SNDT Women’s University, Mumbai

Undergraduate Degree / UG Programme (Syllabus as Per NEP) - Faculty of Science & Technology

Bachelor of Science (Mathematics)

B.Sc. In Mathematics

As Per NEP – 2020

Semester – V & VI

Syllabus
(W.E.F. Academic Year 2026-27)

Terminologies

Vertical	Full-Form/Definition	Remarks	Related To Major And Minor Courses
Major (Core)	Subject Comprising Mandatory and Elective Courses, Major Specific IKS, Vocational Skill Courses, Internship/ Apprenticeship, Field Projects, Research Projects Connected to Major	Minimum 50% Of Total Credits Corresponding to Three/Four - Year UG Degree- Mandatory Courses	Related To The Major
Minor Course	Course From Same Or Different Faculty	Minimum 18-20 Credits to Be Completed in The First Three Years of UG Programme	Related To the Minor
OEC	Open Elective Courses/ Generic Courses	10-12 Credits to Be Offered in I And/Or II Year. Faculty-Wise Baskets of OEC To Be Prepared	OEC Is to Be Chosen Compulsorily from Faculty Other Than That of the Major
VSC	Vocational Skill Courses, Including Hands On Training Corresponding To The Major And/Or Minor Subject	8-10 Credits, To Be Offered in First Three Years, Wherever Applicable Vocational Courses Will Include Skills Based on Advanced Laboratory Practical's of Major	Related To the Major or Minor
SEC	Skill Enhancement Courses	06 Credits, To Be Offered in I And II Year, To Be Selected from The Basket of Skill Courses Approved by University	Related To the Major or Minor Any Relevant Skill
AEC	Ability Enhancement Courses	08 Credits, To Be Offered in I And II Year, English: 04 Credits to Be Earned in Sem - I, Modern Indian Language Of 04 Credits to Be Offered in II Year	NA
VEC	Value Education Courses	Understanding India, Environmental Science/Education, Digital	NA

		and Technological Solutions, Health & Wellness, Yoga Education, Sports, And Fitness	
IKS	Indian Knowledge System	Generic IKS Course: Basic Knowledge Of The IKS To Be Offered At First Year Level	Major-Specific IKS Courses: Advanced Information About the Major, Part of the Major Credit to Be Offered at Second- Or Third-Year Level
OJT	On-Job Training (Internship / Apprenticeship)	Corresponding To the Major Subject	Related To The Major
FP	Field Projects	Corresponding To the Major Subject	Related To the Major
CC	Co-Curricular Courses	Health And Wellness, Yoga Education Sports, And Fitness, Cultural Activities, NSS/NCC And Fine/ Applied/Visual/ Performing Arts	NA
CE	Community Engagement and Service		Related To Major
RP	Research Project	Corresponding To the Major Subject	Related To Major

Programme Template

Degree		B.A. / B.Sc. (Honours / Honours with Research)
Programme		Mathematics (2024 Pattern)
Preamble		This program's distinctive approach provides fundamental, high-quality knowledge in all significant fields of both pure and applied mathematics. In addition, it offers a comprehensive instructional programme with thoughtfully thought-out credit distribution. Fifty percent of the credits are made up of the major core courses, major specific elective courses, and relevant skill courses. Interdisciplinary minors, open electives, and major-specific IKS courses are added to this course to enhance the curriculum and promote flexibility. Vocational skill courses and skill enhancement courses are designed to enhance practical skills, whereas ability enhancement courses, IKS, and value education courses emphasize overall growth. Managing our daily lives and minimizing chaos using the help of mathematics is a powerful instrument that not just helps us understand the world around us but also serves as an efficient means of cultivating mental discipline. It is anticipated that students will acquire life skills including communication, argumentation, and general social values— all of which are essential for leading a fulfilling, wealthy, and successful life. Additionally, the students are in high demand due to their computational expertise and mathematical modelling models.
Programme Specific Outcomes (PSOs)		After completing this programme, Learners will be able to
	1	Demonstrating basic knowledge of mathematical skills, programming, and computational techniques required for employment.
	2	Applying the foundational understanding of mathematical concepts and programming techniques to solve real-life problems effectively.
	3	Designing mathematical models for real-life situations by utilizing programming and computational techniques as required.
	4	Critically analyzing results obtained from mathematical models and problem-solving processes, evaluating their effectiveness, and identifying areas for improvement.
	5	Applying acquired knowledge and skills to solve complex problems, demonstrating the potential to contribute as a researcher in mathematics and related fields.
	6	Demonstrating effective communication skills in both written and verbal forms to convey mathematical

		concepts, research findings, and problem-solving methodologies clearly and effectively.
Eligibility Criteria for Programme		H.S.C. / (10+2) with mathematics or equivalent from a recognized board **or** 10+3 Diploma (any stream) awarded by any state board of technical education.
Intake		

Structure with Course Titles

B.Sc. In Mathematics

Semester – V

Sr. No.	Course	Type of Course	Credits	Marks	Int Marks	Ext Marks
	Semester – V					
50132311	Group Theory (Th+Pr) (2+2)	Major (Core)	4	100	50	50
50132312	Real Analysis (Th+Pr) (2+2)	Major (Core)	4	100	50	50
51032311	The Introduction to Ancient Mathematics & Astronomy (Th)	IKS (Major Specific)	2	50	0	50
50232311	Differential Geometry (Th+Pr) (2+2)	Major (Elective) **(Any One)**	4	100	50	50
50232312	Laplace Transform (Th+Pr) (2+2)					
50232313	Probability and Statistics – I (Th+Pr) (2+2)					
50332311	Introduction to Mathematics for signal Processing (Th+Pr) (2+2)	Minor Stream **(Any One)**	**4**	100	50	50
50332312	Partial Differential Equations I (Th+Pr) (2+2)					
50632301	R- Programming	VSC-4	2	50	50	0
51332301	Field Project	FP	2	50	50	0
			22	**550**	**300**	**250**

Semester – VI

Sr. No.	Course	Type of Course	Credits	Marks	Int Marks	Ext Marks
	Semester - VI					
60132311	Ring Theory (Th+Pr) (2+2)	Major (Core)	4	100	50	50
60132312	Introduction to Complex Analysis (Th+Pr) (2+2)	Major (Core)	4	100	50	50
60232311	Operations Research (Th+Pr) (2+2)	Major (Elective) **(Any One)**	4	100	50	50
60232312	Probability and Statistics-II (Th+Pr) (2+2)					
60332311	Fourier Series and Boundary Value Problem	Minor Stream	2	50	0	50
60332312	Image Processing-II (Th+Pr) (2+2)	Minor Stream **(Any One)**	**4**	100	50	50
60332313	Partial Differential Equations-II (Th+Pr) (2+2)					
61232321	OJT (Pr)	OJT	4	100	50	50
			22	**550**	**250**	**300**

Exit with Degree (3-year)

Course Syllabus

Semester – V

.5.1 Major (Core)

Course Titles	**Group Theory (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	After going through the course, learners will be able to
	1. Identify and determine whether given mathematical structures form groups, and classify them as abelian, cyclic, or permutation groups.
	2. Understand homomorphism and isomorphism.
	3. Understand and apply new operations to construct a group.
	4. Apply normal subgroup to construct Factor Group
Module 1 (Credit 1) – Groups	
Learning Outcomes	After learning the module, learners will be able to
	1. Use Langrange's theorem and its application to order of group.
	2. Define and compute the coset.
Content Outline	• Groups • Properties of group • Subgroup • Order of elements in group • Cosets and Langrange's Theorem
Module 2 (Credit 1) – Homomorphism	
Learning Outcomes	After learning the module, learners will be able to
	1. Identify Isomorphism between two groups.
	2. Find the kernel of homomorphism.
Content Outline	• Homomorphism • Kernel of a homomorphism • Factor Groups, Normal subgroups, Simple group, Fundamental theorem of homomorphism • Isomorphism and Automorphism • Properties of group homomorphism.
Module 3 & 4	**List of Practical's** • Examples on identification of group • Groups of symmetry of equilateral triangle, rectangle and square

	• Finding a generator of subgroup of cyclic group • Examples Order of an Element in a Group • Examples on verification of subgroup • Examples on Verification of Lagrange's Theorem • Examples on verification of group homomorphism • Finding the kernel of a group homomorphism • Test whether a given subgroup is normal in a group • Examples on Isomorphism Between Group • Examples on Factor groups and Normal subgroups • Examples on Isomorphism and Automorphism

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE) –

- Students are instructed to construct different examples of the group. Classify these groups as abelian, cyclic, simple and normal subgroups. (CO1, CO2)
- Students are suggested to use Langrange's Theorem and homomorphism Theorem. (CO3)

References

1. N. Herstein, Topics in Algebra, John Wiley and Sons.
2. N.S. Gopalakrishnan, University Algebra, Second Edition, New Age International, New Delhi Delhi,
3. Joseph A. Gallian, Contemporary Abstract Algebra (4th Edition), Narosa Publishing House.
4. P.B. Bhattacharya, S.K. Jain and S.R. Nagpal, Basic Abstract Algebra, Second Ed., Foundation Books, New Delhi, 1995.
5. U. M. Swamy, A. V. S. N. Murthy, Algebra Abstract and Modern, Pearson

