Logbook and Attendance	15
Internship Report	20
Presentation and Viva Voce	15

SDG Mapping for this Course

SDG	**Title**	**Contribution**
SDG 4	Quality Education	Experiential learning
SDG 8	Decent Work and Economic Growth	Work-readiness, industry exposure
SDG 9	Industry, Innovation and Infra	Understanding real-world systems
SDG 10	Reduced Inequalities	Application in tribal/rural/NGO contexts

SEMESTER – V(With Double Major)

Paper Code	**Paper Name**	**Credits**	**L-T-P**
MT30001	Metric Spaces and Complex Analysis	4	3-1-0
MT30003	Operations Research	4	3-1-0
MT30005	Abstract Algebra-I	4	3-1-0
MT30007	Differential Geometry	4	3-1-0
MT32001	Logic and Boolean Algebra	4	3-1-0

MT32003	Stochastic Calculus	4	3-1-0
MT32005	Advanced Analysis	4	3-1-0
MT32007	Mathematical Programming Using C	4	3-1-0
IP37081	Internship	2	0-0-2

Course Code: MT32003
Course Title: Stochastic Calculus
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

Students will be able to articulate and describe:

1 .Martingales in Discrete times.

2. Basic concepts Brownian motion

3. Stochastic integration

4. Basics concepts of Change of measures and Girsanov's Theorem

Course Outcomes:

After completing this course the students will be able to:

CO1: Remember the martingales in discrete times.

CO2: Understand Structure of Brownian motion

CO3: Apply the Concept of Stochastic integration

CO4: Analyze the Basics and examples of . Stochastic integration

CO5: Evaluate the concept of Change of measures and Girsanov's Theorem

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	1	–	–	–	–	1	–	–	–	3	1	1	1	2
CO2	–	3	–	2	–	--	–	–	1	–	–	–	3	2	1	2	2
CO3	–	3	–	2	–	–	–	–	1	–	–	–	2	3	2	2	2
CO4	–	3	–	3	–	–	–	–	1	–	–	–	2	3	2	3	2
CO5	–	3	–	3	–	–	–	–	1	–	–	–	2	3	3	3	3

Course Inputs:

UNIT-I (Martingales and Stochastic Integration with Random Walks)(11 classroom contact hours)

Conditional expectation , Martingales ,Optional sampling theorem ,Martingale convergence Square integrable martingales ,Integrals with respect to random walk ,A maximal inequality

UNIT-II (Brownian Motion and Limit Theorems))(11 classroom contact hours)

Limits of sums of independent variables ,Multivariate normal distribution ,Limits of random walks ,Brownian motion ,Construction of Brownian motion ,Understanding Brownian motion ,Brownian motion as a continuous martingale ,Brownian motion as a Markov process ,Brownian motion as a Gaussian process ,Brownian motion as a self-similar process ,Computations for Brownian motion ,Quadratic variation ,Multidimensional Brownian motion

UNIT-III (Stochastic Integration and Itô Calculus) (11 classroom contact hours)

Stochastic integral ,Review of Riemann integration ,Integration of simple processes ,Integration of continuous processes ,Itˆo's formula ,More versions of Itˆo's formula ,Diffusions ,Covariation and the product rule .

UNIT-IV (Advanced Martingale Theory and Financial Applications) (12 classroom contact hours)

Martingales and local martingales ,An example: the Bessel process ,Feynman-Kac formula , Binomial approximations ,Continuous martingales . Absolutely continuous measures ,Giving drift to a Brownian motion ,Girsanov theorem ,Black-Scholes formula ,Martingale approach to Black-Schole's equation ,Martingale approach to pricing ,Martingale representation theorem

Recommended Learning Resources

Text book:

[1] I. Karatzas and S. E. Shreve, Brownian motion and stochastic calculus, 2nd ed., Graduate Texts in Mathematics, vol. 113, Springer-Verlag, New York, 1991. MR1121940 (92h:60127)
[2] B. Øksendal, Stochastic differential equations, 6th ed., Universitext, Springer-Verlag, Berlin, 2003. An introduction with applications. MR2001996 (2004e:60102)

Reference Book:

[1] H. Kunita, Stochastic flows and stochastic differential equations, Cambridge Studies in Advanced Mathematics, vol. 24, Cambridge University Press, Cambridge, 1997. Reprint of the 1990 original. MR1472487 (98e:60096)
[2] A. Friedman, Stochastic differential equations and applications, Dover Publications Inc., Mineola, NY, 2006. Two volumes bound as one; Reprint of the 1975 and 1976 original published in two volumes. MR2295424 (2007k:60005)
[3] L. C. G. Rogers and D. Williams, Diffusions, Markov processes, and martingales. Vol. 1, Cambridge Mathematical Library, Cambridge University Press, Cambridge, 2000. Foundations; Reprint of the second (1994) edition. MR1796539 (2001g:60188)
[4] L. C. G. Rogers and D. Williams, Diffusions, Markov processes, and martingales. Vol. 2, Cambridge Mathematical Library, Cambridge University Press, Cambridge, 2000. Itˆo calculus; Reprint of the second (1994) edition. MR1780932 (2001g:60189)

CODE-MT32005

COURSE TITLE- Advanced Analysis

Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

Course Learning Objectives: Students will be able to articulate and describe:

1. Some vital parts of analysis such as Integration of vector valued functions
2. Basic concepts of Fourier series, Riemann integral and types of measures
3. Understanding Measureable Sets and Lebesgue measure,
4. The Rieman Integral, The Lebesgue integral of a bounded function

Course Outcomes:

After completing this course the students will be able to:

CO1: Remember the Integration of vector valued functions

CO2: Understand concepts of Fourier series, Riemann integral and types of measures

CO3: Apply the Basic properties of harmonic functions, harmonic functions on a disk

CO4: Analyze The Rieman Integral, The Lebesgue integral of a bounded function.

CO5: Evaluate The Rieman Integral, The Lebesgue integral of a bounded function

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	1	–	–	–	–	1	–	–	–	3	1	1	1	2
CO2	–	3	–	2	–	--	–	–	1	–	–	–	3	2	1	2	2
CO3	–	3	–	2	–	–	–	–	1	–	–	–	2	3	2	2	2
CO4	–	3	–	3	–	–	–	–	1	–	–	–	2	3	2	3	2
CO5	–	3	–	3	–	–	–	–	1	–	–	–	2	3	3	3	3

Course Inputs:.

Unit-1: (Vector-Valued Functions, Approximation Theory and Fourier Series)

(12 classroom contact hours)

Integration of vector valued functions, rectifiable curves, equi-continuous families of function. The stone Weierstrass theorem , Fourier Series, Orthogonal and Orthonormal system of functions

Unit-II(Fourier Analysis and Harmonic Functions) (12 classroom contact hours)

Bersets inequality, Dirichlet-kernel, point wise convergence of Fourier series ,Approximation theorems, Parseval's theorem**.** Harmonic function, Basic properties of harmonic functions, harmonic functions on a disk.

Unit-III: (Potential Theory, Entire Functions and Introduction to Measure Theory) (12 classroom contact hours)

Dirchlet problem, Green's function, Entire functions, Jensons Formula, Genus and order of an entire function, Hadmard factorization theorem .Outer measure, Lebesgue Measure, Measureable Sets and Lebesgue measure, Non measurable sets, Measureable functions

Unit-IV: (Lebesgue Integration and Measure Spaces) (12 classroom contact hours)

The Rieman Integral, The Lebesgue integral of a bounded function , The general Lebesgue integral,Measure spaces, Measureable functions, Integration, General convergence theorems

Unit-V:

Advanced Measure Theory and L_p-Spaces
(12 classroom contact hours)

Signed measures, The Lp-spaces, Outer measure and measurability , The extension theorem The Lebesgue Stieltjes integral, Product measures.

Recommended Learning Resources

Text book:

1.Principles of Mathematical Analysis –W.Rudin 3rd edition

.2. Royden, H. L. Real Analysis, (Prentice Hall, 1988)

Reference Books:

1.D. Smith, M. Eggen and R. ST. Andre, A transition to Advanced Mathematics, (Brooks Cole, 2004)

2. Seymour Lipschutz, Set Theory and Related Topics, (McGraw Hill, 1964)

3. Frankel, A. Abstract Set theory, (North Holland Publishing Co., 1961)

4. Suppes, P. Axiomatic Set Theory, (Dover Publications Inc.,May 1973)

5. Halmos, P. R. Naive Set Theory, (Springer, 1974)

6. Halmos, P. R. Measure Theory, (Springer, 1974)

7. Rudin, W. Real and Complex Analysis, (McGraw-Hill Higher Education, 1987)

Note: Latest edition of the text books should be used.

SDG Mapping

SDG	Title	Contribution
4	Quality Education	Prepares students for **advanced Research in mathematics, physics, engineering, and finance**.
9	Industry, Innovation & Infra	Fourier and harmonic analysis underpin **technological innovations** in communications, image processing, and computational engineering..
16	Peace, Justice & Institutions	Fosters **objective reasoning, transparency, and evidence-based decision-making** through rigorous mathematical modeling..

COURSE CODE-MT32007
COURSE TITLE: Mathematical Programming Using C
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Objectives:

Students will be able to articulate and describe:

1 . Introduce the fundamentals of programming using the C language.

2. Develop algorithmic thinking and problem-solving skills for mathematical applications

3. Apply C programming to solve mathematical and numerical problems

4.. Implement algorithms for matrix operations, numerical methods, and statistical computations.

5 . Enable students to use C programming for computational mathematics and scientific computing.

Course Learning Outcomes:

After completing this course the students will be able to:

CO1: Remember the Computer Fundamentals, Evolution of Programming Languages, Structure of C program

CO2: Understand the syntax, structure, and programming constructs of C

CO3: Apply theConcept of Opps, C++, Class and Objects, Principle of Object Oriented Programming language

CO4: Analyze the Basics and examples Function Overloading.

CO5: Evaluate the different programming languages and their structures

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	1	–	–	–	–	2	–	–	–	3	1	1	1	2
CO2	–	3	–	2	--	--	–	–	2	–	–	–	3	2	1	2	2
CO3	–	3	–	3	–	–	–	–	3	–	–	–	2	3	2	2	2
CO4	–	3	–	3	–	–	–	–	2	–	–	–	2	3	2	3	2
CO5	–	3	–	3	–	–	–	–	2	–	–	–	2	3	3	3	3

Course Inputs:

UNIT-I Fundamentals of C Programming (12 classroom contact hours)

Introduction to computers and programming, Algorithms and flowcharts, Structure of a C program Character set, tokens, identifiers, keywords, Variables, constants, data types ,Input and output functions Operators and expressions, Decision-making statements (if, if-else, switch)Iterative statements (for, while, do-while)

UNIT-II Functions, Arrays and Strings (11 classroom contact hours)

User-defined functions Function prototypes Recursion One-dimensional and two-dimensional arrays Matrix representation String handling Storage classes

Mathematical Applications: Matrix addition, Matrix multiplication, Matrix transposes, Determinant of a matrix Polynomial evaluation

UNIT-III Pointers, Structures and File Handling (11 classroom contact hours)

Pointers, Pointer arithmetic, dynamic memory allocation, Structures, Arrays of structures File handling, Reading and writing files

Mathematical Applications: Student data processing, Statistical data storage, Reading numerical data from files, writing computational results to file

UNIT-IV Mathematical Programming Applications (11 classroom contact hours)

Numerical computation using C , Approximation of roots (Bisection and Newton–Raphson methods) , Numerical integration (Trapezoidal and Simpson's rules) , Solution of linear equations (Gaussian Elimination) , Mean, variance, and standard deviation , Random number generation, Introduction to computational modelling

Suggested Readings:

1. E. Balaguruswamy, The C Programming Language, TMH.
2. E. Balaguruswamy, The C++ Programming Language, TMH.
3. B.W. Kernighan, Dennis M. Ritchie, The C Programming Language, PHI/Pearson Education, 2 edition (1990)
5. Bjarne Stroustrup,The C++ Programming Languages, Addison-Wesley Professional, 4th ed., 2013.

PROGRAMMING LAB-

The candidates should be able to do the following Programmes by using C Languages.

