

GURU KASHI UNIVERSITY



**Master of Science in Mathematics
(M.Sc. Mathematics)**

Session: 2025-26

Faculty of Sciences, Humanities and Languages

Graduate Attributes of the Programme: -

Type of learning outcomes	The Learning Outcomes Descriptors
Graduates should be able to demonstrate the acquisition of:	
Learning outcomes that are specific to disciplinary/interdisciplinary areas of learning	Demonstrate in-depth conceptual clarity and analytical abilities in the chosen field.
	Ability to apply mathematical methods to model and solve complex problems.
	Integrate knowledge across multiple domains to solve real-world challenges.
	Adapt emerging technologies and methodologies from diverse scientific and professional fields.
Generic learning outcomes	Ability to analyze, synthesize, and interpret complex scientific problems using logical reasoning.
	Proficiency in technical writing, publishing research articles, preparing reports, and presenting findings at conferences.

Programme learning outcomes: An Postgraduate degree is awarded to students who have demonstrated the achievement of the outcomes located at level 6.5:

Element of the Descriptor	Programme learning outcomes relating to Postgraduate Diploma
The graduates should be able to demonstrate the acquisition of:	
Knowledge and understanding	Acquire insights into advanced computational methods
	Gain comprehensive knowledge of optimization in relative mathematical Science.
	Develop a strong theoretical foundation in Mathematical modeling, Astronomy, Algebra, Geometry, Analysis and Statistical Mathematics.
	Learn experimental techniques in MATLAB and LaTeX.
General, technical and professional skills required to perform and accomplish tasks	Develop analytical and problem-solving skills by applying pure and applied mathematical methods to real-world problems.
	Enhance technical computing skills for mathematical modeling and numerical analysis.
Asssspplication of knowledge and skills	Apply pore and applied principles to understand and predict mathematical phenomena.
Generic learning outcomes	Adapt to new technologies and methodologies in scientific research and industry.
Constitutional, humanistic, ethical, and moral values	Uphold scientific integrity, ethical research practices, and professional responsibility.
Employability and job-ready skills, and entrepreneurship skills and capabilities/qualiti es and mindset	Exercising full personal responsibility for the output of own work as well as for group/team outputs and for managing work that is complex and unpredictable requiring new strategic approaches.
Credit requirements	44 credits
Entry requirements	Bachelor's Degree in Science (B.Sc.) with Mathematics as a major or core subject.

Program Structure**SEMESTER: 1st**

SEMESTER: 1 st									
Course Code	Course Title	Type of Course	L	T	P	No. of Credits	Int.	Ext.	Total Marks
MMH1400	Abstract Algebra	Core Course	4	0	0	4	30	70	100
MMH1401	Real Analysis	Core Course	4	0	0	4	30	70	100
MMH1402	Ordinary and Partial Differential Equations	Core Course	4	0	0	4	30	70	100
MMH1403	Complex Analysis	Core Course	4	0	0	4	30	70	100
IKS0018	Astronomy in India	IKS Course	2	0	0	2	15	35	50
Elective-I (Any one of the following)									
MMH1404	Integral Transformat ions and Their Application	Discipli ne Elective Course	4	0	0	4	30	70	100
MMH1405	Probability and Mathematic al Statistics								
Total			22	0	0	22	165	385	550

SEMESTER: 2 nd									
Course Code	Course Title	Type of Course	L	T	P	No. of Credits	Int.	Ext.	Total Marks
MMH2450	Calculus of Variations and Integral Equations	Core Course	4	0	0	4	30	70	100
MMH2451	Functional Analysis	Core Course	4	0	0	4	30	70	100
MMH2452	Fluid Dynamics	Core Course	4	0	0	4	30	70	100
MMH2453	Differential Geometry	Core Course	4	0	0	4	30	70	100
MMH2454	Topology	Entrepreneurship Skill	2	0	0	2	15	35	50
Elective-II (Any one of the following)									
MMH2455	Discrete Mathematics	Discipline Elective Course	4	0	0	4	30	70	100
MMH2456	Mathematical Modeling								
Total			22	0	0	22	165	385	550

Programme learning outcomes: An Postgraduate Diploma is awarded to students who have demonstrated the achievement of the outcomes located at level 6/7:

Element of the Descriptor	Programme learning outcomes relating to Postgraduate Degree
The graduates should be able to demonstrate the acquisition of:	
Knowledge and understanding	A strong understanding of pure and applied mathematics.
	Research methodologies, including data collection, statistical analysis, and scientific interpretation.
	Computational and numerical techniques applied in Computational and Scientific Research Writing.
	Fundamental and advanced principles of Algebra, Analysis, Astronomy and Mathematical Modelling.
General, technical and professional skills required to perform and accomplish tasks	Hands-on experience in computational simulations and data visualization using mathematical-based software tools.
	The ability to apply scientific research methodologies, including literature reviews and hypothesis testing.
Application of knowledge and skills	Skills to implement experimental techniques in physics for designing and analyzing real-world problems in materials science and spectroscopy.
Generic learning outcomes	Adaptability to emerging technologies and global scientific trends in pure and applied mathematics.
Constitutional, humanistic, ethical, and moral values	The ability to apply mathematics knowledge for societal benefit, such as radiation safety, applications, and healthcare advancements.
Employability and job-ready skills, and entrepreneurship skills and capabilities/qualities and mindset	Job-ready skills in pure & applied mathematics with applications, and industrial research.
Credit requirements	88 credits
Entry requirements	A Postgraduate Diploma (Level 6) in Mathematics with minimum of 75% marks in diploma.

SEMESTER: 3 rd									
Course Code	Course Title	Type of Course	L	T	P	No. of Credits	Int.	Ext.	Total Marks
MMH3500	Research Methodology	Core Course	4	0	0	4	30	70	100
MMH3501	Operation Research	Core Course	4	0	0	4	30	70	100
MMH3502	Service Learning	Entrepreneurship Skills	0	0	4	2	15	35	50
Discipline Elective-III (Choose any one of the following)									
MMH3503	Mathematical Methods	Discipline Elective Course	4	0	0	4	30	70	100
MMH3504	Special Functions								
Discipline Elective-IV (Choose any one of the following)									
MMH3505	Linear Algebra	Discipline Elective Course	4	0	0	4	30	70	100
MMH3506	Astronomy								
Discipline Elective-V (Choose any one of the following)									
MMH3507	Wavelet Theory	Discipline Elective Course	4	0	0	4	30	70	100
MMH3508	Cryptography								
Total			22	0	0	22	165	385	550

SEMESTER: 4 th									
Course Code	Course Title	Type of Course	L	T	P	No. of Credits	Int.	Ext.	Total Marks
MMH4550	Numerical Analysis	Core Course	4	0	0	4	30	70	100
MMH4551	Scientific Research and Technical Writing	Employability Skill	2	0	0	2	15	35	50
MMH4552	Dissertation	Research Based	0	0	0	12	200	100	300
Discipline Elective-VI (Any one of the following) with its practical									
MMH4553	MATLAB	Discipline Elective Course	3	0	0	3	25	50	75
MMH4554	LaTeX								
MMH4555	MATLAB Lab		0	0	2	1	10	15	25
MMH4556	LaTeX Lab								
Total			9	0	2	22	280	270	550
Grand Total			75	0	2	88	775	1425	2200

Semester-I**Course Title: Abstract Algebra****Course Code: MMH1400**

L	T	P	Cr
4	0	0	4

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Analyze Cauchy's theorem for the Abelian group and Sylow's theorem.
2. Compute the Permutation groups and its Conjugacy.
3. Perform the Homomorphism, Ideals, and Quotient rings in ring theory.
4. Design the Polynomial rings and polynomials over the rational field.

COURSE CONTENT**UNIT-I****15 hours**

Normal subgroups and Quotient Groups-Homomorphism-Cauchy's theorem for Abelian Group, Sylow's theorem for Abelian Group-Automorphism-Cayley's theorem.

UNIT-II**15 hours**

Permutation groups- Conjugacy- Normalizer-Centre-Cauchy theorem-Sylow's Theorem-Direct products. Rings-Homomorphism-Ideals-Quotient Rings- Maximal Ideal-Field of Quotients of integral domain.

UNIT-III**15 hours**

Euclidean rings-Polynomial rings- polynomial over the rational field polynomial rings over commutative rings, Vector space.

UNIT-IV**15 hours**

Elementary basic Concepts-Extension fields-The Transcendence of roots of Polynomials-Construction with straightedge and Compass-Finite fields.

