MANAV RACHNA
Vidyanatariksha

MANAV RACHNA UNIVERSITY

Declared as State Private University vide Haryana Act 26 of 2014

PROGRAMME BOOKLET

M.Sc. Mathematics (MAP01)

(Batch: 2023-2025)

(Syllabus: Scheme B)

Department of Sciences-Program Mathematics

School of Sciences

Manav Rachna University

MANAV RACHNA UNIVERSITY

Vision

To educate students in frontier areas of knowledge enabling them to take up challenges as ethical and responsible global citizens

Mission

- To impart outcome based holistic education
- To disseminate education in frontier areas
- To produce globally competitive, ethical and socially responsible human resources
- To produce human resources sensitive to issues of Environment and Sustainable Development
- To develop Environment and Sustainable development as a thrust area of research and development.

Quality Policy

To continuously learn from the best practices, study role models and develop transparent procedures for empowerment of stakeholders.

Strategic Objectives

- To facilitate, enhance & promote innovation in curriculum design and delivery and have outcome-oriented Learning Culture.
- To promote Research Environment and Management Practices.
- To enhance the quality of the student learning experience.
- To provide Resources and Infrastructure for Academic Excellence.

DEPARTMENT OF SCIENCES

Vision

- To cultivate students in frontier areas of sciences through research and innovation for the sustainable society as competent and socially responsible citizens.

Mission

- To inculcate outcome based holistic education in frontier areas of sciences.
- To provide a niche where students can learn, apply and become proficient in scientific concepts and their applications.
- To develop human resource with better ethical and moral values.
- To innovate environmentally benign products using alternative approaches of the sciences.

PEO's of Department of Sciences:

PEO1: Preparation: To prepare graduates with strong fundamentals required for higher education, teaching or other jobs.
PEO2: Core Competence: Ability to approach problems in an analytical and rigorous way and apply appropriate mathematical skills in solving them.
PEO3: Breadth: To utilize the wide range of mathematical concepts along with pure, applied, mathematical statistics and numerical techniques equipped with mathematical software.
PEO4: Professionalism: To work as team with professional ethical practices.
PEO5: Learning Environment: To develop confidence for lifelong learning.

M.Sc. (MATHEMATICS)

Programme Outcomes (POs)

PO1: Knowledge & Abstract thinking: Ability to absorb and understand the abstract concepts that lead to various advanced theories in mathematical sciences and their applications in real life problems.

PO2: Modelling and solving: Ability in modelling and solving problems by identifying and employing the appropriate existing theories and methods.

PO3: Advanced theories and methods: Understand advanced theories and methods to design solutions for complex mathematical problems and results.

PO4: Applications in Engineering and Sciences: Understand the role of mathematical sciences and apply the same to solve the real-life problems in various fields of study.

PO5: Modern software tool usage: Acquire the skills in handling scientific tools towards problem solving and solution analysis.

PO6: Ethics: Imbibe ethical, moral and social values in personal and social life. Continue to enhance the knowledge and skills in mathematical sciences for constructive activities and demonstrate highest standards of professional ethics.

PO7: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO8: Communication: Develop various communication skills such as reading, listening, and speaking which will help in expressing ideas and views clearly and effectively.

PO9: Research: Demonstrate knowledge, understand mathematical & scientific theories and apply these to one's own work, as a member/ leader in a team to manage projects and multidisciplinary research environments. Also use the research-based knowledge to analyse and solve advanced problems in mathematical sciences.

PO10: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning .

