Rayat Shikshan Sanstha's

Karmaveer Bhaurao Patil College Vashi, Navi Mumbai

Autonomous College

[Affiliated to University of Mumbai]

Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of Course	M.Sc. II Mathematics (CBCS)
2	Eligibility for Admission	M.Sc. I Mathematics
3	Passing Marks	40%
4	Ordinances/Regulations (if any)	
5	No. of Years/Semesters	One year/Two semester
6	Level	P.G.
7	Pattern	Semester
8	Status	New
9	To be implemented from Academic year	2022-2023

AC-19/04/2022

Item No-6.5

Rayat Shikshan Sanstha's
KARMAVEER BHAURAO PATIL COLLEGE, VASHI.
NAVI MUMBAI
(AUTONOMOUS COLLEGE)
Sector-15- A, Vashi, Navi Mumbai - 400 703

Syllabus for M.Sc. II Mathematics

Program: M.Sc.

Course: M.Sc. II Mathematics

(Choice Based Credit System
with effect from the academic year 2022-2023)

Preamble of the Syllabus:

Master of Science (M.Sc.) in Mathematics is a post-graduation programme of Department of Mathematics, Karmaveer Bhaurao Patil College Vashi, Navi Mumbai [Autonomous College]

The Choice Based Credit System to be implemented through this curriculum, would allow students to develop a strong footing in the fundamentals and specialize in the disciplines of his/her liking and abilities. The students pursuing this course would have to develop understanding of various aspects of the mathematics. The conceptual understanding, development of experimental skills, developing the aptitude for academic and professional skills, acquiring basic concepts and understanding of hyphenated techniques are among such important aspects.

Rayat Shikshan Sanstha's
KARMAVEER BHAURAO PATIL COLLEGE, VASHI.
NAVI MUMBAI
(Autonomous)
Department of Mathematics
M. Sc. Mathematics

Program Outcomes (POs)

Learners are able to:

PO-1	**Disciplinary Knowledge and Skills:**	Acquire the comprehensive and in-depth knowledge of various subjects in sciences such as Physics, Chemistry, Mathematics, Microbiology, Bio-analytical Science, Computer Science, Data Science, Information Technology and disciplinary skills and ability to apply these skills in the field of science, technology and its allied branches.
PO-2	**Communication and Presentation Skills:**	Develop various communication skills including presentation to express ideas evidently to achieve common goals of the organization.
PO-3	**Creativity and Critical Judgement:**	Facilitate solutions to current issues based on investigations, evaluation and justification using evidence-based approach.
PO-4	**Analytical Reasoning and Problem Solving**	Build a critical and analytical attitude in handling the problems and situations.
PO-5	**Sense of Inquiry**	Curiously raise relevant questions based on highly developed ideas, scientific theories and its applications including research.
PO-6	**Use of Modern Tools**	Use various digital technologies to explore information/data for business, scientific research and related purposes.
PO-7	**Research Skills**	Construct, collect, investigates, evaluate and interpret information/data relevant to science and technology to adapt, evolve and shape the future.
PO-8	**Application of Knowledge**	Develop a scientific outlook to create consciousness against the social myths and blind faith.
PO-9	**Moral and Ethical Reasoning**	Imbibe ethical, moral and social values to develop virtues such as justice, generosity and charity as beneficial to individuals and society at large.
PO-10	**Leadership and Teamwork:**	Work cooperatively and lead proactively to achieve the goals of the organization by implementing the plans and projects in various field-based situations related to science, technology and society at large.
PO-11	**Environment and Sustainability**	**Environment and Sustainability:** Create social awareness about environment and develop sustainability for betterment of future.

PO-12	**Lifelong Learning:**	Realize that pursuit of knowledge is a lifelong activity and in combination with determined efforts, positive attitude and other qualities to lead a successful life.

Program Specific Outcomes (PSO)

PSO1	Recalling the concepts of mathematics and applying them to the various courses like algebra, analysis, Differential equations, statistics, etc to form mathematical models.
PSO2	Apply Mathematics to interdisciplinary ways like statistician, mathematical finance, industry expertise and interpret quantitative ideas.
PSO3	Apply knowledge of Mathematics for research and engineering.

Rayat Shikshan Sanstha's

KARMAVEER BHAURAO PATIL COLLEGE, VASHI

[AUTONOMOUS COLLEGE]

Department of Mathematics

M.Sc. Mathematics
Choice Based Credit System (CBCS)

Program	SEM	CORE Course (6 credits per course)	DSE (6 credits per course)	SEC (4 credits per course)
MSC-I Mathematics	I	Algebra-I Analysis-I Complex Analysis	Discrete Mathematics **Or** Elementary Probability Theory and Statistics	Introduction to R Programming-I **Or** Advanced Python-I
	II	Algebra-II Topology Research Methodology	Differential Equation **Or** Optimization Techniques	Introduction to R Programming-II **Or** Advanced Python-II
Compulsory Course: Summer Internship for 6 credits (200 Marks)				
MSC-II Mathematics	III	Algebra-III Analysis-II Differential Geometry	Numerical Methods **Or** Graph Theory-I **Or** Design Theory	Integral Transform Or Calculus on Manifolds
	IV	Field Theory Functional Analysis Partial Differential Equations	Fourier Analysis **Or** Graph Theory-II **or** Calculus of variations and Integral Equations	Project

CC: Core Course (these courses are compulsory to the students),

DSE: Discipline Specific Elective (Students can choose anyone)

SEC: Skill Enhanced Course (Compulsory Skill Based Course)

Compulsory: Summer Internship is for 6 credits (200 Marks) during April to July

Credits: Part-I (28+28=56), Part-II (34+28=62), Total Credits: 118

Rayat Shikshan Sanstha's

KARMAVEER BHAURAO PATIL COLLEGE, VASHI.

NAVI MUMBAI (Autonomous)

(w.e.f. academic year 2022-23)

Semester-III

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credit Scheme			
		Lecture	Practical	Tutorial	CIE	Sem End-Exam	Term work	Practical	Oral	Total	Lecture	Practical	Tutorial	Total
PGMT301	Algebra-III	06	-	-	40	60	-	-	-	100	06	-	-	06
PGMT302	Analysis-II	06	-	-	40	60	-	-	-	100	06	-	-	06
PGMT303	Differential Geometry	06	-	-	40	60	-	-	-	100	06	-	-	06
PGMT304A Or PGMT304B Or PGMT304C	Numerical Methods **Or** Graph Theory-I **Or** Design Theory	06	-	-	40	60	-	-	-	100	06	-	-	06
PGMT305A Or PGMT305B	Integral Transform Or Calculus on Manifolds	04	-	-	40	60	-	-	-	100	04	-	-	04
PGMT306	Internship	06	-	-	-	-	**140**	-	**50**	-	-	-	-	06
	Total	**34**	**-**	**-**	**200**	**300**	**140**	**-**	**50**	**700**	**28**	**-**	**-**	**34**
										Total Credit	**28**	**-**	**-**	**34**

Semester-IV

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credit Scheme			
		Lecture	Practical	Tutorial	CIE	Sem End-Exam	Term work	Practical	Oral	Total	Lecture	Practical	Tutorial	Total
PGMT401	Field Theory	06	-	-	40	60	-	-	-	100	06	-	-	06
PGMT402	Functional Analysis	06	-	-	40	60	-	-	-	100	06	-	-	06
PGMT403	Partial Differential Equations	06	-	-	40	60	-	-	-	100	06	-	-	06
PGMT404A Or PGMT404B Or PGMT404C	Fourier Analysis **Or** Graph Theory-II Or Calculus of variations and Integral Equations	06	-	-	40	60	-	-	-	100	06	-	-	06
PGMT405	Project	04	-	-	20	60	-	-	20	100	04	-	-	04
	Total	**28**	**-**	**-**	**180**	**300**	**-**	**-**	**20**	**500**	**28**	**-**	**-**	**28**
										Total Credit	**28**	**-**	**-**	**28**