Semester – V

.5.2 Major (Core)

Course Titles	**Real Analysis (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	After going through the course, learners will be able to
	1. Recognize sequences and their properties such as convergence, divergence, boundedness, and monotonicity.
	2. Demonstrating operations on sequences and analyze concepts like limit superior, limit inferior, and Cauchy sequences.
	3. Demonstrate convergence and divergence of infinite series including special types of series.
	4. Analyze the various convergence tests and analyze the behavior of series under rearrangement
Module 1 (Credit 1) - Sequences of Real Numbers	
Learning Outcomes	After learning the module, learners will be able to
	1. Construct various types of Sequences
	2. Developed Cauchy Sequences
Content Outline	• Definition of sequence and subsequence • Limit of a sequence • Convergent sequences (Definition and Examples only) • Divergent sequences (Definition and Examples only) • Bounded sequences (Definition and Examples only) • Monotone sequences (Definition and Examples only) • Operations on convergent sequences • Operations on divergent sequences • Limit superior and limit inferior • Cauchy sequences
Module 2 (Credit 1) – Series of Real Numbers and Improper Integral	
Learning Outcomes	After learning the module, learners will be able to
	1. Achieve mastery in Series and Improper Integral
	2. Apply the Test of Convergence for series and Improper Integral
Content Outline	• Convergence and divergence • Series with nonnegative terms • Alternating series • Conditional convergence and absolute convergence

	• Rearrangements of series • Tests for absolute convergence • Series whose terms form a non-increasing sequence • Improper Integrals on Closed and Bounded Intervals • Tests for Convergence of Positive Integrands • Improper Integrals on Unbounded Intervals and Tests for their Convergence
Module 3 & 4	**List of Practical** • Limit of a sequence • Convergence and divergence of a sequence • Bounded and Monotone sequences • Operations on Convergent and divergent sequences • Limit superior and Limit inferior • Cauchy sequence • Convergence and divergence of series • Alternating Series and Series with nonnegative terms • Conditional convergence and absolute convergence • Tests of absolute Convergence • Improper Integrals on closed and bounded intervals and test of convergence of positive integrals • Improper Integrals on unbounded intervals and test of convergence {Teacher can choose at list five problems in real-life on specific topic for each practical}

Assignment/Activities towards Comprehensive Continuous Evaluation (CCE),

- Students are instructed to find various types of Sequences and Operations on it. (CO1 and CO2)
- Students are suggested to use various test to check the convergence of series and Improper Integral. (CO4)
- Students are suggested to find Special types of series. (CO3)

Recommended Books:

1. Introduction to Real Analysis, Third edition, Robert, G. Bartle, Donald Sherbert, John Wiley and Sons
2. Methods of Real Analysis, 2nd Ed., Richard R. Goldberg, John Wiley and Sons

Semester – V

.5.3 IKS (Major Specific)

Course Titles	**The Introduction to Ancient Mathematics & Astronomy**
Course Credits	**2 Credit's**
Course Outcomes	After going through the course, learners will be able to
	1. Recognize information about great mathematicians and astronomers who given significant contribution in Indian mathematics and astronomy.
	2. Trace, identify, practice and develop the significant Indian mathematic and astronomical knowledge.
	3. To help to understand the astronomic significance with the human holistic development of physical, mental and spiritual wellbeing and Evaluate various problems easily by using sulabha sutras.
	4. Understand Positional astronomy
Module 1(Credit 1) – Introduction to Ancient Indian Mathematics	
Learning Outcomes	After learning the module, learners will be able to
	1. Identify and classify Mathematical & Astrological achievement in India.
	2. Develop knowledge about Evolution of Indian Numerals (Brahmi (1st century), Gupta (4th century) & Devanagri Script (11th century).
Content Outline	• Brief introduction of inception of Mathematics & Astronomy from vedic periods. • Details of different authors who has given mathematical & astronomical sutra (e.g. arytabhatta, bhaskara, brahmagupta, varamahira, budhyana, yajanvlkya, panini, pingala, 21 bharat muni, sripati, mahaviracharya, madhava, Nilakantha somyaji, jyeshthadeva, bhaskara-II, shridhara) • Periodical enlisting of Mathematical & Astrological achievement in India. • Evolution of Indian Numerals (Brahmi (1st century), Gupta (4th century) & Devanagri Script (11th century). • Veda & Sulvasutras (Pythagoras theorem, Square root & Squaring Circle) (baudhayana sulbhasutra, apastamba sulbhasutra, katyayana sulbhasutra, manava sulbhasutra, maitrayana sulbhasutra, varaha sulbhasutra, vadhula sulbhasutra bhaskara Pingala's chandasutras, sunya, yaat-tavat
Module 2(Credit 1) – Ancient Mathematics and positional Astronomy:	
Learning	After learning the module, learners will be able to

Outcomes	1. Solve various problems easily by using ancient sutras
	2. Apply standard techniques in mathematics given by Aryabhata, Brahmagupta, Acharya ayatavrtta
Content Outline	• Aryabhata (Aryabhatiya, Asanna, ardha-jya, kuttaka,), (trigonometory,shridhara, (Sidhantashiromani), Varamahira panchasiddhantika. mahavira) • Brahmagupta (vargaprakrati, bhramasphuta siddhanta, Bhaskara bhavana) • Acharya ayatavrtta, ganitasarasamgraha, lilavathi, ganesadaivajna, randavantika, suryasidhhanta, grahalaghava, sadratnamala, mandavrtta, sighrartta, Bijaganita, Bakshali manuscript Golavada, Madhyamanayanaprakara, Mahajyanayanaprakara (Method of Computing Great Sines), Lagnaprakarana, Venvaroha, Sphutacandrapti, Aganita-grahacara , Chandravakyani (Table of Moon-mnemonics) • Positional astronomy (sun, planets, moon, coordinate systems, precision of the equinox and its effects, eclipses, comets and meteors), Mahayuga & Kalpa system Yuga system, ayanas, months, tithis and seasons, time units, sun and moon's motion, planet position, ayanachalana, zero-precision year, katapayaadi system, Indian nakshatra system, astronomy

Assignment/Activities towards Comprehensive Continuous Evaluation (CCE),

- Students shall write brief biography of ancient Indian Mathematicians and their work. (CO1)
- Apply Sulabh Sutras to solve problems(CO2), (CO3)
- Write an essay on positional astronomy (CO4)

References

1. Textbook on IKS by Prof. B Mahadevan, IIM Bengaluru.
2. Dharmpal, Indian science and technology in the eighteen century, rashtrottahana sahitya, 1983
3. A Kolachana, Studies in Indian Mathematics and Astronomy, Hindustan Book agency
4. S B Rao, Indian Mathematics and Astronomy: Some Landmarks (Revised Third Edition), Bhartiya Vidhya Bhavan, 2012,
5. G.G. Josheph, Indian Mathematics: Engaging with the World from Ancient to Modern Times, speaking Tiger, 2016
6. B.S. Yadav, Ancient Indian Leaps into Mathematics, brikausher publication, 2010
7. D.P Chatopadhya, Ravinder kumar, Mathematics, Astronomy, and Biology in Indian Tradition: Some Conceptual Preliminaries (Phispc Monograph Series on History of Philosophy, Science and Culture in India, No 3), Munshiram manohalal publication, 1995
8. G.E. Clark, The Aryabhatiya of Aryabhata: An Ancient Indian Work on Mathematics and Astronomy, Kesinger publicaition, 2010

9. K.V. Sharma. Ganita yuktibhasa (Analytical Exposition of the Rationales of Indian Mathematics and Astronomy, Kindle, 2021
10. R Mercier, Studies on the Transmission of Medieval Mathematical Astronomy (Variorum Collected Studies), rout-ledge publication, 2004

Semester – V

.5.4 A. Major (Elective)

Course Titles	**Differential Geometry (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	After going through the course, learners will be able to
	1. CO1: Understand and apply orthogonal transformations and isometries in $\boldsymbol{R^n}$, including rotations, reflections, and translations.
	2. CO2: Understand and analyze parametrized curves in $\boldsymbol{R^2}$and $\boldsymbol{R^3}$, including curvature, torsion, and their geometric properties.
Module 1 (Credit 1) - Isometries of $\boldsymbol{R^n}$	
Learning Outcomes	After learning the module, learners will be able to
	1. Explain and verify properties of orthogonal matrices and orthogonal transformations in $\boldsymbol{R^n}$, including preservation of length, angle, and inner product.
	2. Classify and construct isometries in $\boldsymbol{R^2}$and $\boldsymbol{R^3}$, including reflections, rotations (using Euler's theorem), translations, and glide reflections, and determine whether they preserve or reverse orientation.
Content Outline	• Orthogonal transformations of $\boldsymbol{R^n}$and Orthogonal matrices. • Reflection, Rotations and Translations of $\boldsymbol{R^n}$and $\boldsymbol{R^n}$ • Euler's theorem • Hyperplanes • Reflection map about a hyperplane W of $\boldsymbol{R^n}$through the origin • Isometry of $\boldsymbol{R^n}$ • Isometries of the plane • Orientation preserving and reversing isometries of $\boldsymbol{R^n}$ • Glide reflection.
Module 2 (Credit 1) – Curves	
Learning Outcomes	After learning the module, learners will be able to
	1. Explain parametrized and regular curves, and compute arc length and curvature for plane curves.
	2. Apply concepts of curvature and torsion to study space curves using Serret–Frenet equations and interpret their geometric meaning.
Content Outline	• Parametrized curves • Regular curves in $\boldsymbol{R^2}$ and $\boldsymbol{R^3}$