PO11: Professional Growth: Keep on discovering new avenues in the chosen field and exploring areas that remain conducive for research and development

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SEMESTER - 1								
SUBJECT CODES	**SUBJECT NAME**	****OFFERING DEPARTMENT**	***COURSE NATURE (HARD/SOFT/WORKSHOP/ NTCC)**	**COURSE TYPE (CORE/ELECTIVE / UNIVERSITY COMPULSORY)**	**L**	**P**	**NO. OF CONTACT HOURS PER WEEK**	**NO. OF CREDITS**
MAH514B	ABSTRACT ALGEBRA	MA	HARD	CORE	4	0	4	4
MAH502B	TOPOLOGY-I	MA	HARD	CORE	4	0	4	4
MAH503B	DIFFERENTIAL EQUATIONS	MA	HARD	CORE	4	0	4	4
MAH504B	MEASURE THEORY	MA	HARD	CORE	4	0	4	4
MAH512B	MATHEMATICAL STATISTICS	MA	HARD	CORE	4	0	4	4
MAW515B	EXCEL WORKSHOP	MA	WORKSHOP	CORE	0	2	2	1
MAH506B	MATHEMATICS LAB - I	MA	HARD	ELECTIVE (ANY ONE)	0	2	2	1
CSH511B	PYTHON PROGRAMMING	CS						
CDO511	PROFESSIONAL COMPETENCY PG	CDC	SOFT	AP/ AF	0	2	2	1
	TOTAL (L-P-O/CONTACT HOURS/CREDITS)				**20**	**6**	**26**	**23**

SEMESTER - 2								
SUBJECT CODES	**SUBJECT NAME**	****OFFERING DEPARTMENT**	***COURSE NATURE (Hard/Soft/ Workshop/ NTCC)**	**COURSE TYPE (Core/Elective / University Compulsory)**	**L**	**P**	**NO. OF CONTACT HOURS PER WEEK**	**NO. OF CREDITS**
MAH517B	MATHEMATICAL MODELING	MA	HARD	CORE	4	0	4	4
MAH508B	COMPLEX ANALYSIS	MA	HARD	CORE	4	0	4	4
MAH509B	FUNCTIONAL ANALYSIS	MA	HARD	CORE	4	0	4	4
MAH510B	DIFFERENTIAL GEOMETRY	MA	HARD	CORE	4	0	4	4
MAH604B	OPERATIONS RESEARCH	MA	HARD	CORE	4	0	4	4
MAH516B	MATHEMATICS LAB - II	MA	HARD	ELECTIVE (ANY ONE)	0	2	2	1
CSW519B	PYTHON FOR DATA ANALYSIS	CS						
RDO504	SCIENTIFIC RESEARCH - I	MA	NTCC	CORE	0	4	2	2
CDO503	PROFESSIONAL COMPETENCY PG-I	CDC	SOFT	AP/ AF	0	2	2	1
	TOTAL (L-P-O/CONTACT HOURS/CREDITS)				**20**	**8**	**26**	**24**
MAO513B	**Summer Internship**							**2**

SEMESTER - 3								
SUBJECT CODES	**SUBJECT NAME**	****OFFERING DEPARTMENT**	***COURSE NATURE (Hard/Soft/ Workshop/ NTCC)**	**COURSE TYPE (Core/Elective / University Compulsory)**	**L**	**P**	**NO. OF CONTACT HOURS PER WEEK**	**NO. OF CREDITS**
MAH601B	INTEGRAL EQUATIONS & CALCULUS OF VARIATION	MA	HARD	CORE	4	0	4	4
MAH602B	FLUID MECHANICS	MA	HARD	CORE	4	0	4	4
MAH607B	FOURIER ANALYSIS							
MAH507B	FIELD THEORY							
MAH608B	DIFFERENTIABLE MANIFOLDS							
MAH606B	DESIGN OF EXPERIMENTS							
MAH623B	ADVANCED NUMERICAL ANALYSIS	MA	HARD	ELECTIVE (ANY ONE)	4	0	4	4
MAH614B	ADVANCED OPERATIONS RESEARCH							
MAH625B	FUZZY SETS AND APPLICATIONS							
MAH605B	GRAPH THEORY							
MAH609B	WAVELETS							
MAH610B	TOPOLOGY - II	MA	HARD	ELECTIVE (ANY ONE)	4	0	4	4
RDO604	SCIENTIFIC RESEARCH - II	MA	NTCC	CORE	0	4	2	2