Transaction Mode-: Lecture, Demonstration, Video Based Teaching, Collaborative Teaching, Group Discussion, E-team Teaching, Quiz, Open Talk.

Suggested Readings: -

- *Luther I.S. and Passi I.B.S. (2007). Algebra, Vol.I& II, Narosa Publishing House, New Delhi.*
- *Gallian J.A. (1999). Contemporary Abstract Algebra, Narosa Publishing House, New Delhi.*
- *Singh, Surjeet and QaziZameeruddin (2006). Modern Algebra, Vikas Publishing House, New Delhi .8thEdition.*
- *Bhattacharya P.B, Jain S.K. and Nagpal S.R.(2012). Basic Abstract Algebra. Cambridge University Press, New Delhi.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Real Analysis**Course Code: MMH1401**

L	T	P	Cr
4	0	0	4

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Apply the knowledge and concepts of real analysis in order to study the theoretical development of different mathematical techniques and their applications.
2. Describe the nature of abstract mathematics and explore the concepts in further detail. Identify challenging problems in real variable theory and find their appropriate solutions.
3. Apply the theory of Riemann-Stieltjes integral in solving definite integrals arising in different fields of science and engineering.
4. Extend their knowledge of real variable theory for further exploration of the Course for going into research.

COURSE CONTENT

UNIT-I

15 hours

Sequence and Series of functions: Introduction, Uniform Convergence, Uniform Convergence and Integration, Uniform Convergence and Differentiation, Equicontinuous families of functions, Arzela's Theorem, Weierstrass Approximation theorem.

UNIT-II

15 hours

Measure Sets, Outer Measure, Lebesgue Measure, Properties of Measurable Sets, Non-Measurable Sets. Measurable Functions, Definition & Properties of Measurable Functions, Characteristic Functions, Step Functions, and Simple Functions.

UNIT-III

15 hours

Differentiation and Integration: Differentiation of monotone functions. Application of Differentiation. Absolute continuity. Convex functions. The general integral, Integration of series, Riemann integration

UNIT-IV

15 hours

The Lebesgue integral: The Lebesgue integral of a bounded function over a set of finite measures. The integral of a non-negative function. The general Lebesgue integral. Convergence in measure.

Transaction Mode-: Lecture, Demonstration, Video Based Teaching, Collaborative Teaching, Project-based Learning, Group Discussion, E-team Teaching, Flipped Teaching, Quiz, Open Talk, Case Analysis.

Suggested Readings: -

- *Apostol, Tom. (1987). Mathematical Analysis - A Modern Approach to Advanced Calculus. Addison - Wesley Publishing Company, Inc. Indian Edition by Narosa Publishing House New Delhi.*
- *Goldberg, R.R. (2012). Methods of Real Analysis. Oxford and IHB Publishing Company, New Delhi.*
- *Rudin, Walter. (1983), Principles of Mathematical Analysis. Third Edition (International Student Edition) McGraw-Hill Inc.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Ordinary and Partial Differential Eqn.**Course Code: MMH1402**

L	T	P	Cr
4	0	0	4

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Illustrate ordinary differential equations of various types, their solutions, and fundamental concepts about their existence.
2. Analyze stability of linear and non-linear systems. Solve the first-order linear and non-linear equations.
3. Evaluate problems of ordinary differential equations arising in various fields.
4. Formulate series solution of first order equation and second order linear equation and understand the method of successive approximations

COURSE CONTENT

UNIT-I

15 hours

Linear Second Order Equations, Initial value problem, Existence and Uniqueness by Picard's Theorem, Wronskian, Separation and comparison theorems, Poincare phase plane, Variation of parameters. Existence and uniqueness of solutions of initial value problems for first order ordinary differential equations, singular solutions of first order ODEs, system of first order ODEs.

UNIT-II

15 hours

General theory of homogenous and non-homogeneous linear ODEs, variation of parameters, Sturm-Liouville boundary value problem, Green's function. Power series solutions; Solution near ordinary and regular singular point, Convergence of the formal power series, Applications to Legendre, Bessel, Hermite, Laguerre and hypergeometric differential equations with their properties.

UNIT-III

15 hours

Partial Differential Equations of the First Order : Origin of first order partial differential equations. Lagrange's solution of first order linear partial differential equation. Non-linear partial differential equations of the first order. Cauchy's method of characteristics, Charpit's method and Jacobi's method.

UNIT-IV**15 hours**

Partial Differential Equations of Second and Higher Orders : Origin of second order partial differential equations. Higher order partial differential equations with constant coefficients. Equations with variable coefficients. Classification of second order partial differential equations. Canonical forms. Solution of non-linear second order partial differential equations by Monge's method. Method of separation of variables for solving Laplace, wave and diffusion equations.

Transaction Mode:- Lecture, Demonstration, Video Based Teaching, Collaborative Teaching, Project-based Learning, Group Discussion, E-team Teaching, Quiz, Open Talk.

Suggested Readings:-

- Coddington & N. Levinson (2010), *Theory of Ordinary Differential Equations*, Tata Mc-Graw Hill, India.
- N. P. Bali, Bhavanari Satyanarayana, (2012), *A Text book of Engineering Mathematics*, Indrani Promod Kelkar, University Science Press, New Delhi.
- A.C. King, J. Billingham, S.R. Otto. (2003). *Differential Equations, Linear, Nonlinear, Ordinary, Partial*, Cambridge University Press.
- Williams E. Boyce and Richard C. Di Prima (2001), *Elementary differential equations and boundary value problems*, John Wiley

Course Title: Complex Analysis**Course Code: MMH1403**

L	T	P	Cr
4	0	0	4

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Illustrate fundamental concepts of Complex analysis and its use in mathematics.
2. Define and analyze limits and continuity for functions of complex variables.
3. Evaluate complex integral and apply Cauchy Integral Theorem and formulas.
4. Checking limit and continuity of complex function and apply the concept of analyticity and the Cauchy- Riemann Equation.

COURSE CONTENT

UNIT-I**15 hours**

Complex plane, geometric representation of complex numbers. Elementary functions: Trigonometric function, complex exponential function, logarithmic and hyperbolic functions. Complex valued functions and their continuity. Curves, connectivity through polygonal lines.

UNIT-II**15 hours**

Analytic functions, Cauchy-Riemann equations, Harmonic functions and Harmonic conjugates. Power series, exponential and trigonometric functions, Bilinear transformations, critical points, fixed points, cross ratio, bilinear transformation.

UNIT-III**15 hours**

Complex Integration, line integral, Cauchy's theorem for a rectangle, Cauchy's theorem in a disc, index of a point with respect to a closed curve Cauchy's integral formula, higher derivatives.

UNIT-IV**15 hours**

Morrera's theorem, Liouville's theorem, the general form of Cauchy's theorem. Maximum Modules principle, Schwarz Lemma. Taylor series and Laurent series.

Transaction Mode:- Lecture, Demonstration, Video Based Teaching, Collaborative Teaching, Project-based Learning, Group Discussion, E-team Teaching, Quiz, Open Talk.

Suggested Readings:-

- *Shanti Narayan. (1986), Theory of Functions of a Complex Variable. S. Chand and Co. Seventh Edition.*
- *Knopp, K. (1947), Theory of Functions. (Translated by F. Bagemite) in Two Volumes, Dover Publications, Inc. New York.*
- *Pati, T. (1971), Functions of a Complex Variable. Allahabad, Pothishala.*
- *Deshpande, J. V. (1989), Complex Analysis. Tata McGraw-Hill Publishing Company Ltd.*
- *Ponnusamy S. (2005), Foundations of Complex Analysis. Second Edition Narosa Publishing House, New Delhi.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Astronomy in India**Course Code: IKS0018**

L	T	P	Cr
2	0	0	2

Total Hours: 30

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Understand the historical development of astronomy in India and its cultural and scientific context.
2. Identify key astronomical algorithms developed by Indian astronomers.
3. Explain the mathematical principles underlying these astronomical methods.
4. Explore the practical applications of Indian astronomical knowledge, such as in calendar preparation and timekeeping.