1. Write a program to find the solutions of a Quadratic equation.
2. Write a program to find the addition of two matrices.
3. Write a program to find the Fibonacci series.
4. Write a program to find the GCD and LCM of two numbers.
5. Write a program to test a number is prime or not.
6. Write a program to find the transpose of a matrix.
7. Write a program to find the area of a circle.
8. Write a program to find the area of an ellipse.
9. Write a program to arrange some numbers in ascending order.
10. Write a program to multiply two matrices.
11. Write a program to find the sum of diagonal elements of a matrix.
12. Write a program to find the Factorial of a number.
13. Write a program to find the Surface area of a sphere.
14. Write a program to find the sum of digits of a number.
15. Write a program to find the Volume of a Cone.
16. Write a program to find the Volume of a Sphere.
17. Write a program to check a number is a palindrome or not.
18. Write a program to find Surface area of a Prism.
19. Write a program to calculate the Product of two complex numbers.
20. Write a program to find the Exponential series.
21. Write a program to find the Pascal Triangle.
22. Write a program to find the Sine series and Cosine series.
23. Write a program to find all factors of a number

SDG Mapping

SDG	Title	Contribution

4	Quality Education	Builds foundational programming skills, Encourages problem-solving and logical thinking, Supports life-long learning in computing
9	Industry, Innovation & Infra	C is widely used in embedded systems, OS, and industrial applications..
8	Decent Work & Economic Growth	Prepares students for software development , jobs, Enhances employability in IT and core sectors

SEMESTER – VI (With Single Major)

Paper Code	Paper Name	Credits	L-T-P
MT30002	Probability and Statistics	4	3-1-0
MT30004	Analytical Number Theory	4	3-1-0
MT30006	Graph Theory	4	3-1-0
MT30008	Optimization Techniques	4	3-1-0
MT32002	Numerical Analysis	4	3-0-1

COURSE CODE- MT30002
COURSE TITLE: Probability and statistics
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

Students will be able to articulate and describe:

1 . Analysis of the outcome a random experiment and numerical probability

2. Sample space, Probability axioms, Conditional probability,

3. Poisson theorem, Interchangeable events and their limiting properties

4. Convergence of a sequence of random variables,

Course Outcomes:

After completing this course the students will be able to:

CO1: Remember the probability axioms and distribution functions

CO2: Understand the Conditional probability and probability distribution

CO3: Apply the Poisson theorem, Interchangeable events and their limiting properties

CO4: Analyze the Convergence of a sequence of random variables

CO5: Evaluate the problems based on statistics, regression and correlation.

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	1	–	–	–	–	1	–	–	–	3	1	1	1	2
CO2	–	3	–	2	--	--	–	–	2	–	–	–	3	2	1	2	2
CO3	–	3	–	3	–	–	–	–	2	–	–	–	2	3	2	2	2
CO4	–	2	–	3	–	–	–	–	2	–	–	–	2	3	2	3	2
CO5	–	3	–	3	–	–	–	–	2	–	–	–	2	3	3	3	3

Course Inputs:

UNIT-I: Probability Theory and Random Variables(12 classroom contact hours)

Sample space, probability axioms, real random variables (discrete and continuous), cumulative distribution function, probability mass/density functions, mathematical expectation, moments, moment generating function, characteristic function,

UNIT-II: Probability Distributions and Joint Random Variables(11 classroom contact hours)

Discrete distributions: uniform, binomial, Poisson, geometric, negative binomial, continuous distributions: uniform, normal, exponential. Joint cumulative distribution function and its properties, joint probability density functions, marginal and conditional distributions,

UNIT-III: Bivariate Distributions, Conditional Expectation and Correlation(11 classroom contact hours)

Expectation of function of two random variables, conditional expectations, independent random variables, bivariate normal distribution, correlation coefficient, joint moment generating function (jmgf) and calculation of covariance (from jmgf),

UNIT-IV: Regression and Markov Chain(11 classroom contact hours)

linear regression for two variables. Chebyshev's inequality, statement and interpretation of (weak) law of large numbers and strong law of large numbers, Central Limit theorem for independent and identically distributed random variables with finite variance, Markov Chains, Chapman-Kolmogorov equations, classification of states.

Tutorial:-30 hours

Recommended Learning Resources

Textbook:

1. Robert V. Hogg, Joseph W. McKean and Allen T. Craig, Introduction to Mathematical Statistics, Pearson Education, Asia, 2007.

Reference Books:

1. Irwin Miller and Marylees Miller, John E. Freund, Mathematical Statistics with Applications, 7th Ed., Pearson Education, Asia, 2006.

2. Sheldon Ross, Introduction to Probability Models, 9th Ed., Academic Press, Indian Reprint, 2007.

3. Alexander M. Mood, Franklin A. Graybill and Duane C. Boes, Introduction to the Theory of Statistics, 3rd Ed., Tata McGraw- Hill, Reprint 2007

5. Suppes, P. Axiomatic Set Theory, (Dover Publications Inc.,May 1973)

6. Halmos, P. R. Naive Set Theory, (Springer, 1974)

7. Halmos, P. R. Measure Theory, (Springer, 1974)

8. Rudin, W. Real and Complex Analysis, (McGraw-Hill Higher Education, 1987)

Note: Latest edition of the text books should be used.

SDG Mapping

SDG	Title	Contribution
4	Quality Education	Builds analytical thinking and strong mathematical foundations
9	Industry, Innovation and Infra	Statistical modeling supports engineering, manufacturing, and R&D
8	Decent Work & Economic Growth	Prepares students for data driven decision making roles
11	Sustainable Cities/Communities	Data analysis for urban planning, traffic, and resource optimization

Course Code: MT30004
Course Title: Analytic Number Theory
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

1. Students will be able to articulate and describe:
2. 1. The basics of Analytic Number Theory, Arithmetic Function,
3. 2. Basic concepts of Distribution of Prime Number, Riemann Zeta function and work of Ramanujam

4. **3.** Understanding Brief sketch of an elementary proof of the prime number theorem
5. 4. The Riemann zeta function and the L-function.

Course Outcomes:

After completing this course the students will be able to:

CO1: Remember the concepts of arithmetical Functions and Dirichlet Multiplications

CO2: Understand the averages of arithmetical functions.

CO3: Apply the brief sketch of an elementary proof of the prime number theorem

CO4: Analyze the Riemann zeta function and the L-function

CO5: Evaluate the different areas of number theory.

CO-PO-PSO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	–	3	–	1	–	–	–	–	1	–	–	–	3	1	1	1	2
CO2	–	3	–	2	--	--	–	–	1	–	–	–	3	2	1	2	2
CO3	–	3	–	3	–	–	–	–	2	–	–	–	2	3	2	2	2
CO4	–	2	–	3	–	–	–	–	2	–	–	–	2	3	2	3	2
CO5	–	3	–	3	–	–	–	–	3	–	–	–	2	3	1	3	1

Course Inputs:

UNIT-I : Arithmetical Functions and Dirichlet Multiplications(10 classroom contact hours)

The arithmetical functions and their relations, The Dirichlet product of arithmetical functions, Dirichlet inverses and Mobius inversion formula, Multiplicative functions, The Bell series of an arithmetical function and Dirichlet multiplications, Derivatives of arithmetical functions, The Selberg identity, The big oh notation, Euler's summation formula, Some elementary asymptotic formulas.

UNIT-II : Averages of arithmetical functions (12 classroom contact hours)

The average order of divisor functions, The average order of Euler totient function, The average order of Mobious and Mangoldt functions, The partial sums of a Dirichlet product,

Applications to the Mobius and Mangoldt functions. Some elementary theorems on distribution of prime numbers: Chebyshev's functions and their relations with (x) (The number of primes less than or equal to x), Some equivalent forms of the prime number theorem, Shapiro Tauberian theorem, The partial sums of the Mobius function.

Unit-III: Brief sketch of an elementary proof of the prime number theorem (12 classroom contact hours)

Functions periodic modulo k, Existence of finite Fourier series for periodic arithmetical functions, Ramanujan's sum and generalizations, The half-plane of absolute convergence of a Dirichlet series, Euler products, Analytic properties of Dirichlet series, Mean value formulas for Dirichlet series, An integral formulas for the coefficients and the partial sums of a Dirichlet series

Unit-IV: The Riemann zeta function and the L-function: (11 classroom contact hours)

Properties of the gamma function, Integral representation for the Hurwitz zeta function, Analytic continuation of the Hurwitz zeta function, Analytic continuation of the Riemann zeta function and the L-function, The functional equation for the Riemann zeta function, Properties of Bernoulli numbers and Bernoulli polynomials.

Tutorial:-30 hours

Recommended Learning Resources

Textbook:

1. . Introduction to Analytic Number Theory, T. M. Apostol, Springer-Verlag, New York, 1976.

Reference Books:

1. Analytic Number Theory: Exploring the Anatomy of Integers, Jean-Marie De Koninck, Florian Luca, American Mathematical Society, 2012

2. A Primer of Analytic Number Theory: From Pythagoras to Riemann, Jeffrey Stopple, Cambridge University Press, 2003.

Note: Latest edition of the text books should be used.

SDG Mapping

SDG	Title	Contribution
4	Quality Education	Develops advanced mathematical reasoning, proof techniques, and analytical thinking
9	Industry/Innovation	Supports innovation in cryptography, secure systems, and computational mathematics

Course Code: MT30006

Course Title: Graph Theory

Total Credits: 04 (Credits: Theory-03, Tutorial-01)

Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

Students will be able to articulate and describe:

1 . The concept of model networking problems in physical and biological sciences

2. Application to social media, linguistics, chemical bonds, computational neuro science, market and financial analysis, communication system, data organisation, flows and links

3. Concept of Graphs and Digraphs, Trees

4. Concept of Eulerian Graphs, Planar Graphs

5. Concept of Matching and Factorizations

Course Outcomes:

After completing this course the students will be able to:

CO1: Learn and understand the concept of Graphs and Digraphs

CO2: Understand concept of Trees

CO3: Understand concept of Eulerian Graphs

CO4: Understand concept of Planar Graphs

CO5: Understand the concept of Matching and Factorizations

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	1	–	–	–	–	–	–	–	–	3	2	1	1	2
CO2	–	3	–	2	–	1	–	1	–	–	–	–	3	2	1	2	2

CO3	–	3	–	3	–	2	–	2	–	–	–	–	2	1	2	2	2
CO4	–	2	–	3	–	2	–	2	–	–	–	–	2	3	2	3	2
CO5	–	3	–	3	–	2	–	2	–	–	–	–	2	1	1	3	3

Course Inputs:

Unit – I: Introduction to Graphs and Digraphs (10 Classroom contact hours)

Definitions of some basic terms, representation of graphs, Degree Sequence, characterization of graphical sequence; Graph and Matrices

Unit – II: Trees (10 Classroom contact hours)

Characterizations, Minimum Spanning Trees, counting of trees; Paths and distance in Graphs: Basic Definitions, center and median of Graphs, activity digraphs and critical paths

Unit – III: Eulerian Graphs (10 classroom contact hours)

Characterization, Chinese postman problem; Hamiltonian Graphs: Necessary conditions, sufficient conditions,

Unit – IV: Planar Graphs (10 classroom contact hours)

Properties, Characterization; Graph Coloring: vertex coloring, chromatic polynomials, edge coloring, planar graph coloring, total coloring

Unit – V: Matching and Factorizations (10 classroom contact hours)

Maximum matching in bipartite graphs, maximum matching in general graphs, Hall's marriage theorem, factorization Networks: The Max-flow min-cut theorem, max-flow algorithm, connectivity and edge connectivity, Menger's theorem..

Recommended Learning Resources

Textbook:

1. D.B. West, Introduction to Graph Theory,2nd Edition,2002.

Reference Books:.