CDO603	PROFESSIONAL COMPETENCY PG-II	CDC	SOFT	AP/ AF	0	2	2	1
	TOTAL (L-P-O/CONTACT HOURS/CREDITS)				**16**	**6**	**20**	**19**
SEMESTER - 4								
SUBJECT CODES	**SUBJECT NAME**	****OFFERING DEPARTMENT**	***COURSE NATURE (Hard/Soft/ Workshop/ NTCC)**	**COURSE TYPE (Core/Elective / University Compulsory)**	**L**	**P**	**NO. OF CONTACT HOURS PER WEEK**	**NO. OF CREDITS**
MAH621B	DYNAMICS OF RIGID BODY	MA	HARD	ELECTIVE (ANY ONE)	4	0	4	4
MAH612B	COMPUTATIONAL FLUID DYNAMICS							
MAH613B	GENERALIZED FUZZY SET THEORY							
MAH624B	ADVANCED DISCRETE MATHEMATICS							
MAH618B	LIGHTLIKE MANIFOLDS							
MAH616B	STOCHASTIC PROCESSES							
MAH617B	HARMONIC ANALYSIS	MA	HARD	ELECTIVE (ANY ONE)	4	0	4	4
MAH615B	CODING THEORY							
MAH619B	WAVELETS & IT'S APPLICATIONS							
MAH620B	ALGEBRAIC TOPOLOGY							
MAN626B	PROJECT	MA	NTCC	CORE	0	16	2	8
	TOTAL (L-P-O/CONTACT HOURS/CREDITS)				**8**	**16**	**10**	**16**

GRAND TOTAL OF CREDITS	**84**

Total Credits Scheme

S. No.	Semester	Contact Hours	Credits
1	I	26	23
2	II	26	24
3	Summer Training (Post II Sem)	60	02
4	III	20	19
5	IV	10	16
Total		**142**	**84**

MAP01- Semester-I

SUBJECT CODES	SUBJECT NAME	**OFFERING DEPARTMENT	*COURSE NATURE (HARD/SOFT/WORKSHOP/ NTCC)	COURSE TYPE (CORE/ELECTIVE / UNIVERSITY COMPULSORY)	L	P	NO. OF CONTACT HOURS PER WEEK	NO. OF CREDITS
MAH514B	ABSTRACT ALGEBRA	MA	HARD	CORE	4	0	4	4
MAH502B	TOPOLOGY-I	MA	HARD	CORE	4	0	4	4
MAH503B	DIFFERENTIAL EQUATIONS	MA	HARD	CORE	4	0	4	4
MAH504B	MEASURE THEORY	MA	HARD	CORE	4	0	4	4
MAH512B	MATHEMATICAL STATISTICS	MA	HARD	CORE	4	0	4	4
MAW515B	EXCEL WORKSHOP	MA	WORKSHOP	CORE	0	2	2	1
MAH506B	MATHEMATICS LAB - I	MA	HARD	ELECTIVE (ANY ONE)	0	2	2	1
CSH511B	PYTHON PROGRAMMING	CS						
CDO511	PROFESSIONAL COMPETENCY PG	CDC	SOFT	AP/ AF	0	2	2	1
	TOTAL (L-P-O/CONTACT HOURS/CREDITS)				**20**	**6**	**26**	**23**

DETAILED SYLLABUS
MAP01 – SEMESTER-I

Course Title/Code	ABSTRACT ALGEBRA (MAH514B)	
Course Type	Core (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	To familiarize students with the structure theory of groups and module theory.	
Course Outcomes (COs)		**Mapping**
CO1	To elaborate the algebraic structure with two binary operations such as Ring and Fields.	**Skill Development**
CO2	To characterize the polynomials over ring and fields.	**Skill Development**
CO3	To identify and construct example of modules and their application to finitely generated abelian groups.	**Skill Development**
CO4	To define and characterize Notherian, Artinian module, and their applications in structure theorem.	**Skill Development**
Prerequisites (if any)	**N.A**	

SECTION A

Rings, zero divisors of a rings, Integral domain, divison ring, fields. Mapping on rings, Ideals & quotient rings. Definitions and elementary properties, Kernel of homomorphism, Definitions and elementary properties, fundamental theorem, Maximal Ideals, Prime Ideals, Prime fields.