Syllabus of CBCS CURRICULUM

COURSE STRUCTURE FOR M.Sc. II MATHEMATICS

SEMESTER III

	Course Code	Unit	Topic	Credit	L/W
CORE COURSES			**Algebra III**		
	PGMT301	I	Groups	6	6
		II	Representation of finite groups		
		III	Modules		
		IV	Modules over PID		
			Analysis II		
	PGMT302	I	Measures	6	6
		II	Measurable functions		
		III	Integration of measurable functions		
		IV	Convergence theorem and $L^p(\mu)$ spaces		
			Differential Geometry		
	PGMT303	I	Geometry of $\mathbb{R}^n$	6	6
		II	Plane and Space Curves		
		III	Regular Surfaces		
		IV	Curvature		
DISIPLINE SPECIFIC ELECTIVE (DSE-A)			**Numerical Methods**		
	PGMT304 A	I	Basics of Numerical Analysis	6	6
		II	Solution of Algebraic & Transcendental Equations		
		III	System of linear equations and solutions		
		IV	Interpolation		
DISIPLINE SPECIFIC ELECTIVE (DSE-B)			**Graph Theory-I**		
	PGMT304 B	I	Connectivity	6	6
		II	Trees		
		III	Eulerian and Hamiltonian Graphs		
		IV	Matching and Ramsey Theory		
DISIPLINE SPECIFIC ELECTIVE (DSE-C)			**Design Theory**		
	PGMT304 C	I	Introduction to Balanced Incomplete Block Designs	6	6
		II	Symmetric BIBDs		
		III	Difference sets and automorphisms		
		IV	Hadamard Matrices and Designs		
SKILL ENHANCEMENT COURSE(SEC)			**Integral Transform**		
	PGMT305A	I	Laplace Transform	4	4
		II	Fourier Transform		
		III	Mellin Transform		
		IV	Z-Transform		

SKILL ENHANCEMENT COURSE(SEC)	**Calculus on Manifolds**				
	PGMT305B	I	Multilinear algebra	4	4
		II	Differential forms		
		III	Basics of submanifolds of $\mathbb{R}^n$		
		IV	Stoke's Theorem		

SEMESTER IV

	Course Code	Unit	Topic	Credit	L/W
CORE COURSE	**Field Theory**				
	PGMT401	I	Algebraic Extensions	6	6
		II	Normal and Separable Extensions		
		III	Galois Theorems		
		IV	Applications		
CORE COURSE	**Functional Analysis**				
	PGMT402	I	Baire spaces, Hilbert spaces	6	6
		II	Normed Linear Spaces		
		III	Bounded Linear Transformations		
		IV	Basic Theorems		
CORE COURSE	**Partial Differential Equations**				
	PGMT403	I	Classification of second order Linear partial differential equations	6	6
		II	Laplace operator		
		III	Heat operator		
		IV	Wave operator		
DISIPLINE SPECIFIC ELECTIVE (DSE-A)	**Fourier Analysis**				
	PGMT404 A	I	Fourier series	6	6
		II	Dirichlet's theorem		
		III	Fejer's Theorem and applications		
		IV	Dirichlet problem in the unit disc		
DISIPLINE SPECIFIC ELECTIVE (DSE-B)	**Graph Theory-II**				
	PGMT404 B	I	Graph Colouring	6	6
		II	Planar Graph		
		III	Flow Theory		
		IV	Characteristic Polynomials		
DISIPLINE SPECIFIC ELECTIVE (DSE-C)	**Calculus of Variations and Integral Equations**				
	PGMT404 C	I	Calculus of Variations	6	6
		II	Euler's equation and variational problems		
		III	Integral Equations: Fredholm and Volterra equations		
		IV	Applications of Integral Equations		

SKILL ENHANCEMENT COURSE(SEC)	PGMT405	**PROJECT**	4	4

Note: 1. Blue Highlighted Topic / Course has focused on employability/ entrepreneurship/skill development

2. Yellow Highlighted Topic / Course is related to professional ethics, gender, human values, Environment & sustainability
3. Green Highlighted Topic / Course is related to local/national/regional & global development needs.

Teaching Pattern for Semester I and II:

1. Six lectures per week per course. Each lecture is of 60 minutes duration.
2. For SEC four lectures per week per course. Each lecture is of 60 minutes duration.
3. In addition, there shall be tutorials, seminars as necessary for each of the five courses.

Objective:

1. Giving an adequate knowledge of basic with fundamental principles to understand the numerous powers of mathematical ideas and tools for modelling, solving and interpreting.
2. Developing analytical methods mathematical tools for continuing further study in various fields of science.
3. Enhancing students' overall development and to equip them with mathematical modelling abilities, problem solving skills, creative talent and power of communication necessary for various kinds of employment.
4. A student should get adequate exposure to global and local concerns that explore them many aspects of Mathematical Sciences.
5. The main objective of this course is to introduce mathematics and statistics to students of science, so that they can use them in the field of commerce and industry to solve the real-life problems.

SEMESTER III

PGMT301: ALGEBRA III

(All Results have to be done with proof unless otherwise stated).

Unit I. Groups (15 Lectures)
Simple groups, A_5 is simple. Solvable groups, Solvability of all groups of order less than 60, Nilpotent groups, Isomorphism theorem, Jordan-Holder theorem, Direct and Semi-direct products, Examples such as group of affine transformations and Dihedral groups as semi-direct product. Classification of groups of finite order (up to 21).
Unit II. Representation of finite groups (15 Lectures)
Linear representations of a finite group on a finite dimensional vector space over $\mathbb{C}$, Maschke's theorem. The space of class functions, Characters and Orthogonality relations. Irreducible representations of finite groups and Schur's lemma.
Character tables with emphasis on examples of groups of small order.
Reference: Chapter 2, 3 from Benjamin Steinberg, Representation Theory of Finite groups.
Unit III. Modules (15 Lectures)

Modules over rings, Abelian groups as $\mathbb{Z}$ -modules, Submodules. Annihilators. Module homomorphisms, kernels. Quotient modules. Isomorphism theorems. Generating sets of modules and finitely generated modules, (internal) direct sums and equivalent conditions. Free modules, free module of rank n.
Invariant basis property of commutative ring.
Matrix representations of homomorphisms between free modules of finite ranks.

Unit IV. Modules over PID (15 Lectures)

Noetherian modules and equivalent conditions. Torsion elements of a module, torsion free modules, submodule of a free module over a PID, Structure theorem for finitely generated modules over a PID: Fundamental theorem, Existence (Invariant Factor Form and Elementary Divisor Form), Fundamental theorem, Uniqueness. Applications to the Structure theorem for finitely generated Abelian groups and linear operators.

Reference Books:

1. D.S. Dummit and R.M. Foote, Abstract Algebra, John Wiley and Sons.
2. S. Lang, Algebra, Springer Verlag, 2004
3. N. Jacobson, Basic Algebra, Volume 1, Dover, 1985.
4. M. Artin, Algebra, Prentice Hall of India.
5. Benjamin Steinberg, Representation Theory of Finite groups.

PGMT301 Algebra III

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

CO1: Define character of a linear representation and list the properties exhibited by them.

CO2: Find the character table of groups of small order.
CO3: Explain the structure theorem for finitely generated modules over a ring and its applications to abelian groups and matrices.
CO4: Design, analyze and implement the concepts of homomorphism and isomorphism between modules for solving different types of problems, for example, Isomorphism theorems, quotient modules etc.
CO5: Identify and analyze different types of algebraic structures such as solvable groups, simple groups and alternate groups to understand and use the fundamental results in algebra.