1.John Clark and D.A .Holton A First Look at Graph Theory , World Scientific and Allied Publisher

SDG Mapping

SDG	Title	Contribution
8	Decent Work & Economic Growth	Prepares students for careers in **network analysis, algorithms, and optimization**
4	Quality Education	Develops analytical thinking, logical reasoning, and mathematical problem-solving
9	Industry, Innovation and Infra	Graph theory underpins **transport networks, communication systems, and industrial planning**
11	Sustainable Cities & Communities	Graph algorithms contribute to **urban planning, traffic management, and efficient resource allocation**
16	Peace, Justice & Strong Institutions	Enables secure and reliable network systems, ethical use of connectivity and communication networks

Course Code: MT30008
Course Title: Optimization Techniques
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Learning Objectives:

1. Students will be able to articulate and describe:
2. Basic concepts of Markov process, transition matrix,
3. Basic concepts of Inventory decision, cost associated with inventory
4. Basic concepts of Queuing system, Operating characteristic,
5. The concept of NLPP with constrained optimization

Course Outcomes:

After completing this course the students will be able to:

CO1: Learn and understand concept of Markov process

CO2: Understand basic concepts of Inventory decision, cost associated with inventory

CO3: Understand basic concepts of Queuing system, Operating characteristic

CO4: Understand the concept of NLPP with constrained optimization,

CO5: Evaluate the optimization techniques

CO-PO –PSO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	–	3	–	2	–	–	–	–	2	–	–	–	3	1	1	1	2
CO2	–	3	–	3	–	1	–	1	2	–	–	–	3	2	1	2	2
CO3	–	3	–	3	–	2	–	2	3	–	–	–	2	3	2	2	2
CO4	–	2	–	3	–	2	–	2	3	–	–	–	2	3	2	3	2
CO5	–	3	–	3	–	2	–	2	3	–	–	–	2	3	1	3	1

Course Inputs:

Unit-I : **Markov Analysis and Network theory(10 Classroom contact hours)**

Markov process, transition matrix, transition diagram, construction of transition matrix, n- step transition prob. Equilibrium condition, Markov analysis algorithm, Nerwork Scheduling by PERT/CPM.

Unit-II : **Inventory Theory(12 Classroom contact hours)**

Inventory decision, cost associated with inventory, Factors affecting inventories, EOQ, Deterministic inventories with no shortage and with shortage, inventory with uncertain demand, System of inventory control, Probabilistic inventory problems.

Unit-III : Queuing Theory(12 Classroom contact hours)

Queuing system, Operating characteristic, probability distribution, Classification of queuing models, Transient and Steady state, Poisson and Non-Poisson Queuing 35 System, Cost model in queuing, Queuing control, Queuing Theory and Inventory control.

Unit-IV: Non linear programming problem(11 Classroom contact hours)

Formulation of Non Linear programming, Constrained optimization. with equal- ity constraint and inequality constraint, Saddle point and NLLP. Graphical solution, Kuhn- Tucker conditions, Quadratic Programming,Wolfes' and Beales' method.

Tutorial;-30 hours

Recommended Learning Resources

Textbook:

1. S. S. Rao, *Engineering Optimization: Theory and Practice*, John Wiley & Sons, 4th Edition, 2009.

Reference Books:.

1. Kambo.,NS : Mathemetical Pro.gramming Tech., Affiliated East- West press,1991.

2. Hadley, G. , Linear Programming, Narosa, 1987.

Note: Latest edition of the text books should be used.

SDG Mapping

SDG	Title	Contribution
8	Decent Work & Economic Growth	Prepares students for careers in **operations research, supply chain, logistics, and industrial optimization**
4	Quality Education	Develops analytical thinking, decision-making, and mathematical modeling skills
9	Industry, Innovation and Infra	Optimization techniques support **efficient industrial processes and innovative solutions**
11	Sustainable Cities & Communities	Queuing and inventory models contribute to **urban planning, transport, and public service efficiency**

Course Code-MT32002
Course Title- Numerical Analysis
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical -30

Course Objective:

Students will be able to articulate and describe:

1. Calculation of error and approximation is a necessity in all real life, industrial and scientific computing.
2. Various methods of finding solution of different type of problems such as locating roots of equations.
3. Solution of nonlinear equations, systems of linear equations, differential equations,
4. Evaluate approximate Eigen values by using different methods.

Course Outcomes:
After completing this course the students will be able to:

CO1: Analyse and understand Iteration methods based on first degree equations

CO2: Understand Lagrange and Newton interpolations, Finite differences

CO3: Understand Methods based on Interpolation, Methods based on Finite Differentials

CO4: Understand Numerical Solution of system of linear equations

CO5: Evaluate the Numerical techniques.

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	–	–	3	3	2	–	–	2	1	–	2	3	1	1	1	2
CO2	3	3	2	3	3	2	–	1	2	2	–	2	3	2	1	2	2
CO3	3	3	2	3	3	2	–	2	3	2	–	2	2	3	2	2	2
CO4	3	2	2	3	3	2	–	2	3	2	–	2	2	3	2	3	2
CO5	–	3	2	3	3	2	–	2	3	3	–	2	2	3	1	3	1

Course Syllabus:

UNIT-I: Algorithms, Convergence, Errors(11 classroom contact hours)

Relative, Absolute, Round off, Truncation. Transcendental and Polynomial equations: Bisection method, Newton's method, Secant method. Rate of convergence of these methods.

UNIT-II: System of linear algebraic equations(11 classroom contact hours)

Gaussian Elimination and Gauss Jordan methods. Gauss Jacobi method, Gauss Seidel method and their convergence analysis. Interpolation: Lagrange and Newton's methods. Error bounds.

UNIT-III: Finite difference operators. (12 classroom contact hours)

Gregory forward and backward difference interpolation. Numerical Integration: Trapezoidal rule, Simpson's rule, Simpsons 3/8th rule.

UNIT-IV: Numerical Integration(11 classroom contact hours)

Midpoint rule, Composite Trapezoidal rule, Composite Simpson's rule.

List of Practicals (using any software)(Flow chart) (30 classroom contact hours)

(iv) Calculate the sum 1/1 + 1/2 + 1/3 + 1/4 + ----------+ 1/ N.

(v) To find the absolute value of an integer.
(vi) Enter 100 integers into an array and sort them in an ascending order.

(iv) Bisection Method.

V) Newton Raphson Method.

(vi) Secant Method.

(vii) Regulai Falsi Method.

(viii) LU decomposition Method.

(ix) Gauss-Jacobi Method.

(x) SOR Method or Gauss-Siedel Method

(xi) Lagrange Interpolation or Newton Interpolation.

(xii) Simpson's rule.

Note: For any of the CAS (Computer aided software) Data types-simple data types, floating data types, character data types, arithmetic operators and operator precedence, variables and constant declarations, expressions, input/output, relational operators, logical operators and logical expressions, control statements and loop statements, Arrays should be introduced to the students

Textbook:

1 M. K. Jain, S. R. K. Iyengar, and R. K. Jain, *Numerical Methods for Scientific and Engineering Computation*, New Age International Publishers, 7th Edition, 2012.

Reference Books:.

1 .**S. S. Sastry**, *Introductory Methods of Numerical Analysis*, PHI Learning Pvt. Ltd., 5th Edition, 2012.

2.**Richard L. Burden and J. Douglas Faires**, *Numerical Analysis*, Cengage Learning, 10th Edition, 2016.
3.**Kendall E. Atkinson**, *An Introduction to Numerical Analysis*, John Wiley & Sons, 2nd Edition, 1989.

SDG Mapping for this Course

SDG #	SDG Title	Contribution & Relevance
3	Good Health & Well-being	Numerical models in biomedical engineering, dosing, epidemiology
4	Quality Education	Strengthens computational and problem-solving skills of STEM learners

7	Affordable & Clean Energy	Simulation and optimisation of renewable energy systems and grids
9	Industry, Innovation & Infrastructure	Core numerical tools for engineering design and industrial computation
12	Responsible Consumption & Production	Optimisation in supply chains, resource allocation, and waste minimisation
13	Climate Action	Numerical approximation in climate, weather, and environmental impact modelling

SEMESTER – VI(With Double Major)

Paper Code	Paper Name	Credits	L-T-P
MT30002	Probability and Statistics	4	3-1-0
MT30004	Analytical Number Theory	4	3-1-0
MT30006	Graph Theory	4	3-1-0
MT30008	Optimization Techniques	4	3-1-0
MT32002	Numerical Analysis	4	3-1-0
MT32004	Topics in Calculus	4	3-1-0
MT32006	Statistical Methods	4	3-1-0
MT32008	Data Structure for problem solving	4	3-0-1

COURSE CODE-MT32004
COURSE TITLE-TOPICS IN CALCULUS
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

The primary objective of this course is to:

1. Introduce the basic tools of calculus which are helpful in understanding their applications in many real-world problems.
2. Understand/create various mathematical models in everyday life.

Course Outcomes:

This course will enable the students to

CO1: Remember continuity and differentiability in terms of limits and graphs of certain functions.

CO2: Understand asymptotic behaviour in terms of limits involving infinity.

CO3: Apply derivatives to explore the behaviour of a given function locating and classify its Extrema and graphing the function.

CO4: Analyze the concepts of asymptotes, and inflexion points in tracing of Cartesian

curves.

CO5: Evaluate the reduction formulae of standard transcendental functions with applications.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	2	–	–	–	–	–	–	–	–	3	1	1	1	2
CO2	–	3	–	2	–	–	–	–	–	–	–	–	3	2	1	2	2
CO3	–	3	–	3	–	–	–	–	–	–	–	–	2	3	2	2	2
CO4	–	3	–	3	–	–	–	–	–	–	–	–	2	3	2	3	2
CO5	–	3	–	2	–	–	–	–	–	–	–	–	2	3	1	3	1

Course Inputs:

UNIT-I Limits, Continuity and Differentiation (10 classroom contact hours)

Limit of a function, Definition of a limit, continuity of a function, Discontinuities, Differentiability of a function, Successive differentiation: Calculation of the nth derivatives, Leibnitz theorem;

UNIT-II: Partial Differentiation and Mean Value Theorems (10 classroom contact hours)

Partial differentiation, Euler's theorem on homogeneous functions. Rolle 's Theorem, Mean value theorems and applications to monotonic functions and inequalities;

UNIT-III Taylor's Theorem and Series Expansions(10 classroom contact hours)

Taylor's theorem, Taylor's series, Maclaurin's series expansions of e^x, sin$x$, cos$x$, Indeterminate, forms.

UNIT-IV: Curve Tracing and Reduction Formulae(15 classroom contact hours)

Asymptotes (parallel to axes and oblique), Concavity and inflexion points, Singular points, Tangents at the origin and nature of singular points,Curve tracing(cartesian and polar equations).Reduction formulae for their applications.

Textbook:

1. Prasad, Gorakh (2016). Differential Calculus(19thed.).Pothishala Pvt. Ltd. Allahabad

Reference Books:.

1.Prasad, Gorakh (2016). Differential Calculus(19thed.).Pothishala Pvt. Ltd. Allahabad.
2. Prasad, Gorakh(2015). Integral Calculus. Pothishala Pvt. Ltd. Allahabad.
3. Apostol, T. M. (2007). Calculus: One-Variable Calculus with An Introduction to Linear Algebra (2nd ed.). Vol. 1. Wiley India Pvt. Ltd.
4. Ross, Kenneth.A.(2013).Elementary Analysis: The Theory of Calculus(2nded.). Undergraduate Texts in Mathematics, Springer.

SDG Mapping

SDG	Title	Contribution
8	Decent Work & Economic Growth	Prepares students for careers in **engineering, physics, economics, and applied mathematics**
4	Quality Education	Enhances **analytical thinking, problem-solving, and mathematical modeling** skills
9	Industry, Innovation and Infra	Optimization techniques support **efficient industrial processes and innovative solutions**
11	Sustainable Cities & Communities	Calculus supports **modeling, optimization, and engineering design**

Course Code: MT32006
COURSE TITLE-STATISTICAL METHODS
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

The learning objectives include:

1. To know the difference between discrete and continuous random variables.
2. To develop the thinking of students so that they can use the concepts of statistical probability distribution in real life.
3. To understand the concept of random variables, probability distributions and expectation

Course Outcomes:

After completing this course, students should have developed a clear understanding of:

CO1: Remember concept of random variables.

CO2: Understand basic concepts of discrete & continuous random variables.

CO3: Apply Moments generating functions& Cumulative generating functions

CO4 Analyze the concept of joint, marginal and conditional probability distribution for two dimensional random variables and their independence.