Course Content

Unit – I

8 Hours

Astronomy before Āryabhaṭa:

- a) Astronomical references in the Vedas
- b) Astronomical model and algorithms of the Vedāṅga-jyotiṣa
- c) The Pañca-siddhāntikā of Varāhamihira

Unit – II

7 Hours

Important astronomers and texts – I

- a) A brief historical overview
- b) Āryabhaṭīya of Āryabhaṭa

Unit – III

7 Hours

Important astronomers and texts – II:

- a) Important astronomical instruments described in Indian texts
- b) Tantrasaṅgraha of Nīlakaṇṭha Somayājī

Unit – IV

8 Hours

Calendrical computations

- a) Construction of the Indian luni-solar calendar
- b) Indian records of astronomical observations (inscriptions, copper plates, texts etc.

Transactional Mode

Seminars, Group discussion, Team teaching, Focused group discussion, Assignments, Project-based learning, Simulations, reflection and Self-assessment

Suggested Readings

- *The Science of the Śulba*, B. Datta, University of Calcutta, 1932
- *History of Hindu Mathematics: A Source Book*, B. Datta and A. N. Singh, Asia Publishing House, 1962
- *Āryabhaṭīya of Āryabhaṭa*, K. S. Shukla and K. V. Sarma, Indian National Science Academy, 1976
- *Geometry in Ancient and Medieval India*, T. A. Sarasvati Amma, Motilal Banarasidass, 2007
- *Gaṇita-yukti-bhāṣā of Jyeṣṭhadeva*, K. V. Sarma et. al., Hindustan Book Agency, 2008
- *Studies in Indian Mathematics and Astronomy: Selected Articles of Kripa Shankar Shukla*, Kolachana et. al. (eds.), Culture and History of Mathematics 12, HBA, 2019
- *Līlāvati of Bhāskarācārya*, H. T. Colebrooke, ed. by H. C. Banerji, Kitab Mahal, 1967
- *Mathematics in India: From Vedic Period to Modern Times*, M. D. Srinivas and K. Ramasubramanian and M. S. Sriram, NPTEL course

Course Title: Integral Transformation and Their Applications**Course Code: MMH1404**

L	T	P	Cr
4	0	0	4

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Familiar with the notation and terminology related to differential equations, Laplace Transform, Fourier Transform.
2. Differentiate between ODE and PDE, know the methods to solve differential equations and be able to solve ODE and PDE of special type.
3. Analyze the utility of Laplace Transform and Fourier series in solving PDE.
4. Integrate and differentiate the Hankel transform and Fourier transform functions and examine the theory of integral equations.

COURSE CONTENT**Unit-I****15 hours**

Laplace Transforms, Existence theorem, Convolution theorem, Differentiation and Integration of Laplace transform, the inverse Laplace transform and examples, Tauberian theorems for Laplace transforms and Watson's Lemma, Laplace transforms of fractional integrals and derivatives.

Unit-II**15 hours**

Applications of Laplace Transform, Ordinary and partial differential equations, Initial and boundary value problems, Integral equations, Definite integrals, Difference equations and Differential-difference equations. Finite Laplace Transforms.

Unit-III**15 hours**

Hankel Transforms, operational properties, Applications to solve partial differential equations. Fourier Transforms, Fourier Integral formulas, Fourier cosine and sine transforms and examples, Fourier cosine and sine transforms, Multiple Fourier transforms.

Unit-IV**15 hours**

Ordinary and Partial differential equations, Integral equations, Definite integrals. Applications of Multiple Mellin Transforms: Basic operational properties and Applications.

Transaction Mode- Lecture, Demonstration, Video Based Teaching, Collaborative Teaching, Project-based Learning, Group Discussion, E-team Teaching, Quiz, Open Talk.

Suggested Readings:-

- Loknath Debnath (1995), *Integral Transforms and Their Applications*, CRC Press, Inc.
- P.P.G. Dyke (2001) *An Introduction to Laplace Transforms and Fourier Series*, Springer-Verlag, London.
- Austin Keane (1965), *Integral transforms*, Science Press.
- Brian Davies (2001), *Integral Transforms and their Applications*, 3rd Edition, Springer-Verlag, New York, Inc.
- Suggested digital platform: NPTEL/SWAYAM/MOOCs.

Course Title: Probability and Mathematical Statistics**Course Code: MMH1405**

L	T	P	Cr
4	0	0	4

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Compute the probabilities of composite events using the basic rules of probability.
2. Demonstrate understanding the random variable, expectation, variance and distributions. Explain the large sample properties of sample mean.
3. Apply the concept of the sampling distribution of a statistic, and in particular describe the behaviors of the sample mean.
4. Analyze the correlated data and fit the linear regression models.

COURSE CONTENT**Unit-I****15 Hours**

Central and non-central moments, Sample and Population variance. Skewness and Kurtosis. Correlation & Regression Analysis: Scatter diagram. Karl Pearson's and Spearman's rank correlation coefficient. Linear Regression and its properties. Multiple Regression, Partial and multiple correlation.

Unit-II**15 Hours**

Random Variables and Distribution, Discrete and Continuous random variables. Probability mass function and Probability density function. Cumulative distribution function. Expectation of single- and two-dimensional random variables.

Unit-III**15 Hours**

Random variables. Moment generating function and probability generating functions. Discrete Distributions: Bernoulli distribution. Binomial distribution. Poisson distribution, Negative Binomial and Hypergeometric distributions. Uniform.

Unit-IV**15 Hours**

Continuous Distributions, Normal distribution. Normal approximation to Binomial and Poisson distributions. Beta, Gamma, Chi-square and Bivariate normal distributions, Sampling distribution of mean and variance, Chebyshev's inequality.

Transaction Mode- Lecture, Demonstration, Video Based Teaching, Collaborative Teaching, Project-based Learning, Group Discussion, E-team Teaching, Quiz, Open Talk.

Suggested Readings: -

- Goon, A.M., Gupta, M.K., Dasgupta, B. (1998), *Fundamentals of Statistics, Vol-I & Vol-II . 7th Ed.*
- Sheldon Ross. (2002), *A First Course in Probability, 6th edition, Pearson Education Asia.*
- Meyer, P.L. (1970), *Introductory Probability and Statistical Applications. Generic Publisher.*
- Hogg, R.V. and Craig, T.(2002), *Introduction to Mathematical Statistics. MacMillan.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Semester-II

Course Title: Calculus of Variation and Integral Equations

Course Code: MMH2450

L	T	P	Cr
4	0	0	4

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Explain the methods to reduce Initial value problems associated with linear differential equations to various integral equations.
2. Categorise and solve different integral equations using various techniques
3. Describe the importance of Green's function method for solving boundary value problems associated with nonhomogeneous ordinary and partial differential equations.
4. Evaluate various mathematical and physical problems using variational techniques.

COURSE CONTENT**Unit-I****15 Hours**

Linear Integral equations, some basic identities, Initial value problems reduced to Volterra integral equations, Methods of successive substitution and successive approximation to solve Volterra integral equations of second kind, Iterated kernels and Neumann series for Volterra equations.

UNIT-II**15 hours**

Boundary value problems reduced to Fredholm integral equations, Methods of successive approximation and successive substitution to solve Fredholm equations of second kind, Iterated kernels and Neumann series for Fredholm equations. Resolvent kernel, Fredholm resolvent kernel as a ratio of two series. Fredholm equations with separable kernels, Fredholm Alternative, Non homogenous Fredholm equations with degenerate kernels.

UNIT-III**15 hours**

Green function, Use of method of variation of parameters to construct the Green function for a nonhomogeneous linear second order boundary

value problem, Basic four properties of the Green function, Alternate procedure for construction of the Green function by using its basic four properties. Reduction of a boundary value problem to a Fredholm integral equation with kernel as Green function, Hilbert-Schmidt theory for symmetric kernels.

UNIT-IV

15 hours

Motivating problems of calculus of variations, shortest distance, Minimum surface of revolution, Brachistochrone problem, Isoperimetric problem, Geodesic. Fundamental lemma of calculus of variations, Euler equation for one dependent function and its generalization to 'n' dependent functions and to higher order derivatives. Conditional extremum under geometric constraints and under integral constraints.

Transaction Mode-: Lecture, Demonstration, Video Based Teaching, Collaborative Teaching, Project-based Learning, Group Discussion, E-team Teaching, Quiz, Open Talk.