	• Arc length parametrization • Curvature and torsion of curves in $\boldsymbol{R}^3$ • Plane curves • Signed curvature for plane curves • Fundamental theorem for plane curves • Space curves • Serret-Frenet equations. • Fundamental theorem for space curves.
Module 3 & 4	**List of Practical** • Orthogonal transformations of $\boldsymbol{R}^n$and Orthogonal matrices • Reflection, Rotations and Translations of $\boldsymbol{R}^2$and $\boldsymbol{R}^3$ • Euler's theorem • Hyperplanes • Reflection map about a hyperplane W of $\boldsymbol{R}^n$through the origin • Isometry of $\boldsymbol{R}^n$and Isometries of the plane • Orientation preserving and reversing isometries of $\boldsymbol{R}^n$ • Glide reflection. • Parametrized curves, Regular curves in $\boldsymbol{R}^2$ and $\boldsymbol{R}^3$ • Arc length parametrization, Curvature and torsion of curves in $\boldsymbol{R}^3$ • Plane curves, Signed curvature for plane curves • Fundamental theorem for plane curves • Space curves • Serret-Frenet equations • Fundamental theorem for space curves.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE) –

- Analyze geometric transformations and verify their properties such as isometry and orientation.
- Study parametrized curves by computing arc length, curvature, torsion, and sketching curves.

References

1. M. Artin, Algebra, Prentice Hall of India, 2011.
2. C. Bar, Elementary Differential geometry, Cambridge University Press, 2010.
3. M. DoCarmo, Differential geometry of curves and surfaces, Prentice Hall Inc., 1976.
4. S. Kumaresan, Linear Algebra, A Geometric Approach, 2000.

5. A. Pressley, Elementary Differential Geometry, Springer UTM.

Semester – V

.5.4 B. Major (Elective)

Course Titles	**Laplace Transform (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	After going through the course, learners will be able to
	1. Students will be able to know the use of Laplace transform in system modeling, digital signal processing, process control.
	2. Demonstrate the Inverse Laplace transform and Convolution theorem
	3. Solve an initial value problem for an nth order ordinary differential equation using the Laplace transform.
	4. Solve the system of differential equations
Module 1(Credit 1) - The Laplace Transform	
Learning Outcomes	After learning the module, learners will be able to
	1. Construct sufficient condition for existence of Laplace transform and properties.
	2. Developed advanced problem-solving skills in evaluation of integral and transform of special functions
Content Outline	• Definition and Laplace Transform of some elementary functions. • Sufficient condition for existence of Laplace Transform • Some important properties of Laplace Transform. • Methods of finding Laplace Transform: Direct Method, Series Method • Evaluation of Integration • Some Special Functions
Module 2(Credit 1) – The Inverse Laplace Transform and Applications	
Learning Outcomes	After learning the module, learners will be able to
	1. Achieve mastery in Inverse Laplace transform
	2. Apply the transform to solve differential equations and system of differential equations
Content Outline	• Definition of inverse Laplace transform and, Some inverse Laplace Transform. • Some important properties of Inverse Laplace Transform. • Methods of finding inverse Laplace Transforms: Partial Fraction Method and Series Method. • The Heaviside's Expansion formula. • Beta function, Evaluation of Integration.

	• Applications to Differential Equations ○ Ordinary Differential Equations with constant coefficients. ○ Ordinary Differential Equations with variable coefficients. ○ Simultaneous Ordinary Differential Equations.
Module 3 & 4	**List of Practical's** • Laplace transform of standard functions • Problems based on properties of L.T. • Problems by using direct method • Problems by using series method • Integrals • Special functions • Inverse L.T. • Finding Inverse Laplace Transform by Partial fraction Method • Finding Inverse Laplace Transform by Series Method • **Beta function and integration** ○ Ordinary Differential Equations with constant coefficients ○ Ordinary Differential Equations with variable coefficients ○ Simultaneous Ordinary Differential Equations I ○ Simultaneous Ordinary Differential Equations II

Assignment/Activities towards Comprehensive Continuous Evaluation (CCE),

- Students are instructed to find Laplace transform and inverse Laplace transform of some functions. (CO1 and CO2)
- Students are suggested to use Laplace transform to solve differential equations and system of differential equations. (CO3)
- Students are suggested to solve system of differential equations

References

1. Schaum's Outline Series-Theory and Problems of Laplace Transform by Murray R. Spiegel.
2. Joel L. Schiff, The Laplace Transforms- Theory and Applications, Springer Verlag New York 1999.
3. Lokenath Debnath and Dambaru Bhatta, Integral Transforms and Their Applications, Third Edition, CRC Press.
4. M.D. Raising hania, - H.C. Saxsena and H.K. Dass ; Integral Transforms , S.Chand and Company pvt. Ltd., New Delhi. (2014).

Semester – V

.5.4 C. Major (Elective)

Course Titles	**Probability and Statistics -I (Th+Pr)**
Course Credits	**4 Credit's**
Course Outcomes	After going through the course, learners will be able to
	1. Recognize Sample space, Events and Probabilities
	2. Demonstrating the additive rule, Conditional probability and Multiplication rule
	3. Demonstrate Bayee's theorem and its applications to real world problems.
	4. Analyze the random Variable, Independent random variable,
Module 1(Credit 1) - Introduction to Probability	
Learning Outcomes	After learning the module, learners will be able to
	1. Construct Events and their probabilities.
	2. Developed advanced problem-solving skills in Additive rule, Conditional probability, Multiplicative rule and Baye's rule.
Content Outline	• Sample space and events • probability of an event • additive rules • conditional probability • Multiplicative rule • Bayes' rule.
Module 2(Credit 1) – Random Variable	
Learning Outcomes	After learning the module, learners will be able to
	1. Achieve mastery in Random variables and Independent random Variables.
	2. Apply the properties of discrete probability distribution, Continuous probability distribution and joint probability distributions.
Content Outline	• Concept of a random variable • discrete probability distribution • continuous probability distribution • joint probability distribution • Independent random variables and Chebyshev's theorem • Mean of a random variable • Variance and Covariance

	• Mean and Covariance of linear combinations of random variables • Functions of random variables and transformations of variables • Moments and Moment Generating Functions, definition of Expectation, theorems on Expectation and its related problems, Variance in terms of Expectation and related problems
Module 3 & 4	**List of Practical** • Sample space and events • probability of an event • additive rules • conditional probability • Multiplicative rule • Bayes' rule. • Concept of a random variable • discrete probability distribution • continuous probability distribution • joint probability distribution • Independent random variables and Chebyshev's theorem • Mean of a random variable • Variance and Covariance • Mean and Covariance of linear combinations of random variables • Functions of random variables and transformations of variables • Moments and Moment Generating Functions, definition of Expectation • Theorems on Expectation and its related problems, Variance in terms of Expectation and related problems

Assignment/Activities towards Comprehensive Continuous Evaluation (CCE),

- Students are instructed to find probability of given event and apply addition rule, multiplication rule in various situations. (CO1 and CO2)
- Students are suggested to use Baye’s theorem. (CO3)
- Students are suggested to find Mean, Variance and Covariance of a random Variable.

References

1. R. Walpole, R.H. Myers, S.L. Myers, and K. Ye ; Probability and Statistics for Engineers and Scientists (Seventh Edition, Pearson India).
2. Sheldon M. Ross ; Introduction to Probability and Statistics for Engineers and Scientists, (Fourth Edition).

3. M. Samules, J. Witmer and A. Schaffner ;Statistics for the Life Sciences (Fifth Edition, Pearson India)
4. Richard Gupta, C B Gupta.; Probability and Statistics for Engineers.
5. Sheldon M. Ross ; A first course in Probability (Nineth Edition).
6. J. N. Kapoor, H. C. Saxena; Mathematical Statistics, S. Chand.