CO5: Evaluate discrete probability distributions with their properties. Continuous probability distributions with their properties.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	2	–	–	–	–	–	–	–	–	3	1	1	1	2
CO2	–	3	–	2	–	–	–	–	–	–	–	–	3	2	1	2	2
CO3	–	3	–	3	–	–	–	–	–	–	–	–	2	3	2	2	2
CO4	–	3	–	3	–	–	–	–	–	–	–	–	2	3	2	3	2
CO5	–	3	–	2	–	–	–	–	–	–	–	–	2	3	1	3	1

Course Inputs:-

UNIT-I: Random variables(12 classroom contact hours)

Discrete and continuous random variables, pmf ,pdf and cdf,illustrations of random variables and its properties, expectation of random variable and its properties .Variance, covariance and their properties with illustrations. Moments and cumulants ,moment generating function with properties, cumulants generating function and characteristic function.

UNIT-II: Probability Distribution (11 classroom contact hours)

Bivariate Probability Distribution ,marginal and conditional distributions, independence of variates(only general idea to be given).Transformation in univariate and bivariate distributions.

UNIT-III: Discrete Probability Distributions(11 classroom contact hours)

Binomial, Poisson- measures of central tendency, dispersion, skewness and kurtosis, recurrence relations based on moments, moment generating function, cumulant generating function, characteristic function, additive property ,fitting of distribution and examples.

UNIT-IV*:* Continuous Probability Distribution(11 classroom contact hours)

-Normal-measures of central tendency, dispersion, skewness and kurtosis, recurrence relations based on moments, moment generating function, cumulant generating function, characteristic function, additive property and examples. Exponential distribution – moment generating function and lack of memory. Gamma distribution–moment generating function cumulant generating function and additive property.

Recommended Learning Resources

Textbooks:

1. Gupta, S.C. and Kapoor, V.K. (2020). *Fundamentals of Mathematical Statistics*, 12th Ed., Sultan Chand and Sons.

Reference Materials & Digital Resources

1.Goon, M., Gupta, M.K. and Dasgupta, B. (2003). *An outline of Statistical Theory*, Vol. I, 4th Ed., World Press, Kolkata.

2. Hogg, R. V., McKean, J., and Craig, A. T. (2005). *Introduction to*

mathematical statistics. Pearson Education.
3. Rohtagi, V.K. and Saleh, A.K. Md. E. (2009). *An Introduction to Probability and Statistics*, 2nd Ed., John Wiley and Sons.
4. Ross, S.A. (2007). *Introduction to Probability Models*, 9 Ed., Academic Press
5. Mood, A.M., Graybill, F.A. and Boss, D.C. (2007). *Introduction to the Theory of Statistics*, 3rd Ed., Tata McGraw Hill Publication.

SDG Mapping

SDG	Title	Contribution
8	Decent Work & Economic Growth	Prepares students for careers in **data analytics, finance, insurance, and industrial statistics**
4	Quality Education	Develops analytical thinking, problem-solving, and statistical modeling skills
9	Industry, Innovation and Infra	Supports **process optimization, predictive modeling, and innovation in engineering and business analytics**
11	Sustainable Cities & Communities	Statistical modeling helps in **urban planning, traffic management, and resource allocation**

Course Code: MT32008
Course Title: Data structure for problem solving
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Objectives:

This course introduces fundamental data structures and algorithms used to solve computational and mathematical problems efficiently. Students learn to analyze algorithm performance, implement linear and non-linear data structures, and apply appropriate data structures to real-world problem-solving using the C programming language.

Course Outcomes:

CO1: Remember the concepts of algorithms, abstract data types, and complexity analysis.
CO2: Understand linear data structures such as arrays, linked lists, stacks, and queues.
CO3: Apply trees and graph data structures to solve searching and traversal problems.
CO4: Analyze efficient searching and sorting algorithms
CO5: Evaluate suitable data structure-based solutions for real-world and mathematical applications.

CO-PO-PSO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5

CO1	–	3	–	2	–	–	–	–	–	–	–	–	3	1	1	1	2
CO2	–	3	–	2	–	–	–	–	–	–	–	–	3	2	1	2	2
CO3	–	3	–	3	–	–	–	–	–	–	–	–	2	3	2	2	2
CO4	–	3	–	3	–	–	–	–	–	–	–	–	2	3	2	3	2
CO5	–	3	–	2	–	–	–	–	–	–	–	–	2	3	1	3	1

Course Inputs:

Unit-I : **Introduction to Data Structures and Algorithm Analysis(11 classroom contact hours)**

Introduction to Problem Solving , Algorithms and Flowcharts ,Characteristics of Algorithms, Abstract Data Types (ADT) ,Time and Space Complexity ,Asymptotic Notations: Big-O, Big-Ω, Big-Θ , Arrays: One-dimensional and Two-dimensional Arrays ,Sparse Matrices Applications of Arrays

Unit-II : **Linear Data Structures(12 classroom contact hours)**

Singly Linked List , Doubly Linked List ,Circular Linked List ,Operations: Insertion, Deletion, Traversal, Stack Operations ,Stack using Arrays, Stack using Linked Lists Applications of Stacks ,Expression Conversion (Infix, Prefix, Postfix) ,Parentheses Matching, Linear Queue , Circular Queue , Priority Queue, Deque ,Queue using Linked Lists, Applications of Queues

Unit-III : **Non-linear Data Structures(11 classroom contact hours)**

Tree Terminology, Binary Trees Binary Search Trees, Tree Traversals, Heap , Heap Sort, Applications of Trees, Graph Representation , Adjacency Matrix ,Adjacency List, Breadth First Search (BFS) ,Depth First Search (DFS) , Applications of Graphs

Unit-IV : **Searching, Sorting and Applications (11 classroom contact hours)**

Linear Search, Binary Search, Bubble Sort, Selection Sort, Insertion Sort , Merge Sort ,Quick Sort ,Hash Functions , Collision Resolution Techniques ,Data Structures in Mathematical Computing ,Polynomial Representation ,Sparse Matrix Operations ,Symbol Tables ,Problem Solving Case Studies

Practical(30 hours)

1. Write a program for Linear and Binary Search.
2. Implement Bubble, Selection, and Insertion Sort.
3. Implement Stack using Array.
4. Convert Infix to Postfix Expression.
5. Evaluate a Postfix Expression.
6. Implement Queue and Circular Queue.
7. Create and manipulate Singly and Doubly Linked Lists.
8. Implement Polynomial Addition using Linked Lists.
9. Construct a Binary Search Tree and perform traversals.
10. Perform BFS and DFS on a graph.
11. Implement Dijkstra's shortest path algorithm.
12. Implement Prim's or Kruskal's Minimum Spanning Tree algorithm.

Suggested Readings:

1. M. A. Weiss. Data Structures and Algorithm Analysis in C++ (3rd edition), by Addison-Wesley
2. Alfred V. Aho, Jeffrey D. Ullman, John E. Hopcroft. Data Structures and Algorithms. Addison Wesley, 1983.
3.Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein. Introduction to Algorithms. McGraw-Hill, 2001.
4. Donald E. Knuth. The Art of Computer Programming, Volumes 1-3. Addison-Wesley Professional,.

SDG Mapping

SDG	Title	Contribution
8	Decent Work & Economic Growth	Prepares students for **software development, IT, and data-intensive industrie**
4	Quality Education	Develops analytical thinking, problem-solving, and programming skills
9	Industry, Innovation and Infra	Supports **efficient computation, algorithm design, and technological innovation**
11	Sustainable Cities & Communities	Data structures support applications in **traffic modeling, smart cities, and resource management**

SEMESTER – VII(With single Major)

Paper Code	Paper Name	Credits	L-T-P
MT40001	Advanced Abstract Algebra	4	3-1-0
MT40003	Advanced Real Analysis	4	3-1-0
MT40005	Advanced Differential Equations	4	3-1-0
IK40055	Scientific Research Methods	4	3-1-0
MT42001	Linear Programming	4	3-1-0

Course code-MT40001
Course Title-Advanced Abstract Algebra
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

Students will be able to articulate and describe:

1 .Group automorphism and its properties

2. Algebraic structures like ring, types of rings with their properties

3. Algebraic structures like field and its properties

4. Some important results with their applications.

Course Outcomes:

After completing this course the students will be able to:

CO1: Remember the concepts of group automorphism and its properties

CO2: Understand Parameters defining group, ring and field theory

CO3: Apply some important results like Sylow Theorems

CO4: Analyze Some results on roots of polynomials

CO5: Evaluate the different problems relating to the theorems.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, "_" - No Correlation).*

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	1	–	–	–	–	–	–	–	–	3	1	1	1	2
CO2	–	3	–	2	–	–	–	–	–	–	–	–	3	2	1	2	2
CO3	–	2	–	3	–	3	–	–	–	–	–	–	2	3	2	2	2
CO4	–	2	–	3	–	–	3	–	–	–	–	–	2	3	2	3	2
CO5	–	2	–	3	–	–	–	3	–	–	–	–	2	3	1	3	1

Course Inputs:

Unit - I : Group automorphism and its Properties(10 Classroom contact hours)

Automorphism, inner auto orphism, automorphism groups, automorphism groups of finite andinfinite cyclic groups, applications of factor groups to automorphism groups. Characteristic subgroups. Commutator subgroup and its properties, Properties of external direct products, the group ofunits modulo n as an external direct product, internal direct products, Fundamental Theorem of finite abelian groups

.

Unit-II : Group Actions and its applications(10 Classroom contact hours)

Group actions, stabilizers and kernels, permutation representation associated with a given group action, Application of group actions:

Generalized Cayley's theorem, Index theorem. Groups acting on themselves by conjugation, class equation and consequences, conjugacy in Sn, p – groups, Sylow's theorems and consequences, Cauchy's theorem, Simplicity of An for n ≥ 5,non–simplicity tests

Unit - III: Rings and its properties (09 Classroom contact hours)

Ring, Integral domain, Characteristic of an Integral domain, Homomorphism, Isomorphism, Ideals, Maximal ideal, Prime ideal, Quotient rings.

Unit - IV: Types of Rings (08 Classroom contact hours)

Euclidean rings, Gaussian integers, Polynomial rings, Principal ideal domain, unique factorization domain, Modules, Sub modules, Quotient modules, Direct Sums.

Unit-V: Galois Theory and Field Theory (08 Classroom contact hours)

The elements of Galois Theory, Solvability by Radicals, Galois groups over the Rationals .Extension of Fields, Transcendence of e, Roots of polynomials, construction with straight edge & compass, more about roots.

Tutorial:-30 hours

Recommended Learning Resources

Textbook:

1. Topics in Algebra, I.N. Herstein, Wiley India Pvt. Ltd, 2nd Edition, 2006.
2. Contemporary Abstract Algebra, Joseph A. Gillian, Cengage Learning, 9th Edition, 2017.

Reference Books:

1.Topics in Algebra, S. Nanda, Allied Publishers, New Delhi.

2.A First Course on Abstract Algebra, John B. Fraleigh, 7th Edition, 2008.

SWAYAM Course

SDG Mapping

SDG NO.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Provides advanced conceptual knowledge, logical reasoning, and higher-order thinking skills essential for quality higher education.
SDG 9	Industry, Innovation and Infrastructure	Algebraic structures form the foundation for cryptography, coding theory, and technological innovation.

Course Code: MT40003
Course Title: Advanced Real Analysis

Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives: Students will be able to articulate and describe:

1 .Metric space, sequence and series of functions and its convergence .