Suggested Readings:-

- *Jerri, A.J., Introduction to Integral Equations with Applications, A Wiley- Interscience Publication, 1999.*
- *Kanwal, R.P., Linear Integral Equations, Theory and Techniques, Academic Press, New York.*
- *Lovitt, W.V., Linear Integral Equations, McGraw Hill, New York.*
- *Hilderbrand, F.B., Methods of Applied Mathematics, Dover Publications.*
- *Gelfand, J.M., Fomin, S.V., Calculus of Variations, Prentice Hall, New Jersey, 1963.*

Course Title: Functional Analysis**Course Code: MMH2451**

L	T	P	Cr
4	0	0	4

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Explain convergence of operators by using a suitable norm, compute the dual spaces.
2. Analyze weak and strong convergence and uniform boundedness theorem, open mapping theorem and closed graph theorem.
3. Explain the properties of compact operators.
4. Apply the operators into self-adjoint, unitary and normal operators

COURSE CONTENT

UNIT-I

15 hours

Curves in space R^3 reparameterization (by arc length), tangent, principal normal, binormal, osculating plane, normal plane, rectifying plane, curvature and torsion of smooth curves, Frenet-Serret formulae, Frenet approximation of a space curve, parameterized curves, regular curves, helices, arc length.

UNIT-II

15 hours

Osculating circle, osculating sphere, spherical indicatrices, involutes and evolutes, intrinsic equations of space curves, isometries of R^3 , fundamental theorem of space curves, surfaces in R^3 , regular surfaces, co-ordinate neighborhoods, parameterized surfaces, change of parameters, level sets of smooth functions on R^3 .

UNIT-III

15 hours

Surfaces of revolution, tangent vectors, tangent plane, differential of a map, Normal fields and orientability of surfaces, angle between two intersecting curves on a surface, Gauss map and its properties, Weingarten map, second and third fundamental forms, classification of points on a surface.

UNIT-IV

15 hours

Curvature of curves on surfaces, normal curvature, Meusnier theorem, principal curvatures, geometric interpretation of principal curvatures, Euler theorem, mean curvature, lines of curvature, umbilical points, minimal surfaces,

Gaussian curvature, intrinsic formulae for the Gaussian curvature, isometries of surfaces, Gauss Theorem Egregium (statement only).

Transaction Mode-: Lecture, Demonstration, Video Based Teaching, Collaborative Teaching, Project-based Learning, Group Discussion, E-team Teaching, Quiz, Open Talk.

Suggested Readings: -

- *M. P. Do Carmo, Differential Geometry of Curves and Surfaces, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1976.*
- *B. O' Neill, Elementary Differential Geometry, Academic Press, 1997.*
- *A. Gray, Differential Geometry of Curves and Surfaces, CRC Press, 1998.*
- *D. Somasundaram, Differential Geometry, A First Course, Narosa Publishing House, New Delhi, 2005.*
- *L. P. Eisenhart, A Treatise on the Differential Geometry of Curves and Surfaces, Ginn and Company, Boston, 1909.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Topology**Course Code: MMH2454**

L	T	P	Cr
2	0	0	2

Total Hours: 30

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Explain interior, closure, and boundary points, limit points of subsets and basis and sub basis of topological spaces.
2. Analyse the continuous maps between two spaces and maps from space into product space and determine a common topological property of given two spaces.
3. Illustrate the connectedness and path connectedness of the product of an arbitrary family of spaces.
4. Apply Urysohn's lemma, Tietze's extension theorem, Urysohn's metrization theorem and Analyze Hausdorff spaces.

COURSE CONTENT

UNIT-I

8 hours

Topological spaces, basis and sub basis, ordered topology, quotient topology, product topology, Limit points, adherent points, Derived sets, Closure, interior, exterior and boundary points of a set, subspace.

UNIT-II

8 hours

Continuity, homeomorphism, countability axioms, first and second countable spaces, Separable Space Connectedness: connected sets, component, path component, local connectedness, disconnected sets, Totally Disconnected sets, locally connected spaces.

UNIT-III

6 hours

Compact spaces; limit point compact and sequentially compact spaces, local compactness and one point compactification, finite product of compact spaces, Tychonoff's theorem (without proof).

UNIT-IV

8 hours

Separation axioms (T₀, T₁, T₂, T₃ spaces, Regular space, completely regular spaces, Normal spaces), their characterizations and basic

properties, Urysohn's lemma, Statement of Tietze's extension theorem, statement of Urysohn's metrization theorem.

Transaction Mode-: Lecture, Demonstration, Video Based Teaching, Collaborative Teaching, Project-based Learning, Group Discussion, E-team Teaching, Quiz, Open Talk.

Suggested Readings:-

- *James R. Munkers (2002), Topology. Second Edition. Prentice Hall of India.*
- *Singh T.B. (2013), Elements of Topology, CRC Press, Taylor & Francis.*
- *John L. Kelley (2004), General Topology. Dover Publications.*
- *Bourbaki N. (1995), General Topology. Springer-Verlag Berlin Heidelberg.*
- *Simmons, G, F. (1983), Introduction to Topology and Modern Analysis McGraw Hill, New York.*
- *E.T. Copson. (1968), Metric Spaces. Cambridge University Press.*
- *S. Willord. (2012), General Topology. Addison Wesley Publishing Company.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Discrete Mathematics**Course Code: MMH2455**

L	T	P	Cr
4	0	0	4

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Display familiarity with the mathematical models
2. The integral part of the hardware and software of computer science.
3. Elaborate and expand their understanding of the tools helpful in the implementation of circuit design,
4. The AI algorithms and compiler construction.

COURSE CONTENT

UNIT-I

15 hours

Relations and Functions Binary relations, equivalence relations and partitions, partial order relations, inclusion and exclusion principle, Hasse diagram, Pigeon hole principle.

UNIT-II

15 hours

Basic logical operations, conditional and bi-conditional Statements, tautologies, contradiction, quantifiers, prepositional calculus. Trees and Colouring of the graph:

UNIT-III

15 hours

Rooted tree, search tree, tree traversals, spanning trees, minimal spanning trees, Kruskal's algorithm. Chromatic number, four-colour problem, chromatic polynomials.

UNIT-IV

15 hours

Grammar and Languages: Phrase structure grammars, rewriting rules, derivation sentential forms, language generated by grammar, regular, context free and context sensitive grammar and languages.

Transaction Mode- Lecture, Demonstration, Video Based Teaching, Collaborative Teaching, Project-based Learning, Group Discussion, E-team Teaching, Flipped Teaching, Quiz, Open Talk, Case Analysis.

Suggested Readings: -

- *Trambley, J.P. and Manohar,R. (2017), Discrete Mathematical Structure with Applications to computer science. McGraw Hill Education.*
- *Balakrishnan, V. K. (2000), Introductory Discrete Mathematics. Dover Books on Computer Science.*
- *Johnsonbaugh, R. (2007), Discrete Mathematics. Pearson.*
- *Rosen, K. (2019), Discrete Mathematics And its Application. McGraw Hill.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Mathematical Modeling**Course Code: MMH2456**

L	T	P	Cr
4	0	0	4

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Illustrate various techniques of mathematical modeling.
2. Apply mathematical models in different fields and situations.
3. Apply mathematical modeling through partial differential equations.
4. Analyze Stochastic models and their needs.

COURSE CONTENT

Unit-I

15 hours

Introduction and the technique of mathematical modeling, Classification and characteristics of mathematical models, Mathematical modeling through algebra, Effects of Immigration and Emigration on Population size, decrease of temperature, Diffusion, Change of price of a commodity.

Unit-II

15 hours

Logistic law of population growth, A simple compartment models, Diffusion of glucose or a Medicine in the blood stream. Mathematical modelling of epidemics, A simple epidemics model, A susceptible infected-susceptible (SIS) model, SIS model with constant number of carriers, Simple epidemic model with carriers, Model with removal, Model with removal and immigration.

Unit-III

15 hours

Mathematical modeling in economics, Mathematical modeling in medicine, A model for diabetes mellitus, Arms race and battles: Richardson model for arms race, Lamechester combat model. Mathematical modeling through partial differential equations: Mass-balance Equations, Momentum balance Equations, Variational principles, Probability generating function, Modeling for traffic on a highway.

Unit-IV**15 hours**

Stochastic models of population growth, Need for stochastic models, Linear birth-death-immigration emigration processes, Linear birth-death process, Linear birth-death-immigration process, Linear birth-death-emigration process, Non-linear birth-death process.

Transaction Mode-: Lecture, Demonstration, Video Based Teaching, Collaborative Teaching, Project-based Learning, Group Discussion, E-team Teaching, Quiz, Open Talk.