ICT Tools Used: Videos, PPT, Chalk Board

Students Centric Methods: Problem Solving and Participative (Experimental, Participative, Problem Solving)

Links: SWAYAM / MOOCS:
1. https://nptel.ac.in/courses/111102009
2. https://nptel.ac.in/courses/111106137

The CO-PO Mapping Matrix

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	-	1	-	-	-	-	-	-	-	-
CO2	1	-	-	2	-	-	-	-	-	-	-	-
CO3	1	-	-	2	-	-	-	-	-	-	-	-
CO4	2	-	-	2	-	-	-	-	-	-	-	-
CO5	1	-	-	3	-	-	-	-	-	-	-	-

PGMT302: ANALYSIS II

Unit I: Measures (15 Lectures)

Outer measure μ^* on X, μ^* measurable subsets on X (A subsetE of a set X with outer measure μ^* is said to be μ^* measurable if $\mu^*(A) = \mu^*(A \cap E) + \mu^*\big(A \cap (X \backslash E)\big) \forall A \subseteq X$), the collection $\sum$ of all μ^*-measurable subsets of X form a σ-algebra, measure space $(X, \sum, \mu)$.

Volume $\lambda(I)$ of any rectangle in $\mathbb{R}^d$(for interval $I = \prod_{i=1}^{d}(a_i, b_i)$of $\mathbb{R}^d$, $\lambda(I) = \prod_{i=1}^{d}(b_i - a_i)$.
Lebesgue's Outer measure m^*in $\mathbb{R}^d$and results:

1. Lebesgue's outer measure m^* is translation invariant.
2. Let A, B be two subsets of $\mathbb{R}^d$ with $d(A, B) > 0$. Then $m^*(A \cup B) = m^*(A) + m^*(B)$.
3. For any bounded interval $I = (a, b)$ of $\mathbb{R}$, $m^*(I) = b - a$.
4. For any interval I of $\mathbb{R}^d$, $m^*(I) = \lambda(I)$.

The σ −algebra $\mathcal{M}$of all Lebesgue measurable subsets of $\mathbb{R}^d$, the lebesgue measure $m = m^*|_{\mathcal{M}}$ and the measure space $(\mathbb{R}^d, \mathcal{M}, m)$.

Borel $\sigma -$ algebra of $\mathbb{R}^d$, Any closed subset and any open subset of $\mathbb{R}^d$is Lebesgue measurable. Every

Borel set in $\mathbb{R}^d$ is Lebesgue measurable. For any bounded Lebesgue measurable subset E of $\mathbb{R}^d$, given $\epsilon > 0$ there exist compact set K and open set U in $\mathbb{R}^d$, such that $K \subseteq E \subseteq U$ and $m(U - K) <\in$. for any Lebesgue measurable subset E of $\mathbb{R}^d$ there exist Borel set F, G in $\mathbb{R}^d$ such that, $F \subseteq E \subseteq G$ and $m(E - F) = 0 = m(G - E)$.

Existence of subset of $\mathbb{R}$ which is not Lebesgue measurable. F^σ sets, G^δ sets.

Unit II. Measurable functions (15 lectures)

Measurable function on $(X, \sum, \mu)$, simple functions, properties of measurable functions. If $f \geq 0$ is a measurable function, then there exists a monotone increasing sequence (S_n) of a non-negative simple measurable function converging to pointwise to the function f. Convergence in measure.

Complex valued Lebesgue measurable functions in $\mathbb{R}^d$, Lusin's Theorem (Every measurable function is almost a continuous function.)

Unit III. Integration of measurable functions

Integral $\int_X$ Sdμ of a non-negative simple measurable function S defined on the measure space $(X,\sum,\mu)$ and properties, integral of non-negative measurable function, Monotone convergence theorem. If $f \geq 0$ and $g \geq 0$ are measurable functions, then $\int_X (f+g)d\mu = \int_X f\, d\mu + \int_X g\, d\mu$. Lebesgue integral of complex valued measurable functions, approximation of Lebesgue integrable functions by continuous functions with compact support.

Unit IV. Convergence theorem and $L^P(\mu)$ spaces (15 lectures)

Monotone convergence theorem, Fatou's lemma, Dominated convergence theorem, Completeness of $L^1(\mu), L^2(\mu)$

Lebesgue's and Riemann integrals: A bounded real valued function on $[a, b]$ is Riemann integrable if and only if it is continuous at almost every point of $[a, b]$ in this case, its Riemann integral and Lebesgue integral coincide. Product measures and Fubini's theorem.

Recommended Textbooks:

1. H. L. Royden, Real Analysis by PHI
2. Andrew Browder, Mathematical Analysis, An Introduction, Springer Undergraduate Texts in Mathematics
3. Walter Rudin, Real and Complex Analysis, McGraw Hill India, 1974.
4. E. Stein & R. Shakarchi, Real Analysis.

PGMT302: Analysis II

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

CO1: Understand how measures may be used to construct integrals.

CO2: Establish measurability or non-measurability of sets and functions.

CO3: Compute Lebesgue integral and have knowledge of its applications to volume calculations and Fourier analysis.

CO4: Understanding that Lebesgue integration can solve certain problems for which Riemann integration does not provide adequate answers.

CO5: Know the basic convergence theorems for the Lebesgue integral.

ICT Tools Used: Videos, PPT, Chalk Board

Students Centric Methods: Problem Solving and Participative (Experimental, Participative, Problem Solving)

Links: SWAYAM / MOOCS:

1. https://nptel.ac.in/courses/111101005
2. https://nptel.ac.in/courses/111108135

The CO-PO Mapping Matrix

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	1	2	1	-	-	-	-	-	-	-
CO2	1	-	-	1	2	-	-	-	-	-	-	-
CO3	1	-	-	2	1	-	1	3	-	-	-	-
CO4	2	-	-	3	1	-	3	-	-	-	-	-
CO5	1	-	-	1	-	-	-	2	-	-	-	-

PGMT303: DIFFERENTIAL GEOMETRY

Unit I. Geometry of $\mathbb{R}^n$ (15 Lectures)

Inner product in $\mathbb{R}^n$, Lines and planes in $\mathbb{R}^n$ and their Parametric equations, Orthonormal basis, Orthogonal transformations, Orthogonal matrices, Hyperplanes in $\mathbb{R}^n$**,** Reflections and rotations, classification of rotations as elements of the groups SO (2), SO (3), Isometries of $\mathbb{R}^n$- classification. Review of inverse mapping theorem and implicit function theorem.

Reference for Unit I: S. Kumaresan, Linear Algebra, A Geometric Approach

Unit II. Plane and Space Curves (15 Lectures)

Regular curves in $\mathbb{R}^2$and $\mathbb{R}^3$, Arc length parametrization, curvature and signed curvature for plane curves. Fundamental theorem for plane curves, Curvature and torsion for space curves, Serret-Frenet equations, Fundamental theorem for space curves.

Unit III. Regular Surfaces (15 Lectures)

Regular surfaces in $\mathbb{R}^3$, local coordinates and atlas with examples, Surfaces as level sets, Surfaces as graphs, Surfaces of revolution. Tangent vectors and tangent space to a surface at a point, Smooth functions on a surface, Differential of a smooth function defined on a surface, Normal Vector, Orientable surfaces, the first fundamental form.

Unit IV. Curvature of Surfaces (15 Lectures)

The Gauss map, Shape operator, the second fundamental form, Principal curvatures, Euler's formula, Meusnier's Theorem, Normal curvature, Gaussian curvature and mean curvature, Computation of Gaussian curvature, Isometries of surfaces, Gauss's Theorem Egregium (without proof), Geodesics - definition, properties, geodesics and isometries- show that great circles are geodesics in sphere.

Reference for Units II, III, IV:

1. M. DoCarno, Differential geometry of curves and surfaces, Princeton University Press, 1976.
2. S. Montiel and A. Ros, Curves and Surfaces, AMS Graduate Studies in Mathematics, 2009.

3. A. Pressley, Elementary Differential Geometry, Springer UTM, 2009.
4. J. Thorpe, Elementary Topics in Differential Geometry, Springer UTM, 2007.
5. Christian Baer, Differential Geometry, Cambridge University Press.

PGMT303 DIFFERENTIAL GEOMETRY

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

CO1: Understand and solve problems which require the use of differential geometry

CO2: Recognize the basis of notions of the local theory of space curves and the local theory of surfaces.