2. Continuity, uniform continuity and uniform convergence

3. Functions of several variables, Riemann integrals

4. Lebesgue measure on the line, The L_P spaces,

Course Outcomes:
After completing this course the students will be able to:

CO1: Remember the concepts, nature and significance of Metric spaces

CO2: Understand Parameters defining Reimann integral, Lebesgue measure

CO3: Apply some important results on uniform continuity and uniform convergence

CO4: Analyse some results on The L_P spaces,

CO5: Evaluate the different problems relating to the theorems.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	1	–	–	–	–	–	–	–	–	3	1	1	1	2
CO2	–	3	–	2	–	–	–	–	–	–	–	–	3	2	1	2	2
CO3	–	2	–	3	1	–	–	–	–	–	–	–	2	3	2	2	2
CO4	–	2	–	3	1	–	–	–	–	–	–	–	2	3	2	3	2
CO5	–	2	–	3	1	–	–	–	–	–	–	–	2	3	1	3	1

Course Inputs:

Unit – I: Introduction (09 Classroom contact hours)

Sequences of real numbers, Cauchy sequence, completeness, Bolzano Weierstrass theorem, Heine Borel's theorem, Series, convergence, tests of convergence Metric spaces, open sets,

closed sets, Sequence and series of functions, uniform convergence, Weierstrass M Test, Weierstrass approximation theorem, Continuous functions, Definition and general properties, Uniform continuity, power series, Functions of bounded variation, Differentiation, properties , Mean value theorems, Taylor's theorem

Unit – II: Functions of several variables and Lebesgue measure(10 Classroom contact hours)

Functions of several variables, Differentiation in Rn, Partial derivatives, Directional derivatives, Jacobians, Contraction mapping principle, inverse function theorem, implicit function theorem, Lebesgue measure on the line, Outer measure, measurable sets, Properties of measurable sets, non measurable sets, measurable functions, simple functions, Lebesgue integration of simple and measurable functions, convergence theorems

Unit –III: Integration of vector valued functions (08 Classroom contact hours)

Integration of vector valued functions, rectifiable curves, equi-continuous families of function. The stone Weierstrass theorem, Fourier Series, Orthogonal and Orthonormal system of functions**.** Bersets inequality, Dirichlet-kernel, point wise convergence of Fourier series, Approximation theorems,

Unit –IV: Basic properties of harmonic functions(10 Classroom contact hours)

Almost uniform convergence, Counter examples. Fourier Series. Parseval's theorem Harmonic function, Basic properties of harmonic functions, harmonic functions on a disk. Dirchlet problem, Green's function, Entire functions, Jensons Formula, Genus and order of an entire function, Hadmard factorization theorem

Unit – V: L_P spaces and its properties (07 Classroom contact hours)

The L_P spaces, convex function s, Jensen's inequality of Holder and Murkowski, Completeness of L_p, Convergence in measure, Almost uniform convergence, Counter examples. Fourier Series.

Tutorial:-30 hours

Recommended Learning Resources

Text Books

1. Principles of Mathematical Analysis, Walter Rudin, Mc Graw Hill, 3rd edition, 1976.

2. G.De. Brra – Measure theory and integration (willey Eastern Ltd.),

References

1. S. Nanda and V.P Saxena, Real Analysis, Allied Publishers Pvt. Ltd. New Delhi 1999
2. Real Analysis, H.L. Royden, Prentice Hall of India, New Delhi, 3rd Edition, 1988

SDG Mapping

SDG NO.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Strengthens advanced mathematical understanding, critical thinking, and rigorous proof techniques essential for quality higher education.
SDG 9	Industry, Innovation and Infrastructure	Provides analytical foundations used in scientific modeling, signal processing, data science, and technological innovation..

Course Code: MT40005
Course Title: Advanced Differential Equations
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives: Students will be able to articulate and describe:

1. Second order Linear Differential Equations.
2. Oscillations of second Order Equations
3. Existence and Uniqueness of Solutions
4. System of Linear Differential Equation.

Course Outcomes:

After completing this course the students will be able to:

CO1: Remember the concepts, nature and significance of Differential equations

CO2: Understand Parameters defining ordinary differential equations and its solutions

CO3: Apply existence and uniqueness of solutions of differential equation

CO4: Analyze system of differential equations,

CO5: Evaluate the problems based on ordinary differential equations.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5

CO1	–	3	–	1	–	–	–	–	–	–	–	–	3	1	1	1	2
CO2	–	3	–	2	–	–	–	–	–	–	–	–	3	2	1	2	2
CO3	–	2	–	3	2	–	–	–	–	–	–	–	2	3	2	2	2
CO4	–	2	–	3	2	–	–	–	–	–	–	–	2	3	2	3	2
CO5	–	2	–	3	2	–	–	–	–	–	–	–	2	3	1	3	1

Course Inputs:

Unit I: **Higher order differential equation (12 Classroom contact hours)**

exact Linear Differential Equations of nth order – condition of exactness for a linear equation of order n. Integrating factors. Non-linear differential equation of particular forms-exact non-linear differential equations. Riccati,s Equation, Homogeneous equations.

Unit II: **Boundary Value Problems (11 Classroom contact hours)**

Oscillations of second Order Equations*:* Fundamental Results, Sturm's Comparison theorem, Hille-wintner theorem, Oscillations of $x''+a(t)x=0$. Introduction, Strum Liouville Problem, Green's functions, Picard's theorem. Method of Characteristics, Transport Equation, Burgers Equation, Riemann problem, Lax-Oleinik Formulae, Entropy Solution

Unit III: Existence and Uniqueness of Solutions and series solution((11 Classroom contact hours)

Existence of solution, uniqueness of solution, method of successive approximation, system of differential equation, dependence of solution on initial condition and parameters, maximum and minimum solution, variation of solutions Series Solutions of second order Linear Differential Equations, Method of Frobenius, Total differential Equation- Necessary & Sufficient condition for the total Differential Equations,Solution of a Total Equation involving four variables

Unit- IV: System of Differential Equations (11 Classroom contact hours)

System of first order equations, Existence and Uniqueness theorems, Fundamental Matrix, Homogeneous and Non Homogeneous linear systems with constant Co-efficient, linear system with periodic Co-efficient.

Tutorial:-30 hours

Recommended Learning Resources

Textbook:

1. G. F. Simmons, Differential Equations with Applications, McGraw Hill International Edition, 1991.

2. S. G. Deo and V. Raghavendra, Ordinary Differential Equations and stability theory, TATA Mc Graw Hill Ltd, 1980. Chapter 2 (Quick Review) 4,5,6,7.

Reference Books:

1. G. Birkhoff and G. C. Rota-Ordinary Differential Equations-John Wiley and Sons, N.Y., 1989.

2. Cardington and Levinson, Theory of Ordinary Differential Equations, Krieger Pub Co (June 1984)

3. Tyn-Myint-U Ordinary Differential Equations, Elsevier North-Holland, 1987.

SDG Mapping

SDG NO.	SDG Title	Nature of Contribution
SDG 4	Quality Education	Develops advanced analytical, problem-solving, and modeling skills essential for quality higher education and research.
SDG 9	Industry, Innovation and Infrastructure	Differential equations are fundamental to engineering systems, control theory, signal processing, and technological innovation...
SDG 13	Climate Action	Used in climate modeling, environmental dynamics, and sustainability-related simulations.

Course Code: IK40055
Course Title: Scientific Research Methods
Total Credits: 04 (Credits: Theory-03, Practical-01)
Total Lectures: Theory- 45 and Practical-30

Course Learning Objectives

The objectives of this course are as follows:

- To make the students aware of fundamental but mandatory ethical practices in chemistry.
- To introduce the concept of data analysis.
- To learn to perform literature survey in different modes.
- To make the students aware of safety handling and safe storage of chemicals.
- To make students aware about plagiarism and how to avoid it.
- To teach the use of different e-resources.

Course Learning Outcomes:

CO1 Follow ethical practices, safety norms and responsible conduct of research in chemistry.

CO2 Perform data analysis using appropriate statistical tools and software.
CO3 Conduct effective literature survey using print and digital databases and research metrics.
CO4 Use e-resources, software tools and digital platforms for scientific communication and documentation.
CO5 Understand plagiarism, publication ethics and intellectual property rights and avoid unethical practices.

CO-PO-PSO Mapping (High-3, Medium-2, Low-1)

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	2	–	2	2	3	1	–	2	2	3	2	1	–	2	2	–
CO2	–	2	–	3	–	3	–	3	2	–	2	–	3	–	3	1	2
CO3	1	3	2	3	1	3	1	2	2	–	2	–	2	1	3	2	1
CO4	–	2	3	2	–	2	1	3	2	–	2	–	2	–	2	2	1
CO5	3	2	2	2	2	3	–	1	2	2	3	1	1	–	2	2	–

Course Content:

UNIT-I: Scope of Research (5 Classroom contact hours)
Introduction, overview of research process: define research problem, review literature, formulate hypothesis, design research/experiment, collect and analyse data, interpret and report, scope and importance.

UNIT-II: Literature Survey, Databases and Research metrics (15 Classroom contact hours)
Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, Digital: Databases and their responsible use: Google Scholar, Web of science, Scopus, UGC INFONET, SciFinder, PubMed, ResearchGate, E-consortium, e-books; Search techniques: Phrase, Field, Boolean, Proximity, Concept, Limiting/Refining Search Results. Research metrics: Impact factor of Journal, h-index, i10 index, Altmetrics, Citation index. Author identifiers/or profiles: ORCID, Publons, Google Scholar, ResearchGate, VIDWAN

UNIT-III: Communication in Science (13 Classroom contact hours)
Types of technical documents: Full length research paper, book chapters, reviews, short communication, project proposal, Letters to editor, and thesis. Thesis writing – different steps and software tools (Word processing, LaTeX, Chemdraw, Chemsketchetc) in the design and preparation of thesis, layout, structure (chapter plan) and language of typical reports, Illustrations and tables, bibliography, referencing: Styles (APA, Oxford etc), annotated bibliography, Citation management tools: Mendeley, Zotero and Endnote; footnotes. Oral presentation/posters – planning, software tools, creating and making effective presentation, use of visual aids, importance of effective communication, electronic manuscript submission, effective oral scientific communication and presentation skills.

UNIT-IV: Ethical Practices in Research and Publication (12 Classroom contact hours)
Scientific Conduct: Ethics with respect to science and research, Scientific Misconducts: falsification, fabrication and plagiarism, similarity index, software tools for finding plagiarism (Turnitin, Urkundetc), redundant dublications Publication Ethics: Introduction, COPE

(Committee on Publication Ethics) guidelines; conflicts of interest, publication misconduct: problems that lead to unethical behaviour and vice versa, types, violation of publication ethics, authorship and contributorship, predatory publishers and journals IPR - Intellectual property rights and patent law, commercialization, copy right, royalty, trade related aspects of intellectual property rights (TRIPS).

Practicals: **Credits: 01**

(Laboratory periods: 15 classes of 2 hours each)

1. Collection of journal articles on a particular topic using Google Scholar and creating a database.
2. Collection of journal articles on a particular topic using Science Direct and creating a database.
3. Collection of journal articles on a particular topic using Scopus and creating a database.
4. Drawing chemical structure, reactions and mechanisms using Chemsketch or ISIS draw or any other software.
5. Collection of chemical structure using ChemSpider and creating a database.
6. Curve fitting using freely available softwares/apps (any one)
7. Making of power point presentation
8. Experimental learning of safe storage hazardous chemicals
9. Experimental learning of handling of hazardous chemicals
10. Technical writing on topics assigned.
11. Demonstration for checking of plagiarism using recommended software

Essential Readings:

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011) Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow.
2. Hibbert, D. B. & Gooding, J. J. (2006) Data analysis for chemistry, Oxford University Press.
3. Topping, J. (1984) Errors of observation and their treatment, Fourth Ed., Chapman Hall, London.
4. Harris, D. C. Quantitative chemical analysis. 6th Ed., Freeman (2007) Chapters 3-5.
5. Levie, R. de, how to use Excel in analytical chemistry and in general scientific data analysis. Cambridge Univ. Press (2001) 487 pages.
6. Chemical safety matters – IUPAC – IPCS, Cambridge University Press, 1992. OSU safety manual 1.01

SDG Mapping

SDG No.	SDG Title	Rationale
SDG 4	Quality Education	Strengthens research skills, ethical awareness and scientific communication for higher education
SDG 9	Industry, Innovation & Infrastructure	Supports innovation through responsible research, data analysis and publication practices
SDG 16	Peace, Justice & Strong Institutions	Encourages integrity, transparency, accountability and trust in scientific research

Course Code-MT42001
Course Title- Linear Programming
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

Students will be able to articulate and describe:
1. The basics of linear programming problem
2. Basic concepts of simplex method, Big M method
3. Understanding primal and dual problem
4. Assignment method and Transportation problem

Course Outcomes:

After completing this course the students will be able to:

CO1: Remember the meaning of linear programming problem

CO2: Understand the concept of simplex method

CO3: Apply the artificial variable and Big M method

CO4: Analyze the primal and dual problem

CO5: Evaluate the problems relating to Assignment method and Transportation problem

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	–	2	2	–	–	–	–	–	–	1	3	1	1	1	2
CO2	3	3	2	3	3	1	–	–	–	1	–	2	3	2	1	2	2
CO3	3	3	2	3	3	1	–	–	–	2	–	2	2	3	2	2	2
CO4	3	3	2	3	3	2	–	–	–	2	–	2	2	3	2	3	2
CO5	3	3	2	3	3	2	–	–	–	3	–	2	2	3	1	3	1

Course Syllabus:

UNIT-I: Linear Programming and the Simplex Method(12 Classroom contact hours)

Introduction to linear programming problem, Theory of simplex method, optimality and un boundedness, the simplex algorithm, simplex method in tableau format, introduction to artificial variables, two-phase method, Big-M method and their comparison.