Suggested Readings:-

- *Burghes D.N. and Wood A.D. (1980), Mathematical Models in the Social, Management and Life Sciences, John Wiley and Sons.*
- *Andrews J.G. and McLone R.R. (1976), Mathematical Modeling, Butterworths (Pub.) Inc.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Semester-III**Course Title: Research Methodology****Course Code: MMH3500**

L	T	P	Cr
4	0	0	4

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Develop understanding on various kinds of research, objectives of doing research, research process, research designs and sampling.
2. Illustrate main approaches in legal methodology, have basic knowledge on qualitative research techniques.
3. Have adequate knowledge of the key issues of disciplinary and interdisciplinary legal research.
4. Develop an adequate literature review and identify relevant references to formulate a theoretical framework in accordance with the research topic.

Course Content**UNIT I****15 hours**

Research: its concept, nature, scope, need and Objectives of Research, Research types, Research Methodology Research process - Flow chart, description of various steps, Selection of research problem.

UNIT II**15 hours**

Research Design: Meaning, Objectives and Strategies of research, different research designs, important experimental designs,

Methods of Data Collection and Presentation: Types of data collection and classification, Observation method, Interview Method, Collection of data through Questionnaires, Schedules, data analysis and interpretation, editing, coding, content analysis and tabulation.

UNIT III**15 hours**

Sampling Methods: Different methods of Sampling: Probability Sampling methods, Random Sampling, Systematic Sampling, Stratified Sampling, Cluster Sampling and Multistage Sampling. Non probability Sampling methods, Sample size.

UNIT IV**15 hours**

Report writing and Presentation: Types of reports, Report Format – Cover page, Introductory page, Text, Bibliography, Appendices, Typing instructions, Oral Presentation

Transaction Mode- Lecture, Demonstration, Video Based Teaching, Collaborative Teaching, Project-based Learning, Group Discussion, E-team Teaching, Flipped Teaching, Quiz, Open Talk, Case Analysis.

Suggested Readings:-

- *Panneerselvam R , ‘Research Methodology’, PHI, New Delhi.*
- *Cooper, D.R.,Schindler, P.S., ‘Business Research Methods,’ Tata McGraw Hill.*
- *Gupta S P,’ Statistical Methods’, Sultan Chand & Sons, Delhi.*
- *Ronald E Walpole, ‘Probability and Statistics for Engineers and Scientists’ (International Edition) , Pearson Education.*
- *Geode, Millian J. & Paul K. Hatl, “Methods in Research”, McGraw Hills, NewDelhi.*
- *Kothari C.R., “Research Methodology”, New AgePublisher*
- *Nargundkar R, Marketing Research, Tata McGraw Hill, New Delhi,2002.*
- *Sekran, Uma, “Business Research Method”, Miley Education, Singapore.*
- *<https://www.academia.edu>*

Course Title: Operation Research**Course Code: MMH3501**

L	T	P	Cr
4	0	0	4

Total Hours: 60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Establish some real-life problems into Linear programming problems.
2. Apply the simplex method to find an optimal vector for the standard linear programming problem and the corresponding dual problem.
3. Evaluate optimal solutions of transportation problems and assignment problems.
4. Formulate and linear programming model of two-person zero sum game.

COURSE CONTENT

Unit I

15 hours

Linear Programming and examples, Convex Sets, Hyperplane, Open and Closed half-spaces, Feasible, Basic Feasible and Optimal Solutions, Extreme Point & graphical methods. Simplex method, Charnes-M method, two phase method.

Unit II

15 hours

Determination of Optimal solutions, unrestricted variables, Duality theory, Dual linear Programming Problems, fundamental properties of dual Problems, Complementary slackness, Unbounded solution in Primal. Dual Simplex method.

Unit III

15 hours

Revised Simplex method, Transportation Problems, Balanced and unbalanced Transportation problems, U-V method, Paradox in Transportation problem, Assignment problems. Integer Programming problems, Pure and Mixed Integer Programming problems, Travelling salesman problem.

Unit IV**15 hours**

Game theory: Two-person zero-sum game, game with mixed strategy, Dominance property.

Transaction Mode-: Lecture, Demonstration, Video Based Teaching, Collaborative Teaching, Project-based Learning, Group Discussion, E-team Teaching, Flipped Teaching, Quiz, Open Talk, Case Analysis.

Suggested Readings: -

- *G. Hadley (1995), Linear Programming, Narosa Publishing House, 6th edition.*
- *N.S. Kambo (1984), Mathematical Programming Techniques, Affiliated East-West Press Pvt.Ltd. New Delhi, Madras.*
- *Suresh Chandra, Jayadeva, Aparna Mehra (2009), Numerical Optimization with Applications, Narosa Publishing House, 1st edition.*
- *S.M. Sinha (2006), Mathematical Programming, Theory and Methods, Elsevier, 1st edition.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Service Learning**Course Code: MMH3502**

L	T	P	Cr
0	0	4	2

Total Hours: 30

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Explain the meaning of service learning and active learning.
2. Illustrate engaged teaching and engaged research
3. Attain greater levels of civic behaviour and social responsibility.
4. have greater commitment to a service-oriented career.

Course Content

Service learning: principles of service learning; classification of service learning models; difference between service learning and other community experiences; historical context of university community partnership; physics students and service learning. Service Learning for a postgraduate physics student and its scope in research. Conceptualization of the idea of service learning through the following practical implementations:

- (i) conducting awareness programmes on scientific temper for nearby communities,
- (ii) organizing demonstrations of scientific experiments for school children to eradicate the fear of pursuing higher studies in science,
- (iii) surveying the need of the communities and find out various possibilities of providing the solutions from physics point of view
- (iv) providing consultancy to school students for various inter school science competitions. (v) providing video lectures and/or demonstrations for school students..
- (v) organizing demonstrations of scientific experiments for school children to eradicate the fear of pursuing higher studies in science.
- (vi) surveying the need of the communities and find out various possibilities of providing the solutions from physics point of view .
- (vii) Providing consultancy to school students for various inter school science competitions.
- (viii) Providing video lectures and/or demonstrations for school students.

Course Title: Mathematical Methods**Course Code: MMH3503**

L	T	P	Cr
4	0	0	4

Total Hours: 60

Course Learning Outcomes: On the completion of this course, the students will be able to:

1. Understand Co-ordinate Transformation and orthogonal co-ordinates.
2. Understand Fourier series and able to apply Fourier transform.
3. Apply Maline and Hankel transforms.
4. Analyze problems based on Bessel's and Legendre's functions.

COURSE CONTENT

UNIT-I

15 hours

Curvilinear Co-ordinates: co-ordinate transformation, orthogonal co-ordinates, change of coordinates, cartesian, cylindrical and spherical coordinates, expressions for velocity and acceleration, area, volume and surface area in cartesian, cylindrical and spherical coordinates, gradient, divergence, curl, Laplacian coordinates, contravariant and co-variant components of a vector, metric coefficients.

UNIT-II

15 hours

Fourier Series, Periodic Functions, Euler's formulae for Fourier series, Fourier series for discontinuous functions, half range series, Parseval's identity, Fourier integral theorem. Fourier Transform, convolution theorem, application of Fourier transforms to solve ODE and PDE.

UNIT-III

15 hours

Mellin Transform, Mellin transform of derivatives, Integrals, Inverse Mellin transform, Convolution theorem, Inverse Mellin transform of two functions. Hankel Transform, Elementary properties, Hankel transform of derivatives, Exponential functions, Inversion formula for Hankel transformation, Parseval's theorem, relation between Hankel and Laplace transform.

UNIT-IV

15 hours

Bessel's functions, Bessel function of second kind of order n , Trigonometric expansion involving, Bessel Functions, Bessel Integral, Fourier-Bessel Expansion, Legendre's associated functions and differential equation, integral

expression for associated Legendre polynomial, recurrence relation for associated Legendre polynomial.

Transaction Mode- Lecture, Demonstration, Video Based Teaching, Collaborative teaching, Group Discussion, ted talks, E team Teaching, Quiz, Open talk.

SUGGESTED READINGS:-

- *Sneddon, I. N.(1972), The Use of integral Transforms, McGraw Hill.*
- *Bell W. W.(2004), Special Functions for Scientists and Engineers, Courier Corporation.*
- *Spiegel M., Lipschutz S., Spellman D.(2011), Vector Analysis, Schaum's Series.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Special Functions**Course Code: MMH3504**

L	T	P	Cr
4	0	0	4

Total Hours:60

Course Learning Outcomes: On the completion of this course, the students will be able to:

1. Understand the general properties of Hypergeometric series, functions and their linear relationship.
2. Explain methods of studying Legendre's function, recurrence relation and their applications.
3. Solve Bessel's linear differential equations from application point of view.
4. Explore, formulate and solve this concept in real life situation.