CO3: Compute the curvature and torsion of space curves.

CO4: Understand the curvature and torsion of a space curve, how to compute them, and how they suffice to determine the shape of the curve.

CO5: Analyse and solve complex problems using appropriate techniques from differential geometry.

ICT Tools Used: Videos, PPT, Chalk Board

Students Centric Methods: Problem Solving and Participative (Experimental, Participative, Problem Solving)

Links: SWAYAM / MOOCS:

1. https://ocw.mit.edu/courses/18-950-differential-geometry-fall-2008/
2. https://onlinecourses.nptel.ac.in/noc20_ma01/preview

The CO-PO Mapping Matrix

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2		-	1	-	-	-	-	-	-	-	-
CO2	1	-	2	2	-	-	-	-	-	-	-	-
CO3	1	-	-	2	-	-	-	-	-	-	-	-
CO4	2	-	-	2	-	-	-	-	-	-	-	-
CO5	2	-	-	2	-	-	-	-	-	-	-	-

PGMT 304 A: NUMERICAL METHODS

All methods discussed in the course should be illustrated using suitable programming language and conducting practical.

Unit I. Numerical Integration (15 Lectures)

(Review of forward back and ward difference operators, interpolation, extrapolation) Numerical Integration: Newton-Cotes quadrature formula, Trapezoidal rule, Simpson's one third and three eighth rules, Errors in trapezoidal and Simpson's rules, Romberg's method, Gaussian quadrature, Multiple integrals. Develop programing using python.

Unit II. Approximation of functions (15 Lectures)

Least squares approximation, Weighted least squares method, Gram-Schimdt orthogonalizing process, least squares approximation by Chebyshev polynomials, Discrete Fourier transforms, Fast Fourier Transforms. Develop programing using python.

Unit III. Differential Equations (15 Lectures)

Differential equations: Solutions of linear differential equations with constant coefficients, Series solutions, Euler's modified method, Runge-Kutta methods, Predictor corrector Methods, Stability of numerical methods. Develop programing using python.

Unit IV. Numerical Solutions of partial differential Equations (15 Lectures)

Classification, Finite difference approximations to derivatives, Numerical methods of solving elliptic, Parabolic and hyperbolic equations. Develop programing using python.

Reference Books:

1. H. M. Antia, Numerical Analysis for scientists and engineers, TMH 1991.
2. Jain, Iyengar, Numerical methods for scientific and engineering problems, New Age International, 2007.
3. S. S. Sastry, Introductory methods of numerical analysis, Prentice-Hall India, 1977.
4. K.E. Atkinson, An introduction to numerical analysis, John Wiley and sons, 1978.

PGMT 304 A: NUMERICAL METHODS

Course Outcomes: After successful completion of this course, students will be able to:
CO-1: understand the concepts of Numerical Differentiation and Integration
CO-2: perform calculations to solve problems.
CO-3: Solve differential equations & Boundary value problems for ODE and PDE using various methods
CO-4: Design, analyze and implement of numerical methods for solving different types of problems.
CO-5: select numerical methods with the understanding of their limitations so that they can be implemented in order to get acceptable results.
CO-6: Develop programming using python for various numerical methods.

ICT Tools Used: Videos, PPT, Pen-Tablet, python

Students Centric Methods: Problem Solving and Participative
(Experimental, Participative, Problem Solving)

Links: SWAYAM / MOOCS:
1) https://nptel.ac.in/courses/111106101
2) https://nptel.ac.in/courses/111107063
3) https://www.digimat.in/nptel/courses/video/111105093/L07.html

The CO-PO Mapping Matrix

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	2	1	1	1	-	-	-	-	-	-
CO2	2	2	-	2	-	-	-	-	-	-	-	-
CO3	2	1	2	1	-	-	-	-	-	-	-	-
CO4	2	2	-	2	-	-	-	-	-	-	-	-
CO5	1	-	1	2	1	-	-	-	1	-	-	-
CO6	1	1	1	1	1	3	1	1	1	-	-	-

PGMT304B: GRAPH THEORY-I

Unit I. Connectivity (15 Lectures)

Overview of Graph Theory-Definition of basic concepts such as Graph, Subgraphs, Adjacency and incidence matrix, Degree, Connected graph, Components, Isomorphism, Bipartite graphs etc., shortest path problem-Dijkstra's algorithm, Vertex and Edge Connectivity-Result $k \leq k' \leq \delta$, Blocks, Block-cut point theorem, Construction of reliable communication network, Menger's theorem.

Unit II. Trees (15 Lectures)

Trees-Cut vertices, cut edges, Bond, Characterizations of Trees, spanning trees, Fundamental cycles, Vector space associated with graph, Cayley's formula, Connector problem- Kruskal's algorithm, Proof of correctness, Binary and rooted trees, Huffman coding, Searching algorithms- BFS and DFS algorithms.

Unit III. Eulerian and Hamiltonian Graphs (15 Lectures)

Eulerian Graphs- Characterization of Eulerian Graph, Randomly Eulerian graphs, Chinese postman problem- Fleury's algorithm with proof of correctness. Hamiltonian graphs- Necessary condition, Dirac's theorem, Hamiltonian closure of a graph, Chvatal theorem, Degree majorisation, Maximum edges in a non-Hamiltonian graph, Traveling salesman problem.

Unit IV. Matching and Ramsey Theory (15 Lectures)

Matchings-augmenting path, Berge theorem, Matching in bipartite graph, Halls theorem, Konig's theorem, Tutte's theorem, Personal assignment problem, Independent sets and covering- $\alpha + \beta = p$; Gallai's theorem, Ramsey theorem-Existence of r(k, l); Upper bounds of r(k, l); Lower bound for mr(k, l) $\geq 2^{m/2}$ where m = min{k, l}; Generalize Ramsey numbers-r(k_1, k_2,…, k_n); Graph Ramsey theorem, Evaluation of r(G; H) when for simple graphs G = P_3, H = C_4

Recommended Text Books:

1. J. A. Bondy and U.S.R. Murty, Graph Theory with Applications, Elsevier.
2. J. A. Bondy and U.S. R. Murty, Graph Theory, GTM 244 Springer, 2008.
3. M. Behzad and A. Chartrand, Introduction to the Theory of Graphs, Allyn and Becon Inc., Boston, 1971.
4. K. Rosen, Discrete Mathematics and its Applications, Tata-McGraw Hill, 2011.
5. D. B. West, Introduction to Graph Theory, PHI, 2009.

PGMT304B: Graph Theory-I

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

CO1: Describe the origin of Graph Theory.

CO2: Explain the concept of isomorphism in graph theory and its consequences

CO3: Solve problems involving vertex and edge connectivity.

CO4: Apply BFS and DFS algorithm to find the shortest path and Kruskal's algorithm to find minimal spanning tree.

CO5: Find Hamiltonian closure of a graph.

ICT Tools Used: Videos, PPT, Chalk Board

Students Centric Methods: Problem Solving and Participative (Experimental, Participative, Problem Solving)

Links: SWAYAM / MOOCS:

1. https://nptel.ac.in/courses/106108054
2. https://nptel.ac.in/courses/106104170
3. https://onlinecourses.nptel.ac.in/noc22_cs17/preview

The CO-PO Mapping Matrix

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO 7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	-	-	-	-	-	-	-	-	-	-
CO2	3	-	-	-	-	-	-	-	-	-	-	-
CO3	2	-	1	1	-	-	-	-	-	-	-	-
CO4	2	1	-	2	-	1	-	-	-	-	-	-
CO5	1	1	1	1	-	-	-	-	-	-	-	-

PGMT304C: DESIGN THEORY

Unit I. Introduction to Balanced Incomplete Block Designs (15 Lectures)

What Is Design Theory? Basic Definitions and Properties, Incidence Matrices, Isomorphisms and Automorphisms, Constructing BIBDs with Specified Automorphisms, New BIBDs from Old, Fishers Inequality.