UNIT-II: Duality and Transportation Problems(11 Classroom contact hours)

Duality, formulation of the dual problem, primal-dual relationships, economic interpretation of the dual. Transportation problem and its mathematical formulation, northwest-corner method least cost method and Vogel approximation method for determination of starting basic solution.

UNIT-III: Transportation and Assignment Models(11 Classroom contact hours)

Algorithm for solving transportation problem, Assignment problem and its mathematical formulation, Hungarian method for solving assignment problem.

UNIT-IV: Game Theory and Linear Programming Applications(11 Classroom contact hours)

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

Tutorial:-30 hours

Recommended Learning Resources

Textbook:

1. Hamdy A. Taha, Operations Research. An Introduction, 8th Ed., Prentice-Hall India, 2006

Reference Books:

1. Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, Linear Programming and Network Flows, 2nd Ed., John Wiley and Sons, India, 2004.

2. F.S. Hillier and G.J. Lieberman, Introduction to Operations Research, 9th Ed., Tata McGraw Hill, Singapore, 2009.

3.G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.

SDG #	SDG Title	Contribution & Relevance
2	Zero Hunger	Optimisation of agricultural production, storage, and distribution systems
4	Quality Education	Builds optimisation and decision-science literacy
8	Decent Work & Economic Growth	Models for labour planning, production, and operations efficiency
9	Industry, Innovation & Infrastructure	LP-based planning for industrial processes, logistics and network flows
10	Reduced Inequalities	Fair allocation models, equitable resource distribution via constraints/objectives
12	Responsible Consumption & Production	Optimal use of resources, waste minimisation, sustainable supply chain design

13	Climate Action	Incorporating emission and energy constraints into optimisation models

SEMESTER – VII(With Double Major)

Paper Code	Paper Name	Credits	L-T-P
MT40001	Advanced Abstract Algebra	4	3-1-0
MT40003	Advanced Real Analysis	4	3-1-0
MT40005	Advanced Differential Equations	4	3-1-0
IK40055	Scientific Research Methods	4	3-1-0
MT42001	Linear Programming	4	3-1-0
MT42003	Fuzzy Mathematics and Applications	4	3-1-0

Course Code-MT42003

Course Title- Fuzzy Mathematics and Applications

Total Credits: 04 (Credits: Theory-03, Tutorial-01)

Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

Students will be able to articulate and describe:
1. The basics of linear programming problem
2. Basic concepts of simplex method, Big M method
3. Understanding primal and dual problem
4. Assignment method and Transportation problem

Course Outcomes:

CO1: Remember the basic concepts of fuzzy sets, fuzzy logic, and uncertainty.

CO2: Understand operations on fuzzy sets and analyze fuzzy relations.

CO3: Apply fuzzy arithmetic and fuzzy numbers to mathematical problems

CO4: Analyze real-life problems using fuzzy mathematical techniques

CO5: Evaluate the fuzzy inference systems for decision-making and control applications

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	–	2	2	–	–	–	–	–	–	1	3	1	1	1	2
CO2	3	3	2	3	3	1	–	–	–	1	–	2	3	2	1	2	2
CO3	3	3	2	3	3	1	–	–	–	2	–	2	2	3	2	2	2
CO4	3	3	2	3	3	2	–	–	–	2	–	2	2	3	2	3	2
CO5	3	3	2	3	3	2	–	–	–	3	–	2	2	3	1	3	1

UNIT-I: Fundamentals of Fuzzy Mathematics (12 Classroom contact hours)

Classical (Crisp) Sets and Classical Logic , Need for Fuzzy Mathematics ,Historical Development , Uncertainty and Vagueness ,Fuzzy Sets ,Membership Functions ,Types of Membership Functions , α-cuts and Strong α-cuts ,Support, Core, Height and Boundary ,Convex and Normal Fuzzy Sets , Linguistic Variables ,Extension Principle

UNIT-II: Operations on Fuzzy Sets and Fuzzy Relations (11 Classroom contact hours)

Basic Operations on Fuzzy Sets, Complement , Union , Intersection , Difference , De Morgan's Laws , Cartesian Product , Fuzzy Relations , Composition of Fuzzy Relations ,Max-Min Composition , Max-Product Composition ,Equivalence and Compatibility Relations , Fuzzy Equivalence Classes ,Transitive Closure ,Similarity Relations

UNIT-III: Fuzzy Numbers and Fuzzy Arithmetic (11 Classroom contact hours)

Fuzzy Numbers, Triangular Fuzzy Numbers, Trapezoidal Fuzzy Numbers, Arithmetic Operations Ranking of Fuzzy Numbers, Distance Measures, Fuzzy Equations, Fuzzy Linear Programming Fuzzy Optimization, Introduction to Possibility Theory, Possibility and Necessity Measures

UNIT-IV: Fuzzy Logic and Applications (11 Classroom contact hours)

Classical Logic versus Fuzzy Logic, Fuzzy Propositions ,Fuzzy Implications ,Fuzzy Inference Systems ,Mamdani Model ,Sugeno Model ,Defuzzification Methods ,Fuzzy Decision Making Fuzzy Control Systems Applications in Engineering ,Artificial Intelligence ,Pattern Recognition Image Processing ,Medical Diagnosis ,Business Decision Making ,Data Mining ,Environmental Modelling

Recommended Textbooks

1. George J. Klir and Bo Yuan, *Fuzzy Sets and Fuzzy Logic: Theory and Applications*, Prentice Hall.
2. Timothy J. Ross, *Fuzzy Logic with Engineering Applications*, Wiley.
3. H.-J. Zimmermann, *Fuzzy Set Theory and Its Applications*, Springer.
4. Lotfi A. Zadeh, *Fuzzy Sets, Fuzzy Logic and Fuzzy Systems: Selected Papers*, World Scientific.
5. Didier Dubois and Henri Prade, *Fundamentals of Fuzzy Sets*, Springer.

Reference Books

1. Abraham Kandel, *Fuzzy Mathematical Techniques with Applications*.
2. James J. Buckley and Esfandiar Eslami, *An Introduction to Fuzzy Logic and Fuzzy Sets*.
3. Michael Hanss, *Applied Fuzzy Arithmetic*.
4. Witold Pedrycz and Fernando Gomide, *An Introduction to Fuzzy Sets: Analysis and Design*.
5. Krassimir T. Atanassov, *Intuitionistic Fuzzy Sets*.

SDG #	SDG Title	Contribution & Relevance
4	Quality Education	Builds optimisation and decision-science literacy
8	Decent Work & Economic Growth	Models for labour planning, production, and operations efficiency
9	Industry, Innovation & Infrastructure	LP-based planning for industrial processes, logistics and network flows
13	Climate Action	Incorporating emission and energy constraints into optimisation models

SEMESTER – VIII(With Single Major)

COURSE CODE	NAME OF THE COURSE	CREDITS	L-T-P
MT40002	Partial Differential Equations and Transforms	4	3-1-0
MT42002	Fundamentals of Mathematical Analysis	4	3-1-0
RD40082	Research and Dissertation	12	0-0-12
IF NOT GOING FOR RESEARCH WORK			
MT40004	Complex Analysis	4	3-1-0
MT40006	Advanced Linear Algebra	4	3-1-0
MT40008	Functional Analysis	4	3-1-0

Course Code: MT40002
Course Title: Partial Differential Equations and Transforms
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Learning Objectives: Students will be able to articulate and describe:

1. Basic methods for solving Partial Differential Equations first order and second order

2 Charpit's Method, Jacobi Method

3. Methods to solve wave equation, heat equation

4. Classification of Partial Differential Equation and boundary value problems

Course Outcomes:

After completing this course the students will be able to:

CO1: Remember the first order Partial differential equations, Semi-linear and quasi-linear equations

CO2: Understand Cauchy problem, method of characteristics for quasi-linear and non linear partial differential equation

CO3: Apply Linear Second order partial Differential Equations

CO4: Analyze the Laplace equation , Boundary value problems

CO-5: Evaluate the problems relating to Cauchy problem, linear second order partial differential equation and transform problems

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	3	–	2	–	–	–	–	–	1	3	1	1	1	2
CO2	–	3	–	2	–	2	–	–	–	–	–	2	3	2	1	2	2
CO3	–	3	–	3	–	3	–	–	–	–	–	2	2	3	2	2	2
CO4	–	3	–	3	–	3	–	–	–	–	–	2	2	3	2	3	2
CO5	–	3	–	3	–	3	–	–	–	–	–	2	2	3	1	3	1

Course Inputs:.

Unit - I : **Introduction to Partial differential equation(12 Classroom contact hours)**

Meaning of Partial differential equation, Classification of first order Partial differential equations, Semi-linear and quasi-linear equations, Pfaffian differential equations, Lagrange's method, Compatible systems, Charpit's method, Jacobi's method,

Unit-II : **Quasi-linear and non linear partial differential equation(11 Classroom contact hours)**

Integral surfaces passing through a given curve, Cauchy problem, method of characteristics for quasi-linear and non linear partial differential equation, Monge cone, characteristic strip. First order non-liner equations in two independent variables ,Complete integral.

Unit - III :**Linear Second order partial Differential Equations (11 Classroom contact hours)**

Origin of second order PDEs, Classification of Second order Partial Differential Equations., One dimensional Wave equation, Vibration of an infinite string, origin of the equation, D'Alembert's solution, Vibrations of a semi finite string, Vibrations of a string of finite length, existence and uniqueness of solution, Riemann method.

Unit - IV Boundary value problems(11 Classroom contact hours)

Laplace equation , Boundary value problems, Maximum and minimum principles, Uniqueness and continuity theorems, Dirichilet problem for a circle, Dirichlet problem for a circular annulus, Neumann problem for a circle, Theory of Green's function for Laplace equation, Heat equation, Heat conduction problem for an infinite rod, Heat conduction in a finite rod, existence and uniqueness of the solution, Kelvin's inversion theorem, Equipotential surfaces.

Tutorial:-30 hours

Textbook:

1. Ian Sneddon, Elements of Partial Differential Equations, International Students Edition.

2. Phoolan Prasad and Renuka Ravindran, Partial Differential Equations, New Age International, 1985.

Reference Books:

1.F. John - Partial Differential Equations, Springer-Verlag, New York, 1978.

2. Tyn-Myint-U - Partial Differential Equations North Holland Publication.

SDG Mapping

SDG NO.	SDG Title	Nature of Contribution
SDG 9	Industry, Innovation, and Infrastructure	PDEs and transforms are fundamental for modeling, simulation, and innovation in science, engineering, and technological infrastructure.
SDG 4	Quality Education	Develops advanced mathematical knowledge, problem-solving skills, and research orientation in PDEs and transforms
SDG 10	Reduced Inequalities	Encourages inclusive learning and equitable access to advanced mathematical education and resources.

Course Code: MT42002
Course Title: Fundamentals of Mathematical Analysis
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives:

The course aims to:

1. Introduce the foundations of mathematical analysis through rigorous reasoning.
2. Develop understanding of the real number system and elementary topology of the real line.
3. Study sequences, limits, continuity, and differentiability of real-valued functions.
4. Build analytical and problem-solving skills for advanced courses in mathematics.

Course Outcomes

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

CO1: Explain the structure and properties of the real number system and solve problems involving inequalities and absolute values.

CO2: Analyze sequences and determine their convergence using standard convergence theorems.

CO3: Examine the continuity and differentiability of real-valued functions and apply major theoretical results.

CO4: Apply concepts of mathematical analysis to solve theoretical and practical mathematical problems.