Semester – V

.5.5 A. Minor Stream

Course Titles	**Introduction to Mathematics for Signal Processing**
Course Credits	**4 Credit's**
Course Outcomes	After going through the course, learners will be able to
	1. Recognize basic concepts of signals and systems
	2. Demonstrating mathematical tools like Fourier series and transforms.
	3. Demonstrate difference between continuous and discrete signals
	4. Analyze the mathematical concepts to real-world signal processing problems
Module 1 (Credit 1) - Mathematical Representation of Signals	
Learning Outcomes	After learning the module, learners will be able to
	1. Construct Basics of Signals and Systems
	2. Developed Energy and power of signals mathematically
Content Outline	• Definition and classification of signals • Continuous-time and discrete-time signals • Periodic and non-periodic signals • Even and odd signals • Basic operations on signals (shifting, scaling) • Introduction to systems and types • Elementary signals (unit step, impulse, ramp, exponential, sinusoidal) • Signal decomposition • Orthogonality of functions • Energy and power of signals (Introduction only)
Module 2 (Credit 1) – Fourier Series and Transforms	
Learning Outcomes	After learning the module, learners will be able to
	1. Achieve mastery Fourier series and Fourier Transforms for Signal Processing
	2. Apply the properties of Fourier series and transformation to find applications in signal analysis.
Content Outline	• Periodic signals and Fourier series • Dirichlet conditions (only Statement) • Trigonometric Fourier series

	• Complex exponential form • Properties of Fourier series • Definition of Fourier Transform • Properties (linearity, shifting, scaling) • Inverse Fourier Transform • Applications in signal analysis

Module 3 & 4 - Introduction to Mathematics for Signal Processing Practical

Practical 1: Definition and Classification of Signals

- Define a signal and give two real-life examples.
- Classify the signal $x(t) = t^2$ as continuous or discrete.
- Identify whether $x[n] = (-1)^n$ is discrete or continuous.
- Classify signals as deterministic or random with examples.
- Determine whether $x(t) = \sin t$ is analog or digital.

Practical 2: Continuous-Time and Discrete-Time Signals

- Plot $x(t) = t$ for $-2 \leq t \leq 2$.
- Plot $x[n] = n^2$ for $n = -3$ to 3.
- Convert a continuous signal into a discrete signal by sampling.
- Identify sampling interval in a given dataset.
- Compare continuous and discrete signals with examples.

Practical 3: Periodic and Non-Periodic Signals

- Check whether $x(t) = \sin(3t)$ is periodic.
- Find the period of $x(t) = \cos(5t)$.
- Determine if $x(t) = e^t$ is periodic.
- Test periodicity of $x[n] = \sin(\pi n/2)$.
- Give two examples of non-periodic signals.

Practical 4: Even and Odd Signals

- Check if $x(t) = t^2$ is even or odd.
- Determine whether $x(t) = t^3$ is even or odd.
- Decompose $x(t) = t + t^2$ into even and odd parts.
- Verify even/odd nature of $\cos t$ and $\sin t$.
- Find even and odd components of $x(t) = e^t$.

Practical 5: Basic Operations on Signals

- Perform time shifting on $x(t) = t$ to get $x(t-2)$.
- Perform time scaling on $x(t) = t^2$ to get $x(2t)$.
- Sketch $x(t+1)$ for a given signal.
- Compare compression and expansion of signals.
- Apply reflection: find $x(-t)$ for $x(t) = t$.

Practical 6: Elementary Signals

- Define and plot unit step function.
- Define and plot impulse function.
- Sketch ramp signal $r(t) = t\,u(t)$.
- Plot exponential signal e^{-t}.
- Plot sinusoidal signal $\sin(2\pi t)$.

Practical 7: Signal Decomposition

- Decompose a signal into even and odd parts.
- Represent a signal using unit step functions.
- Express a rectangular signal using step functions.
- Decompose a signal into basic signals.
- Verify decomposition using graphical method.

Practical 8: Orthogonality of Functions

- Check orthogonality of $\sin t$ and $\cos t$.
- Verify orthogonality over interval $[-\pi, \pi]$.
- Compute inner product of two functions.
- Show that $\sin(nt)$ and $\sin(mt)$ are orthogonal.
- Give applications of orthogonality.

Practical 9: Energy and Power of Signals

- Define energy of a signal.
- Calculate energy of $x(t) = e^{-t}u(t)$.
- Define power of a signal.
- Compute power of periodic signal $\sin t$.
- Classify signals as energy or power signals.

Practical 10: Introduction to Systems

- Define a system with examples.
- Classify systems as linear or nonlinear.
- Check whether a system is time-invariant.
- Determine if a system is causal.
- Define stable system with example.

Practical 11: Fourier series Basics

- Define Fourier series.
- State Dirichlet conditions.
- Find Fourier series of a simple periodic function.
- Write general trigonometric Fourier series.
- Identify fundamental frequency.

Practical 12: Trigonometric Fourier series

- Find coefficients for $x(t) = \sin t$.
- Compute Fourier coefficients for $\cos t$.
- Expand a square wave into Fourier series.
- Identify sine and cosine terms.
- Plot partial sums of Fourier series.

Practical 13: Complex Exponential Fourier series

- Write exponential form of Fourier series.
- Convert trigonometric to exponential form.
- Find coefficients C_n.
- Show relation between C_n and trigonometric coefficients.
- Solve a simple exponential Fourier series problem.

Practical 14: Fourier Transform

- Define Fourier Transform.
- Find Fourier Transform of $e^{-t}u(t)$.
- State properties: linearity.
- Apply time shifting property.
- Apply scaling property.

Practical 15: Inverse Fourier Transform & Applications

- Define inverse Fourier transform.
- Find inverse transform of a simple function.
- Verify transform pair.
- Apply Fourier transform in signal filtering.
- Discuss application in communication systems.

Assignment/Activities towards Comprehensive Continuous Evaluation (CCE),

- Students are instructed to find even and odd signals, Energy and power of signals. (CO1 and CO3)
- Students are suggested to use Properties of Fourier Transform. (CO2)
- Students are suggested to find Applications in Signal analysis. (CO4)

Recommended Books:

1. Signals and Systems – Alan V. Oppenheim and Alan S. Willsky
2. The Fourier Transform and Its Applications – Ronald N. Bracewell

Reference Books:

1. Signals and Systems – Simon Haykin
2. Fundamentals of Signals and Systems – Michael J. Roberts
3. Discrete-Time Signal Processing – Ronald W. Schafer
4. Signal Processing and Linear Systems – B. P. Lathi

Semester – V

.5.5 B. Minor Stream

Course Titles	**Partial Differential Equations-I**
Course Credits	
Course Outcomes	After going through the course, learners will be able to
	1. CO1: understand the basic concepts and method of finding the solution of first and second order Partial Differential Equations (PDEs).
	2. CO2: Understand and solve second-order partial differential equations and analyze their properties in potential theory.
Module 1 (Credit 1) - First Order Partial Differential Equations	
Learning Outcomes	After learning the module, learners will be able to
	1. Classify and solve semilinear and quasilinear first-order partial differential equations using the method of characteristics and Cauchy problem.
	2. Apply Monge strip and Charpit methods to find complete integrals and solutions of nonlinear partial differential equations.
Content Outline	• First order partial differential equations in two independent variables • Semilinear and Quasilinear equations in two independent variables • method of characteristics • the Characteristics Cauchy Problem • General solutions. • Non-linear equations in two independent variables: Monge Strip and Charpit Equations • Solution of Cauchy problem • Determination of Complete integral • solution of Cauchy problem
Module 2 (Credit 1) – Second Order Partial Differential Equations	
Learning Outcomes	After learning the module, learners will be able to
	1. Classify second-order PDEs and reduce them to normal form to solve Cauchy problems.
	2. Apply concepts of elliptic equations and potential theory, including Poisson’s theorem and maximum–minimum properties.
Content Outline	• Classifications of second order partial differential equations in two and more than two independent variables • method of reduction to normal form

	• the Cauchy problem. • Potential theory and elliptic differential equations • boundary value problems and Cauchy problem • Poisson's theorem • the mean value and the Maximum-Minimum properties
Module 3 & 4	**List of Practical** • First order partial differential equations in two independent variables • Semilinear and Quasilinear equations in two independent variables • Method of characteristics, the Characteristics Cauchy Problem, General solutions. • Non-linear equations in two independent variables: Monge Strip and Charpit Equations • Solution of Cauchy problem, Determination of Complete integral, solution of Cauchy problem

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE) –

- Solve first-order partial differential equations using methods such as characteristics, Cauchy problems, Monge's method, and Charpit equations.
- Analyze second-order partial differential equations by classifying them, reducing to normal form, solving boundary value problems, and verifying key properties.
- Classifications of second order partial differential equations in two and more than two independent variables
- Method of reduction to normal form, the Cauchy problem.
- Potential theory and elliptic differential equations
- Boundary value problems and Cauchy problem
- Poisson's theorem, the mean value and the Maximum-Minimum properties

References

1. Prasad, Phoolan, And Renuka Ravindran. Partial Differential Equations. New Age International, 1985.
2. Pinchover And Rubinstein, Y. "An Introduction To Partial Differential Equations." (2021).
3. Amaranath, T. An Elementary Course In Partial Differential Equations. Jones & Bartlett Learning, 2009.
4. Bers, Lipman, Fritz John, And Martin Schechter, Eds. Partial Differential Equations. American Mathematical Soc., 1964.
5. G.B. Folland, Introduction To Partial Differential Equations, Prentice Hall.