Unit II. Symmetric BIBDs (15 Lectures)

An Intersection Property, Residual and Derived BIBDs, Projective Planes and Geometries, The Bruck-Ryser-Chowla Theorem. Finite a ne and and projective planes.

Unit III. Difference Sets and Automorphisms (15 Lectures)

Difference Sets and Automorphisms, Quadratic Residue Difference Sets, Singer Difference Sets, The Multiplier Theorem, Multipliers of Difference Sets, The Group Ring, Proof of the Multiplier Theorem, Difference Families, A Construction for Difference Families.

Unit IV. Hadamard Matrices and Designs (15 Lectures)

Hadamard Matrices, An Equivalence Between Hadamard Matrices and BIBDs, Conference Matrices and Hadamard Matrices, A Product Construction, Williamson's Method, Existence Results for Hadamard Matrices of Small Orders, Regular Hadamard Matrices, Excess of Hadamard Matrices, Bent Functions.

Recommended Text Books:

1. D. R. Stinson, Combinatorial Designs: Constructions and Analysis, Springer,2004.
2. W.D. Wallis, Introduction to Combinatorial Designs, (2nd Ed), Chapman & Hall.
3. D. R. Hughes and F. C. Piper, Design Theory, Cambridge University Press, Cam-bridge, 1985.
4. T. Beth, D. Jung nickel and H. Lenz, Design Theory, Volume 1 (Second Edition), Cambridge University Press, Cambridge, 1999.

SEC PGMT305A: INTEGRAL TRANSFORMS

Unit I. Laplace Transform (15 Lectures)

Definition of Laplace Transform, Laplace transforms of some elementary functions, Properties of Laplace transform, Laplace transform of the derivative of a function, Inverse Laplace Transform, Properties of Inverse Laplace Transform, Inverse Laplace Transform of derivatives, Convolution

Theorem, Heaviside's expansion theorem, Application of Laplace transform to solutions of ODEs and PDEs.

Unit II. Fourier Transform (15 Lectures)

Fourier Integral theorem, Properties of Fourier Transform, Inverse Fourier Transform, Convolution Theorem, Fourier Transform of the derivatives of functions, Parseval's Identity, Relationship of Fourier and Laplace Transform, Application of Fourier transforms to the solution of initial and boundary value problems.

Unit III. Mellin Transform (15 Lectures)

Properties and evaluation of Mellin transforms, Convolution theorem for Mellin transform, Complex variable method and applications.

Unit IV. Z-Transform (15 Lectures)

Definition of Z-transform, Inversion of the Z-transform, Solutions of difference equations using Z-transform. Applications.

Recommended Text Books:

1. Brian Davies, Integral transforms and their Applications, Springer.
2. L. Andrews and B. Shivamogga, Integral Transforms for Engineers, Prentice Hall of India.
3. I. N. Sneddon, Use of Integral Transforms, Tata-McGraw Hill.
4. R. Bracemell, Fourier Transform and its Applications, MacDraw hill.

SEC PGMT305: INTEGRAL TRANSFORMS

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

CO1: Define integral transforms and Z-Transform
CO2: State properties of Laplace, Fourier, Mellin and Z-Transform
CO3: Apply Fourier transforms to find the solution of initial and boundary value problems.
CO4: Find solutions of difference equations using Z-transform
CO5: Apply Laplace transform to find solutions of differential equation

ICT Tools Used: Videos, PPT, Pen-Tablet, Python, Matlab

Students Centric Methods: Problem Solving and Participative
(Experimental, Participative, Problem Solving)

Links: SWAYAM / MOOCS:

1) https://nptel.ac.in/courses/111106139
2) https://nptel.ac.in/courses/111102129
3) https://nptel.ac.in/courses/108104100
4) https://onlinecourses.nptel.ac.in/noc21_ee28/preview

The CO-PO Mapping Matrix

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	-

CO2	2	2	-	-	-	-	-	-	-	-	-	-
CO3	1	-	1	1	-	-	-	1	-	-	-	-
CO4	1	-	1	2	1	-	-	-	-	-	-	-
CO5	1	-	1	2	1	1	-	1	-	-	-	-

SEC PGMT305B: CALCULUS ON MANIFOLDS

Unit I. Multilinear Algebra (15 Lectures)

Multilinear map on a finite dimensional vector space V over ℝ; and k-tensors on V, the collection $T^k(V)$ (or $\otimes^k(V^*)$) of all k-tensors on V, tensor product $S\otimes T$ of $S\in T^k(V)$ & $T\in T^k(V)$, Alternating tensors and the collection $\wedge^k V^*$ of all k-tensors on V; The exterior product (or wedge product, basis of $\wedge^k V^*$; orientations of a finite dimensional vector space V over ℝ.

Unit II. Differential Forms (15 Lectures)

Differential forms: k-forms on $\mathbb{R}^n$, wedge product $\omega \wedge \eta$ of a k-form ω and l-form η ; the exterior derivative and properties, pull back of forms and properties, Closed and exact forms, Poincare's lemma.

Unit III. Basics of submanifolds of $\mathbb{R}^n$ (15 Lectures)

Submanifolds of $\mathbb{R}^n$; submanifolds of $\mathbb{R}^n$ with boundary, Smooth functions defined on Submanifolds of $\mathbb{R}^n$, Tangent vectors and Tangent spaces of Submanifolds of$\mathbb{R}^n$.

p-forms and differentiable p-forms on a submanifold of $\mathbb{R}^n$; exterior derivative $d\omega$ of any differentiable p-form on a submanifolds of $\mathbb{R}^n$, Orientable submanifolds of $\mathbb{R}^n$and Oriented submanifolds of $\mathbb{R}^n$, Orientation preserving maps, Vector fields on submanifolds of $\mathbb{R}^n$, outward unit normal on the boundary of a submanifold of $\mathbb{R}^n$ with non-empty boundary, induced orientation of the boundary of an oriented submanifold of $\mathbb{R}^n$ with non-empty boundary.

Unit IV: Stoke's Theorem (15 Lectures)

Integral $\int_{[0,1]^k} w$ of a k-form on the cube $[0,1]^k$, integral $\int_c w$ of a k-form on an open subset A of $\mathbb{R}^k$ where c is a singular k-cube in A. Theorm(Stokes's Theorem for k-cubes): If w is a (k-1)-form on an open subset A of $\mathbb{R}^k$ and c is a singular k-cube in A then $\int_c dw = \int_c w$.

Integration of a differentiable k-form on an oriented k-dimensional submanifold M of $\mathbb{R}^n$: Change of variables theorem: If $c_1,c_2 : [0, 1]^k \to M$ are two Orientation preserving maps in M and w is any k-form on M such that w = 0 outside of $c_1([0, 1]^k) \cap c_2([0, 1]^k)$, then $\int_{c_1} w = \int_{c_2} w$, Stokes' theorem for submanifolds of $\mathbb{R}^k$, Volume element, Integration of functions on a submanifold of $\mathbb{R}^k$, Classical theorems: Green's theorem, Divergence theorem of Gauss, Green's identities.

Reference Books:

1. V. Guillemin and A. Pollack, Differential Topology, AMS Chelsea Publishing, 2010.

2. J. Munkres, Analysis on Manifolds, Addison Wesley.
3. A. Browder, Mathematical Analysis, Springer International edition.

SEC PGMT305B: CALCULUS ON MANIFOLDS

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

CO1: Undstand bsic knowledge of tensor calculus for and apply to Riemannian geometry

CO2: Define a multilinear map on a finite dimensional vector space over real numbers.

CO3: Explain wedge products and its properties.

CO4: Find tangent vectors and tangent spaces of submanifolds.

CO5: Explain unification of Green's theorem, Stoke's theorem and Divergence theorem.