CO5: Evaluate the problems relating to metric space and complex integration

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	3	3	3	3	2	–	–	–	–	–	–	1	3	1	1	1	2
CO2	3	3	3	3	2	–	–	–	–	1	–	2	3	2	1	2	2
CO3	3	3	3	3	2	–	–	–	–	2	–	2	2	3	2	2	2
CO4	3	3	3	3	2	–	–	–	–	2	–	2	2	3	2	3	2
CO5	3	3	3	3	2	–	–	–	–	3	–	2	2	3	1	3	1

Course Syllabus:

Unit I: Real Number System and Basic Concepts (12 **Classroom contact hours**)

Algebraic and order properties of real numbers , Absolute value and inequalities , Supremum and infimum ,Archimedean property ,Density of rational and irrational numbers ,Intervals and neighborhoods ,Introduction to mathematical proofs (direct proof, contradiction, mathematical induction)

Unit II: Sequences and Limits (**11 Classroom contact hours**)

Sequences of real numbers ,Bounded, monotone sequences ,Limit of a sequence ,Convergent and divergent sequences ,Limit theorems ,Monotone Convergence Theorem ,Cauchy sequences ,Subsequences ,Bolzano–Weierstrass Theorem

Unit III: Limits and Continuity of Functions (11 Classroom contact hours)

Functions and elementary properties, Limit of a function, One-sided limits, Continuous functions, Continuity of elementary functions, Algebra of continuous functions, Intermediate Value Theorem, Extreme Value Theorem ,Uniform continuity (introduction)

Unit IV: Differentiation and Applications (12 Classroom contact hours)

Derivative and differentiability ,Differentiation rules ,Chain rule ,Rolle's Theorem ,Mean Value Theorem ,Increasing and decreasing functions ,Local maxima and minima ,Taylor's theorem (statement and applications) ,Curve sketching using derivatives

Tutorial:-30 hours

Recommended Learning Resources

Textbooks

1. Robert G. Bartle and Donald R. Sherbert, *Introduction to Real Analysis*, Wiley.
2. Kenneth A. Ross, *Elementary Analysis: The Theory of Calculus*, Springer.
3. Terence Tao, *Analysis I*, Hindustan Book Agency.
4. Charles G. Denlinger, *Elements of Real Analysis*, Jones & Bartlett.

Reference Books

1. Walter Rudin, *Principles of Mathematical Analysis*, McGraw-Hill.
2. Tom M. Apostol, *Mathematical Analysis*, Pearson.
3. S. Kumaresan, *A Course in Real Analysis*, Narosa.
4. Richard R. Goldberg, *Methods of Real Analysis*, Oxford University Press.

SDG	Title	Contribution
4	Quality Education	High-level mathematical training
9	Industry, Innovation & Infra	Tools for advanced modelling and signal/field analysis
13	Climate Action	Underpinning rigorous models in physical sciences

Course Code:RD40082

Course Title: Research and Dissertation

Code	Course Title	Credit	L-T-P
RD40082	**Research and Dissertation**	**12**	**0-0-12**

Course Objectives:

1.To develop independent research and analytical skills

2. To apply computing knowledge to real-world or theoretical problems

3. To gain hands-on experience in designing and implementing solutions

4.To enhance scientific writing and communication skills

Course Outcomes

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

CO1 (Knowledge/Remember): Recall and describe the principles of research problem identification, research objectives, hypothesis formulation, and literature review to establish a clear and relevant research problem.

CO2 (Understanding): Explain and interpret research methodologies, experimental design, data collection techniques, and ethical research practices for conducting systematic scientific investigations.

CO3 (Application): Apply appropriate research methodologies, computational tools, and domain knowledge to design, develop, and implement a working solution, model, or prototype for the identified research problem.

CO4 (Analysis): Analyze experimental results using statistical, computational, and scientific methods to validate findings, evaluate performance, and draw meaningful conclusions.

CO5 (Synthesis/Evaluation): Design, prepare, and evaluate a comprehensive dissertation report by integrating research findings, technical contributions, scientific writing, and professional presentation skills to effectively communicate the outcomes of the research.

CO-PO-PSO Mapping

(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).

CO	PO1	PO2	PO3	PO4	PO 5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	2	3	3	2	–	–	2	–	–	2	-	2	2	-	-
CO2	3	3	2	3	3	3	2	–	2	2	2	2	-	1	-	2	-
CO3	2	3	3	3	3	3	3	2	2	3	3	3	2	3	2	-	-
CO4	2	2	3	2	2	3	3	2	2	3	3	3	-	2	-	-	-
CO5	2	2	3	2	2	3	3	3	2	3	3	3	-	-	2	2	-

Course Duration: 270 hours

Course Syllabus:

UNIT 1: Research Foundations & Problem Identification[50 Lab Contact Hours]

Introduction to research in Computer Science, Types of research: basic, applied, experimental, Identification of research areas (AI, Data Science, IoT, etc.), Problem formulation, objectives, and scope, Feasibility study and planning

UNIT 2: Literature Review & Research Methodology[58 Lab Contact Hours]

Sources of literature: journals, conferences, digital libraries, Review techniques and gap identification, Citation and referencing styles (IEEE/APA), Research methodology: qualitative and quantitative approaches, Experimental design and hypothesis formulation

UNIT 3: System Design & Implementation[60 Lab Contact Hours]

System architecture design, Algorithm/model selection, Dataset identification and preprocessing, Tools and technologies selection, Coding, testing, and debugging

UNIT 4: Experimentation, Analysis & Validation[30 Lab Contact Hours]

Performance metrics (Accuracy, Precision, Recall, F1-score), Statistical and comparative analysis, Result visualization (graphs, charts), Interpretation and validation of results

UNIT 5: Dissertation Writing, Ethics & Defense[72 Lab Contact Hours]

Structure of dissertation: (Abstract, Introduction, Literature Review, Methodology, Implementation, Results & Discussion, Conclusion & Future Work), Research ethics, plagiarism, and IPR, Report formatting (IEEE/APA), Presentation, demonstration, and viva voce

Reference Books

1. C. R. Kothari and GauravGarg, Research Methodology: Methods and Techniques, 4th Edition, New Age International Publishers, 2019.
2. Roger S. Pressman and Bruce R. Maxim, Software Engineering: A Practitioner's Approach, 9th Edition, McGraw-Hill Education, 2019.
3. Ian Sommerville, Software Engineering, 10th Edition, Pearson Education, 2016.
4. Robert C. Martin, Clean Code: A Handbook of Agile Software Craftsmanship, Pearson Education, 2008.
5. Wayne C. Booth, Gregory G. Colomb, Joseph M. Williams, Joseph Bizup, and William T. FitzGerald, The Craft of Research, 4th Edition, University of Chicago Press, 2016.

6. Turabian, Kate L., A Manual for Writers of Research Papers, Theses, and Dissertations, 9th Edition, University of Chicago Press, 2018.
7. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein, Introduction to Algorithms, 4th Edition, MIT Press, 2022.
8. Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides, Design Patterns: Elements of Reusable Object-Oriented Software, Addison-Wesley, 1994.

Online Resources

1. IEEE Xplore Digital Library (https://ieeexplore.ieee.org)
2. ACM Digital Library (https://dl.acm.org)
3. SpringerLink (https://link.springer.com)
4. ScienceDirect (https://www.sciencedirect.com)
5. Google Scholar (https://scholar.google.com)

SDG Mapping for this Course

SDG	Title	Contribution
SDG 4	Quality Education	Research capacity building
SDG 9	Industry, Innovation and Infra	Innovating solutions/research prototypes
SDG 10	Reduced Inequalities	Work on tribal/indigenous issues
SDG 13	Climate Action	Topics on environment, resilience
SDG 16	Peace, Justice & Institutions	Governance, rights, ICT4D research

Course code: MT40004
Course Title: Complex Analysis
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Learning Objectives: Students will be able to articulate and describe:

1 . The theories for functions of a complex variable

2. Complex line integrals and Cauchy's theorem

3. Singularities and residues

4. The applications of the calculus of residues in the evaluation of integrals.

Course Outcomes:

After completing this course the students will be able to:

CO1: Remember the concepts ofcomplex number system and analytic functions

CO2: Understand the Complex line integrals and Cauchy's theorem

CO3: Apply the basics of Singularities and residues

CO4: Analyze the applications of the calculus of residues in the evaluation of integrals.

CO5: Evaluate the problems based on Cauchy integral formula and Cauchy theorem

CO-PO-PSO MAPPING

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	–	3	–	2	–	1	–	–	–	–	–	–	3	1	1	1	2
CO2	–	3	–	3	–	2	–	–	–	–	–	–	3	2	1	2	2
CO3	–	3	–	3	–	3	–	–	–	–	–	–	2	3	2	2	2
CO4	–	3	–	3	–	2	–	–	–	–	–	–	2	3	2	3	2
CO5	–	3	–	3	–	2	–	–	–	–	–	–	2	3	1	3	1

Course Inputs:.

Unit-I :**Complex Number and Conformal Mapping(12 Classroom contact hours)**

The complex number system, The spherical representation, Analytic functions, Exponential and trigonometric functions, The Cauchy-Riemann equations, Power series, Functions defined by power series as holomorphic functions, The linear fractional transformations, Cross ratios and Conformal mappings.

Unit-II : **Complex Integrals (11 Classroom contact hours)**

Complex line integrals and Cauchy's theorem, Cauchy's integral formula, The index of a closed curve, Cauchy's theorem for rectangle, Cauchy's theorem for disc, General form of Cauchy's theorem, Harmonic functions, Fundamental theorem of algebra, Morera's theorem, Open map- ping theorem a Zeros of complex functions.

Unit-III : **Properties of Complex Integrals(11 Classroom contact hours)**

Taylor's series, Laurent's series, Types of singularities, Calculus of residues, Evaluation of definite integrals, The argument principle, Rouche's theorem, The maximum modulus theorem and Schwarz's lemma.

Unit-IV: Application of Complex Analysis(11 Classroom contact hours)

Normal families, Arzela's theorem, Product developments, Hadamard's theorem Riemann zeta functions, Riemann mapping theorem and Weriestrass' theorem.

Tutorial:-30 hours

Recommended Learning Resources

Textbook:

1.James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, Eighth Edition, Mc Graw Hill Education (India) Pvt. Ltd., 2017.

2. W. Rudin, Real and Complex Analysis, Third Edition, Tata McGraw- Hill Publishing Company Ltd., New Delhi.

3. J. B. Conway, Functions of One Complex Variable, Second Edition, Narosa Publishing House, New Delhi.(Sixteenth Reprint, 2002).

Reference Books:

.1. Lars V. Ahlfors, Complex Analysis, Third Edition, Mc Graw Hill Education (India) Pvt. Ltd., Chennai, 2016.

2.Robert E. Greene and Steven G. Krantz, Function Theory of One Complex Variable, Third Edition , American Mathematical Society (Indian Edition),Island, 2011

SDG Mapping

SDG NO.	SDG Title	Nature of Contribution
SDG 9	Industry, Innovation, and Infrastructure	PDEs and transforms are fundamental for modeling, simulation, and innovation in science, engineering, and technological infrastructure.
SDG 4	Quality Education	Develops advanced mathematical knowledge, problem-solving skills, and research orientation in PDEs and transforms
SDG 10	Reduced Inequalities	Encourages inclusive learning and equitable access to advanced mathematical education and resources.

Course Code: MT40006
Course Title: Advanced Linear Algebra
Total Credits: 04 (Credits: Theory-03, Tutorial-01)

Total Lectures: Theory- 45 and Tutorial-30

Course Objectives: Students will be able to articulate and describe:

1 . The concept of Vector Spaces, Subspaces

2. Solution of System of Linear equations

3. Concept of eigen values and Eigen vectors

4. Different canonical forms with examples

Course Outcomes:

After completing this course the students will be able to:

CO1: Remember the concept of Vector Spaces, Subspaces

CO2: Understand System of Linear equations, Characteristic roots

CO3: Apply the Diagonal forms, triangular forms, Jordan form, Quadratic form

CO4: Analyze the Euclidean space, unitary space

CO5: Evaluate the roots and of the system of linear equations

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	1	–	–	–	–	–	–	–	–	3	1	1	1	2
CO2	–	3	–	2	–	1	–	–	–	–	–	–	3	2	1	2	2
CO3	–	3	–	3	–	2	–	–	–	–	–	–	2	3	2	2	2
CO4	–	3	–	3	–	2	–	–	–	–	–	–	2	3	2	3	2
CO5	–	3	–	3	–	2	–	–	–	–	–	–	2	3	1	3	1

Course Inputs:.