Semester – V

.5.6 VSC-4

Course Titles	**R – Programming**
Course Credits	**2 Credit's**
Course Outcomes	After going through the course, learners will be able to
	1. Recognize how to install R software.
	2. Demonstrating use of data structures ad conduct arithmetic operations.
	3. Demonstrate different operations on matrices and test their characteristics.
	4. Analyze the the Mathematical Calculations using a diagrammatic form
Module 1 (Credit 1) - Introduction to R	
Learning Outcomes	After learning the module, learners will be able to
	1. Construct various equations using operators
	2. Developed R objects
Content Outline	• **Introduction:** Getting Started with R Programming R is a free, Open Source Programming Language, so students can download from R Programming project Website and install on their own machine (Linux, Windows or MacOS). They do have RStudio, which is an integrated development environment (IDE) that provides a user-friendly interface. The section covers the following topics. - Installation of R - Use of R console - R script/ editor file, R Prompt, Menu Ribbon, Saving R editor/script file - Clearing R console, - Comments (single line, multiple line) - Packages, - Taking help in R - Closing R session. • **R Operators:** Assignment Operators: =, < − , − > , << − , − >> , assign() Arithmetic Operators: addition (+), subtraction (-), multiplication (*), division(/), exponent (ˆ or **), remainder operator (%%), Integer division (%/%) Comparison Operators: equal to (==), less than (<), greater than (>), less than or equal to (<=), greater than or equal to (>=), not equal to (! =) Logical Operators: element wise logical AND (&), logical AND (&&), element wise logical OR (|), logical OR (| |), logical NOT (!), xor(), isTRUE(), isFALSE(). • **Data Structures and R Objects**: Constants, Variables, Vectors, Matrices, Data Frame, Factors, Lists, Arrays Vectors: creating vectors using scan(), combine (c()), seq(), sequence operator (:), rep(). numeric vector, character vector, factors, converting numeric vectors into character vectors, converting character vectors into factors,

<table>
<tr><td></td><td>checking variable types using class(), type of(), is.numeric(), is.character(), is.factor(), arithmetic operations on vectors, printing vectors using print(), cat() functions. Matrices: creating matrix using matrix(), creating identity matrix using diag(), creating null matrix using diag(), converting matrices into data frames using as.data.frame(), checking the dimensions of the matrix using dim(), nrow(), ncol(), extracting rows, columns or elements of matrix. Data frames: creating data frames using data. Frame(), converting data frames into matrices using as.matrix(), view data frames in a new window using View(), extracting variables from a data frame using $ and [ ], sub setting of data frames using subset() and [ ]. Lists: Creating lists, storing and extracting elements of lists, applying functions on list using l apply().</td></tr>
<tr><td colspan="2">Module 2 (Credit 1) – Matrix Operations in R</td></tr>
<tr><td rowspan="3">Learning Outcomes</td><td>After learning the module, learners will be able to</td></tr>
<tr><td>1. Achieve mastery in R as a Calculator</td></tr>
<tr><td>2. Apply the Test of Convergence for series and Improper Integral</td></tr>
<tr><td>Content Outline</td><td>

R as a Calculator:
BODMAS rule. Basic Mathematical functions: sqrt(), exp(), abs(), round() ceiling(), floor(), log(), log10(), sum(), prod(), cumsum(), cumprod(), min(), max(), diff(), sign(), pi, sort(), order(), etc. Complex Numbers: complex(), is.complex(), as.complex(), Re(), Im(), Mod(), Arg(), Conj() etc. Special Functions: beta(), gamma(), choose() and factorial() in base R, combn() and permn() available in R package combinat. Trigonometric functions: sin(), cos(), tan() etc. Set operations: union(), intersect(), setdiff(), setequal(), is.element(), %in%, all(), cross product of two sets.
Matrix Manipulation: dim(), colnames(), rownames(), cbind() , rbind(), colSums(), rowSums(), colMeans(), rowMeans(), apply().
Arithmetic Operations on matrix: Addition, subtraction, multiplication of matrices, row sums and column sums of matrix, power of a matrix.
Matrix Product: matrix multiplication (%*%), crossprod(), Outer product (%o%).
Rank of matrix using rankMatrix(), transpose of a matrix using t(), Finding determinant of matrix using det(), finding inverse of matrix using solve(), trace of a matrix.
Verifying properties of trace of matrix and transpose of matrix, solving system of linear equations using solve().

</td></tr>
</table>

Assignment/Activities towards Comprehensive Continuous Evaluation (CCE),

- Students are instructed to use of data structures and conduct arithmetic operations. (CO1 and CO2)
- Students are suggested to use various operations on matrices and test their characteristics. (CO3)
- Students are suggested to find Mathematical Calculations using a diagrammatic form. (CO4)

Recommended Books:

1. Long, J.D. Teetor P.(2019). R Cookbook (2nd Ed.). O'Reilly Media, Inc.
2. Pfaff, T. (2019). R For College Mathematics and Statistics (1st Ed.), Chapman and Hall/ CRC., New York.
3. Purohit, S.G.; Gore, S.D. and Deshmukh, S.R. (2015). Statistics using R (2nd Ed.), Narosa Publishing House, New Delhi.
4. Tilman M. Davies (2015). The Book of R: A First Course in Programming and Statistics (1st Ed.), USA.

Semester – V

.5.7 Field Project

It shall be completed in 30 hours.

Guidelines for Field Project:

- **Steps in Project**
  - Selecting a Topic - 3hours
  - Gathering data - 12 hours
  - Developing a model - 8 hours
  - Analyzing the findings - 3 hours
  - Prepare a final report - 3 hours
  - Present the report - 1 hour

- **Following are only sample projects; Teacher can suggest different projects for group of students)**
  - Modelling population growth of a specific area using differential equations
  - Designing a dream house using specific 2D shapes to calculate area and perimeter
  - Study of profit / loss for a shop or bank.
  - Mathematics in insurance.
  - Business application of Python programming
  - Using python automate repetitive tasks
  - Study of Profit /loss to bank on loan account
  - Use of LPP to improve profit in a shop/ Mall.
  - Use of Operations research in business.
  - Weather data prediction
  - Stock price analysis by using python software
  - Use of R software in banking and finance firms

Course Syllabus

Semester – VI

.6.1 Major (Core)

Course Titles	**Ring Theory (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	After going through the course, learners will be able to
	1. Understand the scope of Ring theory in abstract algebra.
	2. Identify Field.
	3. Bridge the group theory to ring theory.
	4. Construct quotient field.
Module 1(Credit 1) – Introduction to Rings	
Learning Outcomes	After learning the module, learners will be able to
	1. Identify and determine mathematical structures to form rings.
	2. Understand the concepts of ideals and classify it into maximal and prime ideals
Content Outline	• Definition, examples and properties of rings. • Integral Domains • Fields • Factor rings • Ideals, prime ideals, maximal ideals
Module 2(Credit 1) – Ring Homomorphisms.	
Learning Outcomes	After learning the module, learners will be able to
	1. Understand and apply the concept of homomorphism further to isomorphism.
	2. Apply fundamental theorem for rings.
Content Outline	• Definition and examples • Ring of Gaussian integers • Properties of ring homomorphisms • The field of quotients • Fundamental theorem
Module 3 & 4	**List of Practical** • Examples on Verification of Rings • Determine types of ring • Determine units and zero divisor • Example on subring

	• Example on integral domain • Examples on coset and quotient ring • Example on fields • Examples on homomorphism and isomorphism • Example on principal ideal • Determine whether an ideal is prime or maximal • Problems on Gaussian integers • Problems based on field of Quotients.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE) –

- Define the operations on set of Integers, Natural Numbers and 3 ×3 matrices over R to form a ring. Make detail note of all axioms. Submit the report to course instructor. (CO2, CO3)
- Make the detail note of all properties of ring. Try to understand the properties conceptually. Distinguish between the properties for ring. Ideals and field. Submit the report to course instructor. (CO2)

References

1. S. D. Adhikari, An Introduction to Commutative Algebra and Number theory, Narosa Publishing House.
2. T.W. Hungerford, Algebra, Springer.
3. D. Dummit, R. Foote, Abstract Algebra, John Wiley & Sons, Inc.
4. I.S. Luthar, I.B.S. Passi, Algebra Vol. I and II, Narosa publication.
5. U. M. Swamy, A. V. S. N. Murthy, Algebra Abstract and Modern, Pearson.
6. Charles Lanski, Concepts Abstract Algebra, American Mathematical Society.
7. Sen, Ghosh and Mukhopadhyay, Topics in Abstract Algebra, Universities press.
8. P. B. Bhattacharya, S. K. Jain, and S. R. Nagpaul, Abstract Algebra, Second edition, Foundation Books, New Delhi.
9. N. S. Gopalakrishnan, University Algebra, Wiley Eastern Limited.
10. I. N. Herstein. Topics in Algebra, Wiley Eastern Limited, Second edition.