SECTION B

Rings of Polynomials, Polynomials in an indeterminate, the evolution of Homomorphism, Kernel of evolution homomorphism, Factorisation of Polynomials over a field, division Algorithm, Irreducible polynomials.

SECTION C

Modules: Modules, Cyclic modules, Simple and semi-simple modules, Schur lemma, Free modules, Torsion modules, Torsion free modules, Torsion part of

a module, Modules over principal ideal domain and its applications to finitely generated abelian groups.

SECTION D

Noetherian and Artinian modules: Noetherian and Artinian modules, Modules of finite length, Noetherian and Artinian rings, Hilbert basis theorem. $Hom_R(R, R)$, Opposite rings, Wedderburn Artin theorem, Maschk theorem, Equivalent statement for left Artinian rings having non-zero nilpotent ideals.

Radicals: Jacobson radical, Radical of an Artinian ring.

TEXTBOOKS

1. Charles Lanski, Concepts in Abstract Algebra, American Mathematical Society, First Indian Edition, 2010.
2. C. Musili, Introduction to Rings and Modules, Narosa Publication House, 1994.
3. N. Jacobson, Basic Algebra, Vol. I & II, W.H Freeman, 1980 (also published by Hindustan Publishing Company).
4. M. Artin, Algebra, Prentice-Hall of India, 1991.
5. Ian D. Macdonald, The Theory of Groups, Clarendon Press, 1968

REFERENCE BOOKS

1. I.S. Luther and I.B.S. Passi, Algebra, Vol. I-Groups, Vol. III-Modules, Narosa Publishing House (Vol. I – 2013, Vol. III –2013).
2. Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House, 1999.
3. D.S. Malik, J.N. Mordenson, and M.K. Sen, Fundamentals of Abstract Algebra, McGraw Hill, International Edition, 1997.
4. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul, Basic Abstract Algebra (2nd Edition),Cambridge University Press, Indian Edition, 1997.

e-Resources (websites/Wikipedia pages/webtutorials/online courses, etc.)

1. https://nptel.ac.in/courses/111105112

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO11
MAH514B	Abstract Algebra	CO1	3	--	3	-	-	1	2	1	3	3	1
		CO2	3	-	3	-	-	1	2	1	3	3	1
		CO3	3	-	3	-	-	1	2	1	3	3	1
		CO4	3	-	3	-	-	1	2	1	3	3	1

Course Title/Code	TOPOLOGY-I (MAH502B)	
Course Type	Core (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	To familiarize students with sets, metric spaces, topological spaces, continuous mappings, connectedness, compactness.	
Course Outcomes (COs)		**Mapping**
CO1	The student will be able to understand terms, definitions and theorems related to topology.	**Skill Development**
CO2	The student will be able to demonstrate concepts of TS such as open and closed sets, interior, closure and boundary.	**Skill Development**
CO3	The student will be able to create new topological spaces by using subspace, product and quotient topologies.	**Skill Development**
CO4	The student will be able to use continuous functions and homeomorphisms to understand structure of topological spaces.	**Skill Development**
CO5	The student will be able to apply theoretical concepts in topology to real world applications.	**Skill Development**
Prerequisites (if any)	**N.A**	

SECTION A

Metric spaces, Topological spaces, Closed set, Closure, Dense subset, Neighborhoods, Interior, Exterior and Boundary, Accumulation point and Derived sets, Bases, Sub–bases, Sub space and Relative topology.

SECTION B

Characterization of topology in terms of base and subbase axioms, Topology generated by a family of subsets, Alternate methods of defining a topology in term of Kwiatkowski closure Operator and Neighborhood System, Continuous functions and Homomorphism.

SECTION C

First and Second Countable spaces, Separable spaces, Second countability and Separability, Separation axioms T0,T1,T2,T3-1\2,T4, Their Characterizations and basic Properties, Urysohn's lemma, Teitze extension theorem.