Unit - I :**Vector space and its properties(12 Classroom contact hours)**

Vector Spaces, Subspaces, Linear independence, bases, Dimension, Projection, Quotient spaces, Isomorphism of vector spaces, Algebra of matrices, Rank and Inverse of matrix, The Algebra of Linear transformation, Kernel, range, matrix representation of a linear transformation, Change of bases.

Unit - II : **System of Linear equations(11 Classroom contact hours)**

System of Linear equations, Characteristic roots and Vectors, eigen values, eigen vectors, Cayley-Hamillton theorem, Annihilator, Modules, finitely generated module. Canonical forms .Canonical Forms: Diagonal forms, triangular forms, Jordan form, Quadratic form, Inner Product spaces.

Unit - III : **Canonical forms .(11 Classroom contact hours)**

Diagonal forms, triangular forms, Jordan form, Quadratic form, Inner Product spaces, Nilpotent transforms, Index of nilpotent, A decomposition of V. Jordan form, Rational canonical form.

Unit-IV: **Unitary space and orthogonality (11 Classroom contact hours)**

Euclidean space, unitary space, Cauchy –Schwartz inequality, orthogonal set, Orthogonal complement, orthogonal projection ,Bessel's inequality, Linear functional and adjoints, Linear operators, Unitary operator and Normal operators

Tutorial:30hours

Textbook:

1.Ramachandra Rao and P. Bhimsankaram. Linear Algebra, Hindustan Book Agency; 2nd Revised edition edition

2. S. Kumaresan-Linear Algebra, Prentice Hall India Learning Private Limited; New title edition (2000).

3. P.P. Halmos - Finite Dimensional Vector Spaces, Springer; 1st ed. 1958. Corr. 2nd printing 1993 edition (August 20, 1993)

Reference Books:

4. N. Herstein - Topics in Algebra , John Wiley and Sons; 2nd Revised edition edition, 1975.

5. J. B. Fraleigh-A first Course in Algebra, Pearson, 7th Ed., 2013.

6. J. Gallian - Contemporary Abstract algebra, Brooks/Cole Pub Co; 8 edition (13 July 2012).

SDG Mapping

SDG NO.	SDG Title	Nature of Contribution
SDG 9	Industry, Innovation, and Infrastructure	Supports mathematical modeling, system analysis, optimization, and computational methods used in industry and technology
SDG 4	Quality Education	Strengthens mathematical foundations, analytical thinking, and problem-solving skills essential for higher education and lifelong learning

SDG 8	Decent Work & Economic Growth	Provides core skills required in engineering, data science, AI, finance, and research-based careers

Course Code-MT40008
Course Title-Functional Analysis
Total Credits: 04 (Credits: Theory-03, Tutorial-01)
Total Lectures: Theory- 45 and Tutorial-30

Course Objectives: Students will be able to articulate and describe:

1. Different function spaces like Banach Spaces, Hilbert Spaces etc

2 Bounded and unbounded Linear Operators on Banach Spaces and its spectral Analysis

3.Solution of nonlinear equations, systems of linear equations, differential equations,

4.Riesz theorem; Hilbert adjoint operator and its basic properties.

Course Outcomes:

After completing this course the students will be able to:

CO1: Remember the definition, examples and basic properties of normed spaces

CO2: Understand the basic properties of bounded linear operators

CO3: Apply the basic properties of Inner product spaces

CO4:Analyze the Hilbert spaces and finite dimensional normed spaces and concepts of different fixed point theorems

CO5: Evaluate the examples of reflexive spaces

CO-PO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	2	–	2	–	–	–	–	–	–	3	1	1	1	2
CO2	–	3	–	3	–	2	–	–	–	–	–	–	3	2	1	2	2
CO3	–	3	–	2	–	3	–	–	–	–	–	–	2	3	2	2	2
CO4	–	3	–	2	–	3	–	–	–	–	–	–	2	3	2	3	2
CO5	–	3	–	3	–	3	–	–	–	–	–	–	2	3	1	3	1

Course Syllabus:

UNIT I :**Normed spaces(10 Classroom contact hours)**

Definition, examples and basic properties of normed spaces; completeness and equivalence of norms on finite dimensional normed spaces; characterization of compact sets in finite dimensional normed spaces; Banach space (definition), L_p space. Cauchy-Schwarz Inequality, Minkowski's inequality, Holder's inequality.

UNIT II :**Linear operators on normed spaces(10 Classroom contact hours)**

Definition and basic properties of bounded linear operators; connection between continuity and boundedness of linear operators; continuity of linear operators on finite dimensional spaces; completeness of normed space of operators; dual spaces of R^n and l^p spaces, Hahn Banach theorem and its extension for normed spaces and its consequences.

UNIT III :**Inner product spaces(IPS) (08 Classroom contact hours)**

Definition and basic properties of IPS; Hilbert spaces; Riesz lemma; existence of minimizing vector; orthogonality; Projection theorem; orthogonal complement of a set and its basic properties; Bessel's inequality; total orthonormal sets; Parseval's relation; connection between separability and orthonormal sets; isomorphism of Hilbert spaces of same dimension.

UNIT IV :**Reflexive spaces and fundamental theorems(08 Classroom contact hours)**

Reflexive spaces; Hilbert spaces and finite dimensional normed spaces as examples of reflexive spaces; separability of dual normed space as a sufficient condition for the separability of the normed space; Baire's theorem; uniform boundedness theorem and its application to space of polynomials; Open mapping and closed graph theorems.

UNIT V : **Fixed Point Theorems(09 Classroom contact hours)**

Riesz theorem; Hilbert adjoint operator and its basic properties; basic properties of self adjoint, unitary and normal operators, Banach fixed point theorem.

Tutorial:-30 hours

Textbook:

1. B. V. Limaye, Function Analysis Wiley Eastern Ltd

Reference Books:

1. B. Choudhary and S. Nanda, Functional Analysis with Applications. New Age International (P) Limited.
2. P. K. Jain, O.P. Ahuja, and K. Ahmed, Functional Anaysis, New Age International (P) Limited.
3. Bachman, G. and Narici, L., (1966), Functional Analysis, Academic Press New York.

4. Rynne, B. P. and Youngson, M. A., (2008), Linear Functional Analysis, 2nd edition, Springer.
5. Siddiqi, A. H., (2004), Applied Functional Analysis, Marcel-Dekker, New York.
6. I. J. Maddox, Elements of Functional Analysis, Cambridge University Press

SDG Mapping

SDG NO.	SDG Title	Nature of Contribution
SDG 9	Industry, Innovation, and Infrastructure	Supports mathematical modeling, operator theory, and functional frameworks applied in engineering, signal processing, and computational research
SDG 4	Quality Education	Develops abstract reasoning, analytical thinking, and problem-solving skills for advanced mathematics and lifelong learning
SDG 8	Decent Work & Economic Growth	Builds core skills required in analytics, data science, AI, finance, and research-based careers

SEMESTER – VIII(With Double Major)

COURSE CODE	NAME OF THE COURSE	CREDITS	L-T-P
MT40002	Partial Differential Equations and Transforms	4	3-1-0
MT42002	Fundamentals of Mathematical Analysis	4	3-1-0
MT 42004	Introduction to Probability and Stochastic Process	4	3-1-0
RD40082	Research and Dissertation	12	0-0-12
IF NOT GOING FOR RESEARCH WORK			
MT40004	Complex Analysis	4	3-1-0
MT40006	Advanced Linear Algebra	4	3-1-0
MT40008	Functional Analysis	4	3-1-0

Course Code: MT42004

Course Title Introduction to Probability & Stochastic Process

Total Credits: 04 (Credits: Theory-03, Tutorial-01)

Total Lectures: Theory- 45 and Tutorial-30

Course Objectives: Students will be able to articulate and describe:

1 . Analysis of the outcome a random experiment and numerical probability

2. Sample space, Probability axioms, Conditional probability,

3. Poisson theorem, Interchangeable events and their limiting properties

4. Convergence of a sequence of random variables, Stochastic Processes, Discrete time Markov Chain

Course Outcomes:

CO1: Remember the concepts of algebra of sets, Fields and Sigma fields

CO2: Understand Conditional probability and probability distribution

CO3: Apply Poisson theorem, Interchangeable events and their limiting properties

CO4: Analyze the convergence of a sequence of random variables

CO5: Evaluate the problems based on Stochastic Processes, Discrete time Markov Chain

CO-PO-PSO MAPPING

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
CO1	–	3	–	1	–	–	–	–	–	–	–	–	3	1	1	1	2
CO2	–	3	–	2	–	–	–	–	–	–	–	–	3	2	1	2	2
CO3	–	2	–	3	–	2	–	–	–	–	–	–	2	3	2	2	2
CO4	–	2	–	3	–	–	–	–	1	–	–	–	2	3	2	3	2
CO5	–	2	–	3	–	–	–	–	–	1	–	–	2	3	1	3	1

Course Inputs:.

Unit-I : **Introduction (09 Classroom contact hours)**

Algebra of sets, Fields and Sigma fields, Limits of sequence of subsets, Sigma field generated by a class of subsets, Borel fields. Probability space, continuity of probability measure.

Unit-II :**Random Variables and its properties(09 Classroom contact hours)**

Sample space, Probability axioms, Conditional probability, Independence of events. Bayes' theorem, Real and vector valued random variables, Distribution function, Discrete and continuous random variables, Distribution of L.V.S. Marginal and conditional distribution. Independence of random variables.

Unit-III :**Conditional Probability(09 Classroom contact hours)**

Poisson theorem, Interchangeable events and their limiting properties, Expectation of a random variable. Linear properties of expectations. Conditional expectation, Moment generating function. Moment inequalities. Characteristic function and its properties.

Unit-IV : **Convergence theorems of random variables(09 Classroom contact hours)**

Convergence of a sequence of random variables, Convergence in distribution, Convergence in probability, Almost sure convergence and Convergence in quadratic mean and their interrelations. Monotone and dominated convergence theorem, Central limit theorem: Lindberg-Levy and Demoivre- Lapalce theorem.

Unit-V: **Introduction to Stochastic Processes(09 Classroom contact hours)**

Introduction to Stochastic Processes, Discrete time Markov Chain, Transition Probability Matrices, Recurrent and Transient states , Chapman Kolmogorov Theorems, Long run behavior of Markov Chain , Reducible and Irreducible , Examples- Inventory model, Urn Model, Random walk, Gambler's ruin, Applications to genetics , queueing. Poisson process, Distribution associated with Poisson process (Poisson Exponential, Gamma , Uniform) , Non Homogeneous and compound Poisson process .Continuous time Markov Chains, Pure birth process, Birth and Death process, Kolmogorov Differential Equations.

Textbook:

1.Probability, Statistics and Stochastic Processes for Engineers and Scientists *Aliakbar Montazer Haghighi, Indika Wickramasinghe & Emmanuel A. Appiah*

Reference Books:

1.M.A.Pinsky,S.Karling,"An Introduction to Stocastic Modeling",

2. S. M. Ross, "Introduction to Probability Models"

3. S.M. Ross , "Stochastic Processes"

4. V.K. Rohatgi , A. K .Saleh " An introduction to Probability and Statistics

This syllabus is designed to align with the requirements of UGC NET and GATE, ensuring that students gain both theoretical knowledge and practical skills in big data technologies.

SDG Mapping

SDG NO.	**SDG Title**	**Nature of Contribution**
SDG 9	Industry, Innovation, and Infrastructure	Reliability analysis, queuing systems, and stochastic industrial models
SDG 4	Quality Education	Enhances analytical thinking, uncertainty modeling, and higher-order reasoning skills
SDG 3	Good Health & Well-being	Stochastic modeling in epidemiology, disease spread, and healthcare systems



KALINGA INSTITUTE OF SOCIAL SCIENCES (KISS)

DEEMED TO BE UNIVERSITY

Higher Education Campus, KISS Campus-3, Bhubaneswar, Odisha, 751024
https://university.kiss.ac.in | https://kiss.ac.in