COURSE CONTENT

UNIT-I

15 hours

Hypergeometric Functions, series, equation, Linear relations between the solutions of the hypergeometric equation, Relations of contiguity, The confluent hypergeometric function, Generalized hypergeometric series.

UNIT-II

15 hours

Legendre Functions, Legendre polynomials, Recurrence relations for the Legendre polynomials, The formulae of Murphy and Roderigues, Series of Legendre polynomials, Legendre's differential equation, Neumann's formula for the Legendre functions, Recurrence relations for the functions.

UNIT-III

15 hours

The use of Legendre functions in potential theory, Legendre's associated functions, Integral expression for the associated Legendre function, Surface spherical harmonics, Use of associated Legendre functions in wave mechanics.

UNIT-IV

15 hours

Bessel Functions, the origin of Bessel functions, Recurrence relations for the Bessel coefficients, Series expansions for the Bessel coefficients, Integral expressions for the Bessel coefficients, Bessel's differential equation, Spherical Bessel functions, Integrals involving Bessel functions, The modified Bessel functions,

Transaction Mode- Lecture, Demonstration, Video Based Teaching, Collaborative teaching, Group Discussion, ted talks, E team Teaching, Quiz, Open talk.

SUGGESTED READINGS: -

- *L. Andrews, (1985), Special Functions for Engineers and Applied Scientists, Macmillan.*
- *N. N. Lebedev, (1976), Special Functions & Their Applications, Revised Edition, Dover.*
- *W. W. Bell,(1968), Special Functions for Scientists and Engineers, Dover.*
- *Sao, G.S.(2020), Special functions, Shree shiksha Sahitya Parkasham , Meerut.*
- *Dhaonchak,P.K.(2016), Special function and Integral functions, Jeevan sons Publications.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: Linear Algebra**Course Code: MMH3505**

L	T	P	Cr
4	0	0	4

Total Hours:60

Course Learning Outcomes: After completion of this course, the learner will be able to:

1. Evaluate the direct sum of vector space.
2. Apply vectors, inner products and linear transformations to real world problems.
3. Develop an algebraic understanding of eigenvalues and eigen vectors.
4. Evaluate unitary and linear transformation to various physical problems.

COURSE CONTENT

UNIT-I

15 hours

Adjoint of a linear transformation, Inner product spaces, Eigen values and eigenvectors of a linear transformation, Diagonalization, Invariant subspaces.

UNIT-II

15 hours

Direct sum of a vector space, Basis, Dimension, Dual Spaces, Annihilator of a subspace, Quotient Spaces, Algebra of Linear transformations.

UNIT-III

15 hours

Canonical forms, Similarity of linear transformations, Reduction to triangular forms, Nilpotent transformations, Primary decomposition theorem, Jordan blocks and Jordan forms, Invariants of linear transformations.

UNIT-IV

15 hours

Hermitian, Self-adjoint, Unitary and normal linear transformation, Symmetric bilinear forms, skew symmetric bilinear forms, Group preserving bilinear forms.

Transaction Mode- Lecture, Demonstration, Video Based Teaching, Collaborative Teaching, Project-based Learning, Group Discussion, E-team Teaching, Quiz, Open Talk.

Suggested Readings:-

- *Herstein I. N. : Topics in Algebra, 2nd Edition, Willey eastern Limited*
- *Hoffman, Kenneth and Kunze R: Linear Algebra, Prentice Hill of India Private Limited., 1984.*
- *Sahi and Bist, Linear Algebra, Narosa Publishing House.*
- *Surjit Singh, Linear Algebra, Vikas publishing House (1997).*

Course Title: Astronomy**Course Code: MMH3506**

L	T	P	Cr
4	0	0	4

Total Hours:60

Course Learning Outcomes: After the completion of the course, students are expected to have the ability to:

1. Use Celestial Coordinates system to specify the positions of stars, planets, satellites, galaxies and other celestial objects in three-dimensional space.
2. Explore the parent star Sun and its importance for sustaining life on the earth.
3. Show familiarity with techniques to explore the solar surface temperature.
4. Understand the solar atmosphere and its effect on the Earth and other planets.

COURSE CONTENT

UNIT-I

15 hours

Celestial sphere Constellations and nomenclatures of stars, The cardinal points and circles on the celestial sphere, Coordinate system, Equatorial, Ecliptic system, Hour angle, Twilight, Spherical triangle, Polar triangle and related problems.

UNIT-II

15 hours

Sun, Interior structure of the Sun, atmosphere, solar activity, sunspots and magnetic field, solar wind. Planets, Study of Terrestrial planets, Jovian planets- their surface features & atmospheres. Tidal forces, Roche limit, Dwarf planets: Definitions and locations, Debris of the Solar system: Comets, Asteroids, Meteoroids.

UNIT-III

15 hours

Stars: Magnitude scales, Colour index, Basic of star formation and evolution. Hertzsprung-Russell (HR) diagram, Spectral classification, Energy generation of Basics of degenerate remnants of stars White dwarfs, Neutron stars, Pulsars, Black Holes, Chandrasekhar limit. Hydrostatic equilibrium, Pressure equation of state, Energy sources, Energy transport and convection.

UNIT-IV

15 hours

Observational tools Blackbody radiation, Specific intensity and flux density, Stellar parallax. Formation & Structure of spectral lines, Radiative transfer. Radiative processes in Astrophysics: Synchrotron emission, Energy loss and electron spectrum, Compton scattering, Bremsstrahlung, Thermal Bremsstrahlung

lung Binary stars, Classification, Accretion disks in binaries, Hulse-Taylor binary pulsar.

Transaction Mode- Lecture, Demonstration, Video Based Teaching, Collaborative Teaching, Project-based Learning, Group Discussion, E-team Teaching, Quiz, Open Talk.

Suggested Readings: -

- *W. M. Smart, Textbook on Spherical Astronomy, Cambridge University Press.*
- *I. Todhunter, Spherical trigonometry, The Macmillan company, London.*
- *Modern Astrophysics, B. W. Carroll and D. A. Ostlie, Addison-Wesley Publishing Co.*
- *Eric Chaisson & Steve Macmillan, Astronomy Today, Prentice Hall, New Jersey.*
- *John D Fix, Astronomy-Journey to the Cosmic Frontier, Mosby, New York.*
- *Introductory Astronomy & Astrophysics, M. Zeilik and S. A. Gregory, 4th Edition, Saunders College Publishing.*
- *Theoretical Astrophysics, Vol. I: Astrophysical Processes, T. Padmanabhan, Cambridge University Press.*
- *Theoretical Astrophysics, Vol. II: Stars and Stellar Systems, T. Padmanabhan, Cambridge University Press.*

Course Title: Wavelet Theory**Course Code: MMH3507**

L	T	P	Cr
4	0	0	4

Total Hours:60

Course Learning Outcomes: After the completion of the course, students are expected to have the ability to:

1. Make plans for higher level research in this area and get funded by the funding agencies
2. Learn about the mathematical analysis involved in Wavelets
3. Know the short comings in the Fourier analysis and how Wavelets help in overcoming those difficulties
4. Review Fourier transformation, continuous wavelet transform, multi-resolution analysis and algebraic constructions, included in the course

COURSE CONTENT

UNIT-I

15 hours

Fourier and inverse Fourier transforms, Convolution and delta function, Fourier transform of Square integrable functions, Continuous Wavelet Transform: The Heisenberg uncertainty principle, the Shannon sampling theorem, Definition and examples of continuous wavelet transforms,

UNIT-II

15 hours

A Plancherel formula, Inversion formulas, the kernel functions, Decay of wavelet transform, Frames: Geometrical considerations, Notion of frames.

UNIT-III

15 hours

Discrete wavelet transforms, signal decomposition (analysis), relation with filter banks, signal reconstruction.

UNIT-IV

15 hours

Multi resolution analysis, axiomatic description, the scaling function, construction of Fourier domain. Orthonormal wavelets with compact support: the basic idea, Algebraic constructions, binary interpolation, spline wavelets.

Transaction Mode- Lecture, Demonstration, Video Based Teaching, Collaborative Teaching, Project-based Learning, Group Discussion, E-team Teaching, Quiz, Open Talk.