ICT Tools Used: Videos, PPT, Pen-Tablet, Python, Matlab

Students Centric Methods: Problem Solving and Participative (Experimental, Participative, Problem Solving)

Links: SWAYAM / MOOCS:

1) https://nptel.ac.in/courses/111108134
2) https://nptel.ac.in/courses/111104095
3) https://nptel.ac.in/courses/111106044

The CO-PO Mapping Matrix

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	1	-	-	-	-	-	-	-
CO2	2	1	1	-	-	-	-	-	-	-	-	-
CO3	1	-	-	-	-	-	-	-	-	-	-	-
CO4	1	-	1	1	1	-	-	-	-	-	-	-
CO5	2	1	1	2	1	1	-	1	-	-	-	-

SEMESTER IV

PGMT401: FIELD THEORY

(All results have to be done with proof unless otherwise stated.)

Unit I. Algebraic Extensions (15 lectures)

Prime sub field of a field, definition of field extension K/F, algebraic elements, set of algebraic elements in a field extension, $F[\alpha]$ as a quotient of $F[x]$, minimal polynomial of an algebraic element, extension of a field obtained by adjoining one algebraic element. Algebraic extensions, Finite extensions, degree of an algebraic element, degree of a field extension. Tower law for field extensions, Transitivity of algebraic extensions. Composite field of two sub fields of a field and examples. (Ref: D.S. Dummit and R.M. Foote, Abstract Algebra).

Unit II. Normal and Separable Extensions (15 lectures)

Splitting field for a set of polynomials, normal extension, examples such of splitting fields of x^p - 2 (p prime), uniqueness of splitting fields, existence and uniqueness of finite fields. Algebraic closure of a field, existence of algebraic closure.Separable elements, Separable extensions, example of non-separable extension. Frobenius automorphism of a finite field. Separability of finite fields, Primitive element theorem.

Unit III. Galois Theory (15 Lectures)

Galois group G (K/F) of a field extension K/F, Galois extensions, Subgroups, Fixed fields, Galois correspondence, Fundamental theorem of Galois theory.

Unit IV. Applications (15 Lectures)

Classical Straight-edge and Compass constructions: definition of Constructible points, lines, circles by Straight-edge and Compass starting with (0, 0) and (1, 0); definition of constructible real numbers. If $\alpha \in \mathbb{R}$ is constructible, then α is an algebraic number and its degree over $\mathbb{Q}$ is a power of 2. Cos (20°) is not a constructible number. The regular 7-gon is not constructible.

The regular 17-gon is constructible. The Constructible numbers form a sub field of $\mathbb{R}$. If a > 0 is constructible, then so is $\sqrt{a}$. Impossibility of the classical Greek problems: 1) Doubling a Cube, 2) Trisecting an Angle, 3) Squaring the Circle is possible.

Cyclotomic field $\mathbb{Q}(\zeta_n)$ (splitting eld of x^n-1 over $\mathbb{Q}$), cyclotomic polynomial, degree of Cyclotomic field $\mathbb{Q}(\zeta_n)$ D.S. Dummit and R.M. Foote, Abstract Algeba). Galois group for an irreducible cubic polynomial, Galois group for an irreducible quadratic polynomial. (Ref: M. Artin, Algebra, Prentice Hall of India). Solvability by radicals in terms of Galois group and Abel's theorem on the insolvability of a general quintic.

Recommended Text Books:

1. D.S. Dummit and R.M. Foote, Abstract Algebra, John Wiley and Sons.
2. M. Artin, Algebra, Prentice Hall of India, 2011.

Additional Reference Books:

1. S. Lang, Algebra, Springer Verlag, 2004
2. N. Jacobson, Basic Algebra, Dover, 1985.

PGMT401 Field Theory

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

CO1: Understand the notion of extension of field.
CO2: Define straightedge and compass construction and explain few results.
CO3: Define radical extension and give examples of a radical extension.
CO4: Identify and analyze different types of algebraic structures such as Algebraically closed fields, Splitting fields, Finite field extensions.
CO5: Create and apply appropriate algebraic structures such as Galois extensions, Automorphisms of groups and fixed fields.

ICT Tools Used: Videos, PPT, Chalk Board

Students Centric Methods: Problem Solving and Participative (Experimental, Participative, Problem Solving)

Links: SWAYAM / MOOCS:

1. NOC:Introduction to Galois Theory
2. NOC:Introduction To Rings And Fields

The CO-PO Mapping Matrix

CO\PO	PO1	PO 2	PO 3	PO4	PO5	PO6	PO 7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	-	-	-	-	-	-	-	-	-	-
CO2	1	1	-	2	-	-	-	-	-	-	-	-
CO3	1	-	-	2	-	-	-	-	-	-	-	-
CO4	2	-	-	2	-	-	-	-	-	-	-	-
CO5	1	-	1	3	-	-	-	-	-	-	-	-

PGMT402: FUNCTIONAL ANALYSIS

Unit I Normed Linear Spaces (15 Lectures)

Normed Linear spaces. Banach spaces and examples. Quotient space of a normed linear space. $l^p(1 \leq p \leq \infty)$ spaces are Banach spaces.

$L^p(\mu)(1 \leq p \leq \infty)$ spaces: Holder's inequality, Minkowski's inequality, $L^p(\mu)(1 \leq p \leq \infty)$ are Banach spaces. Finite dimensional normed linear spaces, Equivalent norms, Riesz Lemma and application to normed linear spaces.

Unit II Bounded Linear Transformations (15 Lectures)

Bounded linear transformations, Equivalent characterizations. The space $\mathcal{B}(X,Y)$ Completeness of $\mathcal{B}(X,Y)$ when Y is complete, dual space of a normed linear space. Riesz Representation theorem for Hilbert spaces. Hahn-Banach theorem.

Unit III Hilbert spaces (15 Lectures)

Hilbert spaces, examples of Hilbert spaces such as $l^2, L^2(-\pi,\pi)\ and\ L^2(\mathbb{R}^n)$. Bessel's inequality. Complete orthonormal set and maximal orthonormal basis. Orthogonal decomposition. Separable Hilbert space, Existence of a maximal orthonormal basis. Parseval's identity. Baire category theorem and applications.

Unit IV. Basic Theorems (15 Lectures)

Applications of Hahn-Banach theorem. Open mapping theorem, closed graph theorem, Uniform boundedness Principle and their Applications.

Recommended Text Books:

1. G. F. Simmons, Introduction to Topology and Modern Analysis, Tata MacGrahill.
2. B.V. Limaye, Functional Analysis, Wiley Eastern.
3. Royden, Real Analysis, Macmillian.
4. E. Kreyszig, Introductory Functional Analysis with Applications, Wiley India.
5. J.R. Munkres, Topology, Pearson.

PGMT402: Functional Analysis

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

CO1: Explain the fundamental concepts of Functional analysis and their role in modern mathematics.
CO2: Understand and apply ideas from the theory of Hilbert spaces to other areas.
CO3: Utilize the concepts of functional analysis, for example, continuous and bounded operators, normed spaces, and Hilbert spaces.
CO4: Define bounded linear transformation and give its equivalent characterizations.
CO5: Understand and apply fundamental theorems from the theory of normed and Banach spaces including the Hahn-Banach theorem, the open mapping theorem, the closed graph theorem, and the uniform boundedness theorem.

ICT Tools Used: Videos, PPT, Chalk Board

Students Centric Methods: Problem Solving and Participative (Experimental, Participative, Problem Solving)

Links: SWAYAM / MOOCS:

1. https://nptel.ac.in/courses/111105037
2. https://nptel.ac.in/courses/111106147

The CO-PO Mapping Matrix

CO\PO	PO1	PO 2	PO 3	PO4	PO5	PO6	PO 7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	-	-	2	-	1	-	-	-	-	-
CO2	3	-	-	-	1	-	-	2	-	-	-	-
CO3	1	-	-	2	-	-	1	1	-	-	-	-
CO4	1	-	-	1	-	-	-	-	-	-	-	-
CO5	1	-	1	2	-	-	1	3	-	-	-	-

PGMT403: PARTIAL DIFFERENTIAL EQUATION

Unit I. First Order Partial Differential Equation (15 Lectures)

First order quasi-linear PDE in two variables: Integral surfaces, Characteristic curves, Cauchy's method of characteristics for solving First order quasi-linear PDE in two variables.