Semester – VI

.6.2 Major (Core)

Course Titles	**Introduction to Complex Analysis (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	After going through the course, learners will be able to
	1. Determine the analytic functions.
	2. Identify singular points of functions.
	3. Evaluate contour integral.
	4. Obtain Taylor series and Laurent series expansion of functions.
Module 1(Credit 1) – Complex Number and Analytic Functions	
Learning Outcomes	After learning the module, learners will be able to
	1. Examine the differentiability of functions.
	2. Understand the geometric interpretation of complex number
Content Outline	• Polar form, exponential form and roots of complex numbers • Point at infinity-extended complex plane • Functions, limit and continuity • Differntiability and Cauchy Riemann Integration • Analytic functions and harmonic functions
Module 2(Credit 1) – Complex Integration.	
Learning Outcomes	After learning the module, learners will be able to
	1. Determine the Residue and Poles
	2. Apply Cauchy's Integral Formula to determine the simple closed contour.
Content Outline	• Power series, types of functions • Integration, contour • Cauchy Gaursat Theorem , Cauchy's Integral Formula • Liouville's Theorem, Taylor's Theorem • Residue and Poles
Module 3 & 4	**List of practical** • Examples on geometry of complex number. • Finding roots of given complex number. • Examples on limit continuity of complex function • Example on Differentiability of complex function • Test functions for differentiability using Cauchy–Riemann equations

	• Example on Harmonic function • Examples on evaluating complex integration • Example on contour integrals • Examples on Cauchy Goursat theorem • Example on Cauchy Integral Formula, singularity of complex functions. • Problems on Liouville theorem and Taylors Theorem • Problems on Residues and Poles

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE) –

- Students are suggested to solve the multiple examples on analytic functions. Also verify Cauchy Riemann Equations. Make the detailed note of your solutions. Submit it to the course instructor (CO2,CO3)
- Students are understand the terms like singular points, poles, and residue. Solve the examples on complex integration by using Cauchy's integral formula and pole's .(CO3)

References

1. J.W. Brown and R.V. Churchill, Complex analysis and Applications, International student edition 8th edition 2009.
2. S. Ponnusamy and H. Silverman, Birkhauser , Complex variables with applications,2006
3. J. B. Conway, Functions of one complex variable, Narosa publication second edition, 1978.
4. Robert E. Greene and Steven G. Krantz, Function theory of one complex variable
5. T.W. Gamelin, Complex analysis

Semester – VI

.6.3 A. Major (Elective)

Course Titles	**Operations Research (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	After going through the course, learners will be able to
	1. Formulate real-world problems into linear programming models,
	2. Apply the Simplex and Big-M methods to obtain the solution of linear programming problems.
	3. Attain mastery in solving assignment problems using the Hungarian Method.
	4. Develop the ability to solve transportation problems.
Module 1(Credit 1) – Linear Programming Problem	
Learning Outcomes	After learning the module, learners will be able to
	1. Apply optimization techniques like Simplex Method, graphical methods.
	2. Solve the dual problem
Content Outline	• Basic Definitions, Formulation of L.P.P. and Graphical Method • Simplex Method • Big-M Method • Definition of duality problem. • Relationship between primal and dual, examples
Module 2(Credit 1) – Transportation and Assignment Problem.	
Learning Outcomes	After learning the module, learners will be able to
	1. Develop mastery in transportation problem solutions using North-West corner rule, matrix minima method, VAM
	2. Solve Travelling salesman problem.
Content Outline	• Introduction to transportation problem, Transportation Algorithms • North-West corner rule, matrix minima method, VAM. • MODI method • Assignment Problem (Hungarian method) • Travelling salesman problem
Module 3 & 4	**List of Practical** • Construction Linear Programming model • Solution of Linear Programming Problem by graphical method.

	• Solution of Linear Programming problem by Simplex method. • Big M method • Examples on MODI method • Solution of transportation problem using North West Corner Method • Solution of transportation problem using Least Cost Method • Solution of transportation problem using Vogel's Approximation Method. • Hungarian Method for assignment problem • Traveling salesman problem

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE) –

- Students are suggested to convert any real world problem into linear programming model. Solve the concern model using any optimization techniques you learn from this course. Submit the report to instructor (CO3, CO4)
- Students are instructed to solve two transportation problem. Use methods North-West Corner Rule, Least Cost Method, Vogel's Approximation Method.(CO2, CO3)

References

1. J K Sharma, Operations Research (Theory and Applications, second edition, 2006), Macmillan India Ltd.
2. Hamdy A. Taha, Operation Research (Eighth Edition, 2009), Prentice Hall of India Pvt. Ltd, New Delhi.
3. S. D. Sharma, Operations Research, Kedar Nath Ram Nath and Company, Thirteenth edition 2001.
4. Hira and Gupta, Operation Research (Twentieth Edition 2009), S. Chand and Company Ltd., New Delhi.
5. Hillier and Lieberman, Introduction to Operations Research.
6. Richard Broson, Schaum Series Book in Operations Research, Tata McGrawHill Publishing Company Ltd.

Semester – VI

.6.3 B. Major (Elective)

Course Titles	**Probability and Statistics -II (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	After going through the course, learners will be able to
	1. Recognize and classify the discrete probability distributions
	2. Demonstrating the Binomial, Hypergeometric, Geometric and Poisson distribution
	3. Demonstrate Continuous Probability distributions
	4. Analyze and apply the continuous probability distributions on various problems.
Module 1(Credit 1) - Some Discrete Probability Distributions	
Learning Outcomes	After learning the module, learners will be able to
	1. Construct Discrete probability distributions.
	2. Developed advanced problem-solving skills in discrete probability distributions.
Content Outline	• Binomial and Multinomial distributions • Hypergeometric distribution • Negative binomial distribution • Geometric distribution • Poisson distribution and Poisson process.
Module 2(Credit 1) – Some Continuous Probability Distributions	
Learning Outcomes	After learning the module, learners will be able to
	1. Achieve mastery in continuous probability distributions like uniform distributions, Normal distributions, Gamma, exponential and Chi Square distributions.
	2. Apply the properties of Continuous probability distribution,
Content Outline	• Continuous Uniform distribution • Normal distribution • area under the normal curve • applications of the Normal distribution • normal approximation to the binomial distribution • Gamma distribution • Exponential distribution • Chi-squared distribution

Module 3 & 4	**List of Practical** • Binomial and Multinomial distributions • Hypergeometric distribution • Negative binomial distribution • Geometric distribution • Continuous Uniform distribution • Normal distribution • area under the normal curve • applications of the Normal distribution • normal approximation to the binomial distribution • Gamma distribution • Exponential distribution • Chi-squared distribution • Poisson distribution and Poisson process

Assignment/Activities towards Comprehensive Continuous Evaluation (CCE),

- Students are instructed to solve problems on Binomial distributions. Hyper geometric distributions, geometric and Poisson distributions (CO1 and CO2)
- Students are suggested to use normal distribution. (CO3)
- Students are suggested apply gamma, Exponential and Chi Square distributions (CO 4)

References

1. R. Walpole, R.H. Myers, S.L. Myers, and K. Ye ; Probability and Statistics for Engineers and Scientists (Seventh Edition, Pearson India).
2. Sheldon M. Ross; Introduction to Probability and Statistics for Engineers and Scientists, (Fourth Edition).
3. M. Samules, J. Witmer and A. Schaffner; Statistics for the Life Sciences (Fifth Edition, Pearson India)
4. Richard Gupta, C B Gupta.; Probability and Statistics for Engineers.
5. Sheldon M. Ross; A first course in Probability (Nineth Edition).
6. J. N. Kapoor, H. C. Saxena; Mathematical Statistics, S. Chand.

Semester – VI

.6.4 A. Minor Stream

<table>
<tr><td>Course Titles</td><td>Fourier Series and Boundary Value Problems (Th)</td></tr>
<tr><td>Course Credits</td><td>2 Credit's</td></tr>
<tr><td rowspan="5">Course Outcomes</td><td>1. Understand Fourier Series Representation
• Express periodic functions as Fourier series using sine and cosine expansions.</td></tr>
<tr><td>2. Compute Fourier Coefficients
• Evaluate Fourier coefficients using integration
• Handle piecewise and discontinuous functions
• Interpret convergence of Fourier series
• Identify even/odd functions and apply half-range expansions</td></tr>
<tr><td>3. Analyze Boundary Value Problems (BVPs)
• Formulate and solve ordinary differential equation-based boundary value problems
• Apply appropriate boundary conditions to obtain meaningful solutions</td></tr>
<tr><td>4. Apply Separation of Variables Technique
• Solve partial differential equations (PDEs) like:
o Heat equation
o Wave equation
o Laplace equation
o Use separation of variables to reduce PDEs into simpler ODEs</td></tr>
<tr><td>5. Interpret Physical Significance
• Relate mathematical solutions to physical systems such as:
o Temperature distribution
o Vibrations and waves
• Analyse steady-state and transient solutions</td></tr>
<tr><td colspan="2">Module 1(Credit 1) – Fourier Series</td></tr>
<tr><td rowspan="2">Learning Outcomes</td><td>1. Understand Basic Concepts
• Define periodic functions and explain the concept of a Fourier series. Distinguish between periodic and non-periodic functions</td></tr>
<tr><td>2. Derive Fourier Series
• Express a given function as a Fourier series using sine and cosine terms
• Derive formulas for Fourier coefficients</td></tr>
</table>