Suggested Readings: -

- *Christian Blatter: Wavelets A Premier, AK Peters, 2002.*
- *C.K. Chui: An Introduction to Wavelets, Academic press.*
- *Daubechies: Ten Lectures on Wavelets, SIAM, Philadelphia.*

Course Title: Cryptography**Course Code: MMH3508**

L	T	P	Cr
4	0	0	4

Total Hours:60

Course Learning Outcomes: After the completion of the course, students are expected to have the ability to:

1. Have a broad theoretical background in cryptography and information security
2. Apply number theory in cryptography
3. Have good knowledge of information security and cryptography which will help them to go in the field of research and industry.

COURSE CONTENT

UNIT-I

15 hours

Secure communication, cryptographic applications, Symmetric cipher model, Substitution technique: Caesar cipher, Mono-alphabetic cipher, Play fair cipher, Hill cipher, polyalphabetic cipher, one-time pad, Transposition techniques, cryptanalysis of classical ciphers.

UNIT-II

15 hours

Pseudorandom bit generator, Blum Blum Shub generator, linear feedback shifts register sequences, Nonlinear feedback shift register, Stream cipher, Modern stream ciphers, RC4 stream cipher.

UNIT-III

15 hours

Block cipher, Feistel cipher, simplified DES, Data encryption standard (DES), Advance encryption standard(AES), S-box design of DES and AES, Boolean functions, bent functions, construction of finite fields, modular polynomial arithmetic. Mode of operations, Attacks on block cipher.

UNIT-IV

15 hours

Public key cryptosystem, RSA cryptosystem, RAS and factoring, Rabin encryption , Key management, Diffie Hellman key exchange, discrete logarithm, ElGamal encryption, Message integrity, cryptographic hash function, Hesh function based on block ciphers, Message authentication, Message authentication codes, digital signature, RSA digital signature scheme, ElGamal digital signature scheme.

Transaction Mode- Lecture, Demonstration, Video Based Teaching, Collaborative Teaching, Project-based Learning, Group Discussion, E-team Teaching, Quiz, Open Talk.

Suggested Readings: -

- *Johannes A. Buchman: Introduction to cryptography, Springer.*
- *William Stallings: Cryptography and network security Principles and practices, Pearson education.*
- *Alferd J. Menezes, Paul C. Van Oorschot, Scott: A Handbook of applied cryptography, Vanstone, CRC press.*
- *Wade Trappe, Lawrance C. Introduction to cryptography and coding theory, Washington.*

SEMESTER: 4th**Course Title: Numerical Analysis****Course Code: MMH4550**

L	T	P	Cr
4	0	0	4

Total Hours:60

Course Learning Outcomes: After the completion of the course, students are expected to have the ability to:

1. Characterize the basic concepts of operators like Solution of algebraic and transcendental equations: Bisection method, False position method, Fixed-point iteration method.
2. Solve problems using Newton forward formula and Newton backward formula and its convergence.
3. Derive Gauss's formula and Stirling's formula using Newton forward formula and Newton backward formula.
4. Calculate Simpson's 1/3, 3/8 rules using Trapezoidal rule and evaluate the summation of series finite difference techniques

Course Content**UNIT I****15 Hours**

Solution of algebraic and transcendental equations: Bisection method, False position method, Fixed-point iteration method, Newton's method and its convergence, Solution of system of non-linear equations by Iteration and Newton-Raphson method.

UNIT II**15 Hours**

Finite difference operators and finite differences, Interpolation and interpolation formulae: Newton's forward and backward difference, Central difference: Sterling's and Bessel's formula, Lagrange's interpolation formula and Newton's divided difference interpolation formula, Newton's divided difference formula

UNIT III**15 Hours**

Direct methods to solve system of linear equations: Gauss elimination method, Gauss-Jordan method, Gauss-Jacobi and Gauss-Seidal methods. The algebraic Eigen value problems LU Decomposition.

UNIT IV**15 Hours**

Numerical differentiation and Numerical integration by Newton cotes formulae, Trapezoidal rule, Simpson's rule, Romberg formula and their error estimation. Numerical solution of ordinary differential equations by Euler's method, Picard's method, Taylor series and Runge-Kutta methods.

Transaction Mode- Lecture, Demonstration, Project Method, Co-Operative learning, Seminar, Group discussion, Team teaching, Tutorial, Problem solving, E-team teaching, Self-learning.

Suggested Readings:-

- *B. Bradie, (2007). A Friendly Introduction to Numerical Analysis, Pearson Education, India,*
- *M. K. Jain, S. R. K. Iyengar and R. K. Jain, (2007). Numerical Methods for Scientific and Engineering Computation, New age International Publisher, India, 5th edition,*
- *C. F. Gerald and P. O. (2008). Wheatley, Applied Numerical Analysis, Pearson Education, India, 7th edition.*
- *M. Pal (2007). Numerical Analysis for scientific and engineering computation, Narosa Publication*
- *N. Ahmad (2008). Fundamental Numerical Analysis with error estimation, Anamaya Publisher.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs*

Course Title: Scientific Research and Technical writing**Course Code: MMH4551**

L	T	P	Cr
2	0	0	2

Total Hours:30

Course Learning Outcomes: After the completion of the course, students are expected to have the ability to:

1. Students will understand the scientific worldview.
2. Evaluate the role of creativity, curiosity, skepticism, open mindedness and diligence of individuals in scientific discovery and innovation.
3. Evaluate the role of communication, collaboration, diversity and peer review in promoting scientific progress.
4. The quality of scientific evidence and ideas, and ensuring compliance with ethical standards.

Course Content

Week 1: Technical Writing - Various forms of scientific writings - theses, technical papers, reviews, manuals, etc;

Week 2: Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion)

Week 3: How to arrange references of a synopsis/thesis/article/dissertation, Writing of abstracts, summaries, etc.; use of abbreviations in the thesis

Week 4: Research communications; illustrations, photographs and drawings with suitable captions;

Week 5: Participation in group discussion: Facing an interview; presentation of scientific papers.

Week 6: How to write a research paper, reference styles, process of submission of a paper;

Week 7: process of proof reading of a research manuscript; process of reviewing. Important journals, How to write a review paper, Plagiarism, Week 8: How to present research paper/research work in a conference/seminar/workshop How to defend synopsis/thesis.

Course Title: Dissertation**Course Code: MMH4552**

L	T	P	Cr
0	0	0	12

Guidelines for Dissertation:

The purpose of the dissertation in M.Sc. 4th semester is to introduce **MATLAB** to the students. It may consist of review of some research papers, development of a laboratory experiment, fabrication of a device, working out some problem related to subject, participation in some ongoing research activity, analysis of data, etc. The work can be carried out in any thrust areas of subject (Experimental or Theoretical) under the guidance of allotted supervisor of the department. The students must submit their dissertation in the department as per the date announced for the submission.

Internal assessment of the dissertation work will be carried out by respective supervisor through

power point presentation given by candidates during the semester. External assessment of the dissertation work will be carried out by an external examiner (nominated by the Chairperson of the Department) through power-point presentation given by candidates. This load (equivalent to 2 hours per week) will be counted towards the normal teaching load of the teacher.

1. Dissertation will contain a cover page, certificate signed by student and supervisor, table of contents, introduction, Objective, Literature review, methodology, results and discussions, conclusion, and references.

- The paper size to be used should be A-4 size.
- The font size should be 12 with Times New Roman.
- The text of the dissertation may be typed in 1.5 (one and a half) space.
- The print out of the dissertation shall be done on both sides of the paper (instead of single side printing)
- The total no. of written pages should be between 40 to 60 for dissertation.

2. The candidate shall be required to submit two soft bound copies of dissertation along with a CD in the department as per the date announced.

3. Dissertation will be evaluated internally by the supervisor allotted to the student during the semester.

4. The candidate will defend her/his dissertation/project work through presentation before the

External examiner at the end of semester and will be awarded marks.

5. In case, a student is not able to score passing marks in the dissertation exam, he/she will have to resubmit her/his dissertation after making all corrections/improvements & this dissertation shall be evaluated as above. The

candidate is required to submit the corrected copy of the dissertation in hardbound within two weeks after the viva -voce.

Course Title: MATLAB**Course Code: MMH4553**

L	T	P	Cr
3	0	0	3

Total Hours:45

Course Learning Outcomes: After the completion of the course, students are expected to have the ability to:

1. Understand the main features of the MATLAB program development environment to enable their usage in the higher learning.
2. Implement simple mathematical functions/equations in numerical computing environment.
3. Interpret and visualize simple mathematical functions and operations there on using plots.
4. Write simple programs in MATLAB to solve scientific and mathematical problems.