First order non-linear PDE in two variables, Characteristic equations, Characteristic strip, Cauchy problem and its solution for first order non-linear PDE in two variables.

Unit II. Laplace operator (15 Lectures)

Classification of PDE and Canonical form of second order PDE, Symmetry properties of the Laplacian, basic properties of the Harmonic functions, the Fundamental solution, the Dirichlet's and Neumann boundary value problems, Green's function. Applications to the Dirichlet's problem in a ball in $\mathbb{R}^n$ and in a half space of $\mathbb{R}^n$. Maximum Principle for bounded domains in $\mathbb{R}^n$ and uniqueness theorem for the Dirichlet boundary value problem.

Unit III. Heat operator (15 Lectures)

The properties of the Gaussian kernel, solution of initial value problem

$u_t - \Delta u$=0 for x∈ $\mathbb{R}^n$ & t > 0 and u(x, 0) = f(x), (x ∈ $\mathbb{R}^n$). Maximum principle for the heat equation and applications.

Unit IV. Wave operator (15 Lectures)

Wave operator in dimensions 1, 2 & 3; Cauchy problem for the wave equation. D Alembert's solution, Poisson formula of spherical means, Hadamard's method of descent, Inhomogeneous Wave equation.

Recommended Text Books:

1. F. John, Partial Differential Equations, Narosa publications.
2. G.B. Folland, Introduction to partial differential equations, Prentice Hall.
3. An elementary course in Partial Differential equations, by T. Amarnath.
4. Partial Differential equations by Phoolan Prasad and Renuka Ravindran.

PGMT403: PARTIAL DIFFERENTIAL EQUATION

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

CO-1: Solve the First order quasi-linear PDE by Cauchy's method
CO-2: Solve linear and non-linear partial differential equation of first order by using Lagrange's and Charpit's method.
CO-3: Classify second order PDE and solve standard PDE using separation of variable method.
CO-4: Explain the properties of the Gaussian kernel.
CO-5: Find the solution of the initial value problems of wave and heat equation

ICT Tools Used: Videos, PPT, Chalk Board

Students Centric Methods: Problem Solving and Participative (Experimental, Participative, Problem Solving)

Links: SWAYAM / MOOCS:

1. https://nptel.ac.in/courses/111103021
2. https://nptel.ac.in/courses/111101153
3. https://www.digimat.in/nptel/courses/video/111105093/L01.html

The CO-PO Mapping Matrix

CO\PO	PO1	PO 2	PO 3	PO4	PO5	PO6	PO 7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	-	-	-	-	-	-	-	-	-	-
CO2	1	-	-	-	-	-	-	-	-	-	-	-
CO3	2	-	1	2	2	-	-	-	-	-	-	-
CO4	2	1	2	1	-	-	-	-	-	-	-	-
CO5	2	-	-	1	1	-	-	-	-	-	-	-

PGMT404A: FOURIER ANALYSIS

Unit I. Fourier series (15 Lectures)

The Fourier series of a periodic function, Dirichlet kernel, Bessel's inequality for a 2π-periodic Riemann integrable function, convergence theorem for the Fourier series of a 2π-periodic and piecewise C^1-function, uniqueness theorem (If f, g are 2π-periodic and piecewise smooth function having same Fourier coefficients, then f = g). Relating Fourier coefficients of f and f' where f is continuous 2π-

periodic and piecewise C^1-function and a convergence theorem: If f is continuous 2π-periodic and piecewise C^1-function, then the Fourier series of f converges to f absolutely and uniformly on $\mathbb{R}$.

Unit II. Dirichlet's theorem (15 Lectures)

Review: Lebesgue measure of $\mathbb{R}$, Lebesgue integrable functions, Dominated Convergence theorem, bounded linear maps (no questions be asked).

Definition of Lebesgue integrable periodic functions (i.e., L^1 -periodic), Fourier Coefficients of L^1 -periodic functions, L^2-periodic functions. Any L^2-periodic function is L^1-periodic. Riemann-Lebesgue Lemma. Converse of Riemann-Lebesgue lemma does not hold (ref: W. Rudin, Real and Complex Analysis, Tata McGraw Hill).

Bessel's inequality for a L^2-periodic function. Dirichlet's Theorem on point-wise convergence of Fourier series (If f is Lebesgue integrable periodic function that is differentiable at a point x_0; then the Fourier series of f at x_0 converges to $f(x_0)$) and convergence of the Fourier series of functions such as $f(x) = |x|$ on $[-\pi, \pi]$.

Unit III. Fejer's Theorem and applications (15 Lectures)

Fejer's Kernel, Fejer's Theorem for a continuous 2π-periodic, density of trigonometric polynomials in $L^2(-\pi, \pi)$, Parseval's identity.

Convergence of Fourier series of an L^2-periodic function w.r.t the L^2-norm, Riesz-Fischer theorem on Unitary isomorphism from $L^2((-\pi, \pi)$ onto the sequence space l^2 of square summable complex sequences.

Unit IV. Dirichlet Problem in the unit disc (15 Lectures)

Laplacian, Harmonic functions, Dirichlet Problem for the unit disc, The Poisson kernel, Abel summability, Abel summability of periodic continuous functions, Weierstrass Approximation Theorem as application, Solution of Dirichlet problem for the disc.

Applications of Fourier series to Isoperimetric inequality in the plane and Heat equation on the circle.

Recommended Textbooks:

1. G. B. Folland, Fourier Analysis and its applications, Wadsworth and Brooks/Cole, California 1992.
2. H. Dym and H. P. McKean, Fourier series and integrals, Academic Press, 1985.
3. E. M. Stein and Rami Shakarchi, Fourier analysis, Princeton University Press, 2003.
4. E. M. Stein and G. Weiss, Introduction to Fourier analysis on Euclidean spaces, Princeton University Press, 1971.
5. W. Rudin, Real and Complex Analysis, Tata McGraw Hill.
6. S. Ponnusamy, Foundations of Functional Analysis, Narosa Publishing House.

PGMT404A: FOURIER ANALYSIS

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

CO1: Define Fourier series and find fourier coffeicient

CO2: Solve problems on different perods 2π, $L^1$and L^2-periodic functions

CO3: Find Fejer's Kernel and apply Fejer's Theorem

CO4: Apply Fourier series to partial differential equation

ICT Tools Used: Videos, PPT, Chalk Board

Students Centric Methods: Problem Solving and Participative (Experimental, Participative, Problem Solving)

Links: SWAYAM / MOOCS:

1. https://nptel.ac.in/courses/111106111
2. https://nptel.ac.in/courses/111106046

The CO-PO Mapping Matrix

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO 7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	-	-	-	1	-	-	-	-	-	-
CO2	2	-	-	-	-	-	-	-	-	-	-	-
CO3	2	-	-	1	-	-	-	-	-	-	-	-
CO4	2	1	-	2	-	-	-	-	-	-	-	-
CO5	1	-	1	1	-	1	-	-	-	-	-	-

PGMT404C: Graph Theory-II

Unit I. Graph Colouring (15 Lectures)

Line Graphs, Edge coloring-edge chromatic number, Vizing theorem, Timetabling problem, Vertex coloring- Vertex chromatic number, Critical graphs, Brook's theorem, Chromatic polynomial of a graph- $\pi_k(G) = \pi_k(G - e) - \pi_k(G.e)$ properties of chromatic polynomial of a graph, Existence of a triangle free graph with high vertex chromatic number, Mycieleski's construction.

Unit II. Planar Graph (15 Lectures)

Planar graph, Plane embedding of a graph, Stereographic projection, Dual of a plane graph, Euler formula, Non planarity of K_5 and $K_{3,3}$, Outer planar graph, Five color theorem, Sub-division, Kuratowski's theorem (Without Proof).