	• Developed advanced problem-solving skills in Additive rule Conditional probability, Multiplicative rule and Baye's rule.
	3. Apply Half-Range Expansions • Construct half-range sine and cosine series • Analyze Convergence • Understand conditions for convergence of Fourier series • Interpret behaviour at points of discontinuity
Content Outline	• Introduction to Fourier Series • Periodic Functions and Preliminaries • Trigonometric Fourier Series • Conditions for Fourier Series (Dirichlet Conditions) • Concept of Convergence • Convergence Theorems • Examples of Convergence • Uniform vs. Point wise Convergence • Applications Related to Convergence • Limitations and Practical Issues
Module 2(Credit 1) – Boundary Value Problems	
Learning Outcomes	After learning the module, learners will be able to
	1. Understand Basic Concepts • Define boundary value problems (BVPs) and distinguish them from initial value problems. • Identify different types of boundary conditions (Dirichlet, Neumann, mixed)
	2. Formulate Mathematical Models • Translate physical problems (e.g., heat flow, vibrations) into differential equations with boundary conditions • Interpret the role of boundaries in determining sol
	3. Solve Second-Order Differential Equations • Solve linear second-order ordinary differential equations arising in BVPs • Apply given boundary conditions to determine constants.
	4. Apply Eigenvalue Methods • Understand the concept of eigenvalues and eigenfunctions • Solve Sturm–Liouville type problems.
	5. Use Separation of Variables

	• Apply separation of variables to reduce partial differential equations (PDEs) into ordinary differential equations • Solve standard equations such as heat and wave equations (introductory level) • Interpret Solutions • Analyze the physical meaning of obtained solutions • Distinguish between trivial and non-trivial solutions.
Contain Outline	• Introduction to Boundary Value Problems • Principle of superposition • Mathematical Formulation • Types of Boundary Conditions • Classification of Boundary Value Problems • Method of sepration of variables • Boundary Value Problems in Partial Differential Equations • To find eigen value eigen functions • Applications of Boundary Value Problems

Assignment/Activities towards Comprehensive Continuous Evaluation (CCE),

- Students are instructed to find Fourier series of piece-wise continuous functions.
- Students are suggested to use convergence theorem.
- Students are suggested to use method of separation of variables, to find eigen value eigenfunctions.
- Students are suggested to write solution of B.V.P. using principle of superposition and use Fourier series to find constants.

References

1. J. W. Brown & R. V. Churchill: Fourier Series and Boundary Value Problems. VIIth Edition, McGraw Hill Education(India) Private Limited, New Delhi.
2. Boundary Value Problems – by David L. Powers.
3. Ordinary and Partial Differential Equations with Fourier Series and Boundary Value Problems – by Ravi P. Agarwal & Donal O'Regan.

Semester – VI

.6.5 A. Minor Stream

Course Titles	**Introduction to Mathematics for Image Processing (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	After going through the course, learners will be able to
	1. Recognize mathematical representation of digital images
	2. Demonstrating linear algebra and transforms in image processing.
	3. Demonstrate image enhancement and filtering techniques
	4. Analyze the mathematical concepts to real-world image applications
Module 1 (Credit 1) - Mathematical Foundation of Digital Images	
Learning Outcomes	After learning the module, learners will be able to
	1. Construct Images as a matrix
	2. Developed Energy of an image
Content Outline	• Definition of digital image • Pixel, resolution, grayscale and color images • Image as a matrix (2D signals) • Sampling and quantization • Image storage and formats • Image as a matrix and vector space • Basics of linear algebra (matrices, eigenvalues – intuition only) • Linear transformations (rotation, scaling only) • Inner product and Orthogonality • Energy of an image (Introduction only)
Module 2 (Credit 1) – Fourier Transformation and Image Processing	
Learning Outcomes	After learning the module, learners will be able to
	• Achieve mastery 2D Fourier Transform
	• s for Image Processing
	• Apply the properties of Fourier Transformation in image processing
Content Outline	• 2D Fourier Transform (concept and intuition) • Frequency domain representation of images • Low-pass and high-pass filtering • Applications in noise removal

	• Convolution in image processing • Kernel operations • Applications: medical imaging, satellite imaging, pattern recognition

Module 3 & 4 - Introduction to Mathematics for Image Processing Practical:-

Practical 1: Digital Image Fundamentals

1. Define a digital image. How does it differ from an analog image?
2. What is a pixel? Express the total number of pixels in an image of resolution $M \times N$.
3. Distinguish between a grayscale image and a color image in terms of bit depth.
4. An image has 1024×1024 pixels with 256 gray levels. Calculate the storage requirement in bits.
5. Represent a 3×3 grayscale image as a matrix with random integer values between 0 and 255.

Practical 2: Image as a 2D Signal and Matrix

1. Write the mathematical representation of a digital image as a 2D discrete signal $f(m, n)$.
2. For a 4×4 image matrix, identify the pixel coordinates (row, column) for the top-left and bottom-right corners.
3. Convert the 1D signal $[1,2,3,4]$ into a 2×2 image matrix using row-major order.
4. Explain how image resolution affects the number of rows and columns in the matrix.
5. Given a 3×3 image matrix, find the value at position $(2,3)$ (assuming 1-based indexing).

Practical 3: Sampling and Quantization

1. Define sampling in the context of image acquisition. What is the sampling interval?
2. Define quantization. If an analog pixel value ranges from 0 V to 5 V and we use 8-bit quantization, what is the quantization step size?
3. How does undersampling affect an image? Name the resulting artifact.
4. A grayscale image uses 4 bits per pixel. How many distinct gray levels are possible?
5. An image of size 256×256 is sampled at half the resolution in both directions. What is the new size?

Practical 4: Image Storage and Formats

1. Name two uncompressed and two compressed image file formats.
2. Calculate the file size (in bytes) of an 800×600 RGB color image with 24 bits per pixel.

3. What is the difference between lossy and lossless compression? Give one example format for each.
4. How does bit depth affect file size and image quality?
5. A 512×512 grayscale image (8-bit) is saved as a JPEG with a 10:1 compression ratio. What is the approximate file size in KB?

Practical 5: Image as a Vector Space

1. Explain how a 2D image matrix can be reshaped into a 1D vector.
2. For a 2×2 image, write the column vector representation (lexicographic ordering).
3. What is the dimension of the vector space for an $M \times N$ grayscale image?
4. Define a standard basis for the space of 2×2 images. Give one basis vector as a 2×2 matrix.
5. If two images are represented as vectors, how do you add them? Give an example with two 2×2 images.

Practical 6: Basics of Linear Algebra for Images

1. Define a matrix for a 3×3 image. Compute its transpose.
2. What is the trace of a 2×2 image matrix? Provide a numeric example.
3. Explain intuitively what eigenvalues represent in the context of image transformations.
4. For a diagonal image matrix (non-zero only on the diagonal), what are its eigenvalues?
5. Compute the sum of two 2×2 image matrices, then multiply the result by the scalar 0.5.

Practical 7: Linear Transformations – Rotation

1. Write the 2×2 rotation matrix for rotating an image by 90° counter-clockwise.
2. Apply a 90° rotation to the 2×2 image matrix $\begin{bmatrix} a & b \\ c & d \end{bmatrix}$ and write the resulting matrix.
3. What happens to pixel coordinates (x, y) when rotated by 180°?
4. Rotate the point $(2,3)$ in an image by 45° using the rotation matrix $\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix}$. Leave the expression in terms of $\cos 45^\circ$ and $\sin 45^\circ$.
5. Why does rotation of a digital image require interpolation? Explain briefly.

Practical 8: Linear Transformations – Scaling

1. Write the scaling matrix that doubles the size of an image in the x-direction and halves it in the y-direction.
2. Apply a scaling factor $(2,1)$ to a 3×3 image. What is the new size?

3. If an image is scaled uniformly by a factor s, how does the number of pixels change?
4. Differentiate between upsampling and downsampling in image scaling.
5. Given a 2×2 image, apply scaling by factor 0.5 in both directions. How many pixels result?

Practical 9: Inner Product and Orthogonality

1. Define the inner product (dot product) for two 2×2 images treated as vectors. Write the formula.
2. Compute the inner product of the two 2×2 images:
   $I_1 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}, \quad I_2 = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}.$
3. What does it mean for two images to be orthogonal? Give a simple example.
4. Show that the basis vectors
   $e_{11} = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}$ and
   $e_{22} = \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix}$ are orthogonal.
5. How is orthogonality used in image compression (e.g., transform coding)?

Practical 10: Energy of an Image (Introduction)

1. Define the total energy of a discrete 2D image $f(m,n)$ of size $M \times N$.
2. Compute the energy of the 2×2 image: $\begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$.
3. How does image energy relate to the sum of squared pixel values?
4. If a constant image has all pixel values equal to c, write its energy in terms of M, N, and c.
5. Explain intuitively why noise removal may reduce or preserve image energy.

Practical 11: 2D Fourier Transform (Concept and Intuition)

1. Write the formula for the 2D Discrete Fourier Transform (DFT) $F(u,v)$ of an $M \times N$ image $f(x,y)$.
2. What does the magnitude spectrum $|F(u,v)|$ represent in an image?
3. What is the physical meaning of the zero-frequency component $F(0,0)$?
4. If an image is constant (all pixel values equal to K), what is its 2D DFT?
5. Explain the concept of spatial frequency in an image using a sinusoidal pattern.

Practical 12: Frequency Domain Representation of Images

1. What is the difference between the spatial domain and the frequency domain representation?
2. How does a high-frequency component appear in an image (e.g., edges vs. smooth regions)?
3. In the frequency domain, where are low-frequency components located – at the center or at the corners?