COURSE CONTENT

UNIT I

10 Hours

Operators:-Arithmetic Operator, Logical, Relational.

UNIT II

11 Hours

Branch and Loop:-If statement, If-else statement, Else-if statement, Pause, Break, Continue Switch-case, try-catch, Return Statement, For Loop, While Loop, Example(like a project).

UNIT III

12 Hours

Script and Function:-Script Design, Function Design, Types Of Function, Example (like a project).

UNIT IV

12 Hours

GUI (Graphical User Interface):-Introduction of GUI, GUI Function Property, GUI Component Design, GUI Container, Writing the code of GUI Callback, Dialog Box, Menu Designing

Transaction Mode- Lecture, Demonstration, Project Method, Co-Operative learning, Seminar, Group discussion, Team teaching, Tutorial, Problem solving, E-team teaching, Self-learning.

Suggested Readings:-

- *Rudra Pratab (2016), Getting Started with MATLAB, Oxford Univ. press, Seventh Edition.*
- *K.Srinivasa Rao (2012), Introduction to MATLAB, IMRF International Publications .*
- *P.Nagarajan, K.Srinivasa Rao (2009), Numerical Methods with Programs in MATLAB, University Press, SCSVMV.*
- *MiszaKalechman (2008), Practical MATLAB-Basics for Engineers, CRC Press.*
- *D.M.Etter (1997), Engineering Problems Solving with MATLAB, Prentice Hall.*
- *Suggested digital platform: NPTEL/SWAYAM/MOOCs.*

Course Title: LaTeX
Course Code: MMH4554

L	T	P	Cr
3	0	0	3

Total Hours:45

Course Learning Outcomes: After the completion of the course, students are expected to have the ability to:

1. Type setting of complex mathematical formulae using LaTeX.
2. Use tabular and array environments within LaTeX.
3. Use various methods to either create or import graphics into a LaTeX document.
4. Typesetting of journal articles, technical reports, and slide presentations.

Course Content

UNIT I

10 Hours

Installation of MikeTeX, Online Overleaf access, TEX and its offspring, Creating a Title, Sections, Command names, and arguments, Labelling Table of Contents, Font Effects, Coloured Text, Font Sizes, Comments & Spacing Special Characters, Line breaking.

UNIT II

11 Hours

Lists, Tables, Figures - List of figures, Equations: Inserting Equations and Mathematical Symbols, Inserting References: Inserting the Bibliography Styles, Technical Report: Writing Thesis/project/report, Classes: article, book, report, beamer, slides. IEEtran.

UNIT III

12 Hours

Document Layout and Organization, Page Layout- Titles, Abstract Chapters, Sections, References, Equation References, citation. List-making environments, Table of contents, generating new commands, Figure handling numbering, Generating index, Loading packages. Parts of the document: Abstract, Chapters, Appendix, Customized head and foot lines,

UNIT IV

12 Hours

Introduction to Beamer, Main features: How to set the document class to beamer, its title, subtitle, author, institute, and date information, Bold, italics and underlining, Highlighting important sentences/words, Customizing presentation: themes (rows) and color themes (columns), Fonts and columns.

Transaction Mode- Lecture, Demonstration, Project Method, Co-Operative learning, Seminar, Group discussion, Team teaching, Tutorial, Problem solving, E-team teaching, Self-learning.

Suggested Readings:-

- *Guide to LATEX, fourth edition, Helmut Kopka, Patrick W.Daly*
- https://www.overleaf.com/learn/latex/Beamer#Reference_guide
- <https://mirror.niser.ac.in/ctan/macros/latex/contrib/beamer/doc/beameruserguide.pdf>.

Course Title: MATLAB Lab**Course Code: MMH4555**

L	T	P	Cr
0	0	2	1

Total Hours:15

Course Learning Outcomes: After the completion of the course, students are expected to have the ability to:

1. Apply MATLAB programming skills to solve mathematical problems and Visualize mathematical functions and data using 2D and 3D plotting tools.
2. Perform matrix operations, apply linear algebra techniques and Solve systems of equations using direct and iterative numerical methods.
3. Implement numerical differentiation and integration techniques by Using MATLAB for solving ordinary differential equations (ODEs) numerically.
4. Perform curve fitting, interpolation, optimization problems and regression analysis using MATLAB toolboxes and Develop scripts and functions for modular and efficient coding practices. Also, interpret computational results and validate them against analytical solutions where possible.

COURSE CONTENT

Sr. No.	Practical Title	Description
1	Matrix Operations and Determinant Calculation	Write a script to perform addition, subtraction, multiplication, transpose, and determinant calculation for matrices
2	Solving Systems of Linear Equations	Solve a system of linear equations using <code>inv()</code> , <code>\</code> operator, and <code>linsolve()</code> ; compare results.
3	Plotting Mathematical Functions	Plot basic functions like $\sin(x)$, $\exp(x)$, $\log(x)$, and a polynomial. Use <code>plot()</code> , <code>fplot()</code> , and <code>ezplot()</code> .
4	Eigenvalues and Eigenvectors	Calculate eigenvalues and eigenvectors of a given square matrix using <code>eig()</code> and interpret their meaning
5	Interpolation and Curve Fitting	Use <code>interp1()</code> , <code>interp2()</code> and <code>polyfit()</code> to interpolate and fit data points. Plot the original and fitted curves.
6	Numerical Differentiation and Integration	Write scripts to perform numerical differentiation (<code>diff()</code>) and integration (<code>trapz()</code> , <code>integral()</code>) on discrete datasets
7	Root Finding for Nonlinear Equations	Use <code>fzero()</code> and <code>fsolve()</code> to find roots of nonlinear functions like $f(x) = x^3 - 2x + 1$

8	Solving Ordinary Differential	Solve $dy/dt = -2y$ with initial condition $y(0) = 1$ using <code>ode45()</code> and plot the solution
9	Fourier Series Approximation	Approximate a periodic function using Fourier series and plot the approximation
10	Optimization Problems	Use <code>fminbnd()</code> and <code>fminsearch()</code> to find minima of functions like $f(x) = (x - 3)^2 + 4$. Interpret results

Course Title: LaTeX Lab**Course Code: MMH4556**

L	T	P	Cr
0	0	2	1

Total Hours:15

Course Learning Outcomes: After the completion of the course, students are expected to have the ability to:

1. Understand the structure of a LaTeX document, including preamble, body, compilation, and create well-formatted mathematical expressions, including equations, fractions, matrices, and special symbols.
2. Typeset complex mathematical environments, like theorems, proofs, definitions, and Format multi-line equations with advanced features like align, gather, and cases. Insert and manage tables, matrices, and arrays in mathematical documents.
3. Use LaTeX to create professional-quality figures with packages like TikZ and PGF Plots. Handle references, citations, and bibliographies for mathematical writing. Develop custom commands and environments for repetitive structures.
4. Generate presentations with Beamer focusing on mathematical content. Produce structured mathematical reports, assignments, and research articles ready for journal submission.

COURSE CONTENT

Sr. No.	Practical Title	Description
1	Basic Document Setup and Inline Mathematics	Create a basic LaTeX document. Include title, author, sections, and inline math expressions like $E = mc^2$.
2	Displaying Equations and Equation Numbering	Typeset display equations (both numbered and unnumbered) such as quadratic formula and basic derivatives
3	Multi-line Equations using align Environment	Write multi-step derivations (e.g., binomial expansion) using the align environment and proper equation numbering
4	Matrices and Determinants	Typeset different types of matrices (bmatrix, pmatrix, vmatrix) and determinants neatly
5	Theorem, Lemma, and Proof Structures	Define and use theorem-like environments for a small mathematical proof (e.g., proof of Pythagoras theorem).

6	Tables and Arrays for Mathematical Data	Create tables showing values of functions (like x , $\sin x$, $\cos x$) and format them properly
7	Plotting Functions Using TikZ and PGFPlots	Plot simple graphs like $y = x^2$ or $y = \sin(x)$ using TikZ or PGFPlots packages
8	Case Analysis and Piecewise Functions	Typeset piecewise-defined functions, e.g., absolute value function $f(x) = x \ (x \geq 0) \text{ or } -x \ (x < 0)$
9	References and Citations in Mathematical Writing	Insert equation references, figure references, and citations from a .bib file into a LaTeX document.
10	Creating a Mathematical Presentation Using Beamer	Design a short Beamer presentation (5 slides) explaining a mathematical concept like Taylor Series or Fourier Series