Unit III. Flow Theory (15 Lectures)

Directed graphs, directed paths and directed cycle, Tournament, Networks, Max flow min cut theorem, Ford- Fulkerson Theorem and Algorithm.

Unit IV. Characteristic Polynomials (15 Lectures)

Spectrum of a graph, Characteristic polynomial of a graph, Coefficients of characteristic polynomial of a graph, Adjacency algebra A(G) of a graph G, Dimension of $A(G) \geq diam(G) + 1$, A connected graph with diameter d has at least d + 1 eigen values, Circulant matrix, Determination of spectrum of graphs.

Reference Books

1. J. A. Bondy and U. S. R. Murty, Graph Theory with Applications, The Macmillan Press,1976.
2. M. Behzad and G. Chartrand, Introduction to the Theory of Graphs, Allyn and Becon Inc., Boston, 1971.
3. K. Rosen, Discrete Mathematics and its Applications, Tata-McGraw Hill, 2011.
4. D.B.West, Introduction to Graph Theory, Prentice-Hall, India, 2009.
5. N. Biggs, Algebraic Graph Theory, Prentice-Hall, India.

PGMT404AB: Graph Theory-II

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

CO1: Solve problems involving edge & vertex colouring and find chromatic number & polynomial.

CO2: Derive Euler's formula and Establish the non-planarity of $K_5, K_{3,3}$.

CO3: Understand the maximum flow minimum cut theorem and Ford Fulkerson algorithm.

CO4: Find the spectrum and characteristic polynomial of a graph.

CO5: Explain connected graph with diameter d has d+1 Eigen values.

ICT Tools Used: Videos, PPT, Chalk Board

Students Centric Methods: Problem Solving and Participative (Experimental, Participative, Problem Solving)

Links: SWAYAM / MOOCS:

4. https://nptel.ac.in/courses/106108054
5. https://nptel.ac.in/courses/106104170
6. https://onlinecourses.nptel.ac.in/noc22_cs17/preview

The CO-PO Mapping Matrix

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO 7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	-	-	-	-	-	-	-	-	-	-
CO2	3	-	-	-	-	-	-	-	-	-	-	-
CO3	2	-	1	1	-	-	-	-	-	-	-	-
CO4	2	1	-	2	-	1	-	-	-	-	-	-
CO5	1	1	1	1	-	-	-	-	-	-	-	-

PGMT404C: CALCULUS OF VARIATIONS AND INTEGRAL EQUATIONS

Unit-I Introduction of Calculus of Variation:

Introduction, Functional; Variation of a functional and its properties; Variational problems with fixed boundaries; Euler's equation, Extremals; The Euler–Lagrange equation, problem of brachistochrone, problem of geodesics, isoperimetric problem, Variation and its properties, functions and functionals, Comparison between the notion of extrema of a function and a functional.

Unit-II Euler's equation and variational problems

Variational problems with the fixed boundaries, Euler's equation, the fundamental lemma of the calculus of variations, examples, Functionals in the form of integrals, special cases containing only some of the variables, examples, Functionals involving more than one dependent variables and their first derivatives, the system of Euler's equations, Functionals depending on the higher derivatives of the dependent variables, Euler- Poisson equation, examples, Functionals containing several independent variables, Ostrogradsky equation, examples, Variational problems in parametric form, applications to differential equations, examples, Variational problems with moving boundaries, pencil of extremals, Transversality condition, examples.

UNIT III: **Linear integral equations**

Volterra integral equations, Fredholm integral equations, some basic identities, Types of kernels: Symmetric kernel, Separable kernel, Iterated kernel, resolvent kernel, Initial value problems reduced to Volterra integral equations, Solution of Volterra integral equation using: Resolvent kernel, Successive approximation, Neumann series method.

UNIT IV: Applications of Integral Equations

Boundary value problems reduced to Fredholm integral equations, Solution of Fredholm integral equations using separable kernel, resolvent kernel. Methods of successive approximation and successive substitution to solve Fredholm equations of second kind. Solution of Homogeneous Fredholm integral equation: Eigen values, eigen vectors.

Recommended Textbooks:

1. Kanwal, R.P. Linear Integral Equation. Theory and Techniques. Academic Press, 2014.
2. Raisinghania M. D. Integral Equation & Boundary Value Problem. S. Chand Publishing, 2007.
3. Jerri, A. Introduction to Integral Equations with Applications, John Wiley & Sons, 1999.
4. Hildebrand, F. B. Method of Applied Mathematics, Courier Corporation, 2012.
5. Wazwaz, A. M. A First Course in Integral Equations. World Scientific Publishing Co Inc, 1997.

PGMT404B: CALCULUS OF VARIATIONS AND INTEGRAL EQUATIONS

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

CO1: Solve various mathematical and physical problems using variational techniques

CO2: Understand Euler equation and solve examples

CO3: Find difference between Volterra and Fredholm Integral Equations, First kind and Second kind

CO4: Reduce Initial value problems to Volterra integral and Boundary value problems to Fredholm integral equations

CO5: Apply various methods to solve Fredholm integral equation

ICT Tools Used: Videos, PPT, Chalk Board

Students Centric Methods: Problem Solving and Participative (Experimental, Participative, Problem Solving)

Links: SWAYAM / MOOCS:

7. https://nptel.ac.in/courses/111107103
8. https://nptel.ac.in/courses/111106144
9. https://www.digimat.in/nptel/courses/video/111104025/L01.html

The CO-PO Mapping Matrix

CO\PO	PO1	PO 2	PO 3	PO4	PO5	PO6	PO 7	PO8	PO9	PO10	PO11	PO12

CO1	2	-	-	-	-	-	-	-	-	-	-	-
CO2	3	1	-	-	-	-	-	-	-	-	-	-
CO3	2	-	-	2	-	-	-	-	-	-	-	-
CO4	2	-	-	2	-	-	-	-	-	-	-	-
CO5	1	-	1	3	-	-	-	-	-	-	-	-

Scheme of Examination

In each semester, the performance of the learners shall be evaluated into two parts. The learner's performance in each course shall be assessed by Continuous Internal Assessment **(CIE)** with 40 marks and conducting the **Semester End Examinations (SEE)** with 60 marks.

Continuous Internal Assessment of 40 marks:

Paper Code	**CIE**	**Unit Tests/Seminar**	**Total**
PGMT301 to PGMT305 and PGMT401 to PGMT404	20 Marks	20 Marks	40 Marks
PGMT304A	20 Marks	20 Marks for Programming using Python	40 Marks

Project Work:

Evaluation of Project work: The evaluation of the Project submitted by a student shall be made by a Committee appointed by the Head of the Department of Mathematics of the college. The presentation of the project is to be made by the student in front of the committee appointed by the Head of the Department of Mathematics. This committee shall have two members, possibly with one external referee.

The Marks for the project are detailed below:

1. Monthly Project Report & Development: 30 Marks.
2. Power Point presentation: 10 Marks.
3. Viva- voce: 20 Marks.
4. Usage of modern tools/ technology: 10 Marks.
5. Innovativeness: 10 Marks.
6. Individual Contribution: 10 Marks.
7. Group activity: 10 Marks.

Semester End Examination of 60 marks:

(i) Duration: - Examination shall be of **Two and Half hours** duration.

(ii) Theory Question Paper Pattern: -

1. There shall be five questions each of 12 marks.
2. On each unit there will be one question and the fifth one will be based on entire syllabus.
3. All questions shall be compulsory with internal choice within each question.
4. Each question may be subdivided into sub-questions a, b, c, d and the allocation of marks depend on the weightage of the topic.
5. Each question will be of 24 marks when marks of all the sub-questions are added (including the

options) in that question.

Questions		Marks
Q 1	Based on Unit I	12
Q 2	Based on Unit II	12
Q 3	Based on Unit III	12
Q 4	Based on Unit IV	12
Q 5	Based on All Units (I to IV)	12
	Total Marks	60