4. If you shift the 2D DFT so that the zero frequency is at the center, what is this operation called?
5. Given a 4×4 image of all zeros except a single white pixel at the center, describe its frequency spectrum qualitatively.

Practical 13: Low-Pass and High-Pass Filtering

1. Define a low-pass filter in the frequency domain. What effect does it have on an image?
2. Write the transfer function of an ideal low-pass filter with cutoff radius D_0.
3. Define a high-pass filter. How does it enhance edges?
4. What is the relationship between a low-pass filter and a high-pass filter (in terms of H_{HP} and H_{LP})?
5. Apply an ideal low-pass filter to remove high-frequency noise. What artifact may appear (ringing)?

Practical 14: Applications in Noise Removal, Convolution, Kernel Operations

1. What is convolution in image processing? Write the 2D convolution formula.
2. Define a 3×3 averaging kernel for smoothing. Write its matrix.
3. How does a Gaussian kernel differ from an averaging kernel?
4. Explain how median filtering removes salt-and-pepper noise without using convolution.
5. Apply a 3×3 averaging kernel to a single pixel at the center of a 5×5 zero image that has a single 1 at the center. What is the output value at the center?

Practical 15: Applications – Medical Imaging, Satellite Imaging, Pattern Recognition

1. Name one medical imaging modality (e.g., MRI) and explain how image processing improves diagnosis.
2. In satellite imaging, why is multi-spectral image registration important?
3. How is pattern recognition used in face detection from images?
4. What role does edge detection play in both medical and satellite imaging?
5. Give one example of a kernel (filter) used for edge detection (e.g., Sobel) and write its horizontal gradient matrix.

Assignment/Activities towards Comprehensive Continuous Evaluation (CCE),

- Students are instructed to find Images as a matrix and Linear transformations applications. (CO1 and CO2)
- Students are suggested to use 2D Fourier Transform. (CO3)
- Students are suggested to find Applications in Image Processing. (CO4)

Reference Books:

1. Fundamentals of Digital Image Processing – Anil K. Jain

2. Fundamentals of Image Processing – Ian T. Young , Jan J. Gerbrands and Lucas J. van Vliet, Delft University of Technology
3. Digital Image Processing – Rafael C. Gonzalez Fundamentals of Signals and Systems – Michael J. Roberts
4. Image Processing, Analysis, and Machine Vision – Milan Sonka, Vaclav Hlavac, and Roger Boyle

Semester – VI

.6.5 B. Minor Stream

Course Titles	**Partial Differential Equations-II (Th+Pr)**
Course Credits	**4 Credit's (2 Th + 2 Pr)**
Course Outcomes	After going through the course, learners will be able to
	1. CO1: know the role of Green's function in the solution of Partial Differential Equations.
	2. CO2: Understand and solve heat and wave equations using analytical methods.
Module 1 (Credit 1) - Green's Functions and Integral Representations	
Learning Outcomes	After learning the module, learners will be able to
	1. Explain singularity functions, fundamental solutions, and Green's identities.
	2. Construct and apply Green's functions and Neumann functions to solve Dirichlet and boundary value problems.
Content Outline	• Singularity functions and the fundamental solution, Green functions, Greens identities, Green's function for m-dimensions sphere of radius R, Green's functions Dirichlet problem in the plane, Neumann's function in the plane.
Module 2 (Credit 1) – The Diffusion Equation & Parabolic Differential Equations	
Learning Outcomes	After learning the module, learners will be able to
	1. Explain existence and uniqueness of solutions and apply maximum–minimum principles for heat equations.
	2. Solve one-dimensional heat and wave equations using separation of variables and boundary value problems.
Content Outline	• Existence and Uniqueness theorem for initial value problem in an infinite domain, semi-infinite domain, one-dimensional Heat equation, maximum and minimum principle for the heat equation and for some parabolic equations, one dimensional wave equation, boundary value problem for the one dimensional heat and wave equations, method of separation of variables.
Module 3 & 4	**List of Practical** • Singularity functions and the fundamental solution • Green functions and Greens identities • Green's function for m-dimensions sphere of radius R • Green's functions Dirichlet problem in the plane • Neumann's function in the plane • Existence and Uniqueness theorem for initial value problem in

	an infinite domain, semi-infinite domain • one-dimensional Heat equation • maximum and minimum principle for the heat equation and • maximum and minimum principle for some parabolic equations • one-dimensional wave equation • boundary value problem for the one-dimensional heat and wave equations • method of separation of variables.

Assignments/Activities towards Comprehensive Continuous Evaluation (CCE) –

- Apply Green's functions and identities to solve boundary value problems including Dirichlet and Neumann problems.
- Solve heat and wave equations using appropriate methods and analyze properties such as existence, uniqueness, and maximum–minimum principles.

References:

1. Prasad, Phoolan, And Renuka Ravindran. Partial Differential Equations. New Age International, 1985.
2. Pinchover And Rubinstein, Y. "An Introduction To Partial Differential Equations." (2021).
3. Amaranath, T. An Elementary Course In Partial Differential Equations. Jones & Bartlett Learning, 2009.
4. Bers, Lipman, Fritz John, And Martin Schechter, Eds. Partial Differential Equations. American Mathematical Soc., 1964.
5. G.B. Folland, Introduction To Partial Differential Equations, Prentice Hall.

6.7 OJT

On-Job Training (OJT) – Syllabus & Guidelines

T.Y. B.Sc. Mathematics (2 Credits, 30 Hours)

1. **Course Title**

On-Job Training (OJT) / Internship in Mathematical Applications

2. **Course Structure**

Component	**Hours**
Weekly Training (2 hrs × 12 weeks)	24 hrs
Evaluation & Reporting	6 hrs
Total	**30 hrs**

3. **Course Objectives (COs)**

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

- Apply mathematical concepts in real-world scenarios.
- Use Python programming for data handling, visualization, and basic modeling.
- Understand workplace practices, teamwork, and professional ethics.
- Develop problem-solving and analytical thinking skills.
- Prepare technical reports and present findings effectively.

4. **Course Outcomes (CO Mapping)**

CO No.	**Outcome**
CO1	Demonstrate application of mathematics in industry
CO2	Use Python for computational tasks
CO3	Analyze real-world datasets
CO4	Communicate findings effectively
CO5	Develop professional and ethical work behavior

5. **Weekly Plan (24 Hours)**

- **Week 1–2: Orientation & Basics**
  - Introduction to organization/industry
  - Understanding workflow and problem areas
  - Basics of Python (NumPy, Pandas)
- **Week 3–4: Data Handling**
  - Data collection and cleaning
  - Basic statistics (mean, variance, correlation)
  - Visualization using Python (Matplotlib)
- **Week 5–6: Mathematical Modeling**
  - Linear models and regression
  - Time-series basics
  - Applications in real datasets
- **Week 7–8: Domain-Specific Work**

- (Depends on organization)
- Finance: Stock trends, risk analysis
- IT: Algorithm testing, data structures
- Education: Content development
- Research: Mathematical simulations
- **Week 9–10: Problem Solving**
- Case study or mini-project
- Application of calculus/algebra/statistics
- Python-based solution development
- **Week 11–12: Report & Presentation Preparation**
- Documentation
- Data interpretation
- PPT preparation

6. Evaluation Scheme (6 Hours)

Component	**Marks**
Attendance & Participation	10
Industry Supervisor Feedback	20
Project/Task Completion	20
Final Report	25
Presentation/Viva	25
Total	**100 Marks**

7. Guidelines for Students

- Minimum 75% attendance is mandatory.
- Maintain a daily logbook.
- Follow professional ethics and discipline.
- Submit final report (15–20 pages).
- Use Python wherever applicable.
- Work on real datasets/problems.

8. Suggested Python Tools

- Libraries: NumPy, Pandas, Matplotlib, SciPy
- Optional: Scikit-learn (basic ML exposure)
- Platforms: Jupyter Notebook, Google Colab

9. Suggested Areas for OJT

- Students can choose training in:
- Data Analysis
- Financial Mathematics
- Statistical Modeling
- Operations Research
- Machine Learning Basics
- Actuarial Science
- Computational Mathematic
- Business Analytics

10.Suggested Organizations / Training Places

- IT & Data Companies
- Tata Consultancy Services
- Infosys
- Wipro
- Capgemini
- Finance & Banking
- HDFC Bank
- ICICI Bank
- National Stock Exchange of India
- Analytics & Startups
- Fractal Analytics
- Mu Sigma
- Research & Academic Institutes
- Indian Statistical Institute
- IIT Bombay
- Government & Applied Sectors
- Meteorological Departments
- Census/Data Offices
- DRDO Labs
- Municipal Data Departments

11.Sample Project Ideas

- Stock price analysis using Python
- Traffic flow modeling
- Weather data prediction
- Sales forecasting
- Optimization problems
- Image processing basics

12.Report Structure

- Introduction to Organization
- Problem Statement
- Methodology (Mathematics + Python)
- Data Analysis
- Results & Interpretation
- Conclusion

13.Expected Skills Developed

- Analytical thinking
- Programming (Python)
- Data interpretation
- Communication skills
- Industry readiness