SECTION D

Compactness, Continuous functions and Compact sets, Basic properties of Compactness, Compactness and finite intersection property, Sequentially and countably compact sets, Connected spaces, Connectedness on the real line, Components, Lindelöf's theorem, Locally connected space.

TEXTBOOKS

1. James R. Munkres, Topology (2nd Edition) Pearson Education Pve. Ltd., Delhi-2002

REFERENCE BOOKS

1. George F. Sinmons, Introduction to Topology and Modern Analysis, McGraw Hill Book Co., 1963
2. J. Dugundji , Topology , Prentice Hall of India, New Delhi, 1975.
3. K. D. Joshi : Introduction to General Topology (Wiley Eastern Limited).
4. S. Kumaresan: Topology of Metric Spaces, alpha science.

e-Resources (websites/Wikipedia pages/webtutorials/online courses, etc.)

1. https://nptel.ac.in/courses/111106159

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH502B	Topology-I	CO1	3	2	–	–	–	1	2	1	3	3	2
		CO2	3	2	–	–	–	1	2	1	3	3	2
		CO3	3	2	3	–	–	1	2	1	3	3	2

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

Course Title/Code	DIFFERENTIAL EQUATIONS (MAH503B)	
Course Type	Core (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	Exposure to Ordinary Differential Equations (Homogeneous and Non homogeneous), Different functions and methods to solve these equations, Stability of autonomous system of differential equation and PDEs and their applications in different physical situations	
Course Outcomes (COs)		**Mapping**
CO1	Illustrate the basic concepts differential equations	**Skill Development**
CO2	Explain the various techniques to solve the different types of differential equations	**Skill Development**
CO3	To understand and apply concept of power series technique to solve the differential equations	**Skill Development**
CO4	Apply the concepts of differential equations in various physical problems (heat equations, wave equations)	**Skill Development**
Prerequisites (if any)	**N.A**	

SECTION-A

Existence and Uniqueness of Ordinary Differential equations, Picard's method (successive approximation or iteration method), solution of simultaneous differential equations with initial conditions by Picard's method. Existence and Uniqueness theorem. Lipschitz condition and Lipschitz constant. System of first order non homogeneous equations, Homogeneous Linear system, Non-homogeneous Linear system, Linear system with constant coefficient. Eigen value and Eigen functions. Strum- Lioville Boundary – Value Problems

SECTION-B

Stability of autonomous system of differential equation, Types of critical points, Critical points and Stability of linear systems, stability by Liapunov's Direct method, Simple critical points of nonlinear systems, Nonlinear mechanics, Periodic solutions, The Poincare – Bendixson Theorem.

SECTION-C

Solution of Cauchy's problem of First order Partial Differential equations, Solution of Non-homogeneous PDE by Jacobi's method, PDE of the Second order (Homogeneous and Non-Homogeneous), Monge's Method, Method of separation of variables, Method of Integral transform.

SECTION-D

Laplace Equation in two-dimension, Green function for Laplace Equation, Dirichlet and Newman problem for Half plane, Dirichlet and Newman problem for circle, Dirichlet and Newman problem for sphere and semi-infinite space, Wave Equation, Diffusion equation.

Recommended Books:

1. G. F. Simmons: Differential equation with Application and Historical Notes, McGraw-Hill
2. Ian Sneddon: Elements of Partial Differential Equations, McGraw-Hill.
3. S. L. Ross: Differential Equations, Wily India.
4. M. D. Raisinghania, Advance Differential equation, S.Chand India.

TEXTBOOKS

1. G. F. Simmons: Differential equation with Application and Historical Notes, McGraw-Hill
2. Ian Sneddon: Elements of Partial Differential Equations, McGraw-Hill.

REFERENCE BOOKS

1. S. L. Ross: Differential Equations, Wily India.

2. M. D. Raisinghania, Advance Differential equation, S.Chand India.

e-Resources (websites/Wikipedia pages/webtutorials/online courses, etc.)

1. https://nptel.ac.in/courses/111106100

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH503B	DIFFERENTIAL EQUATIONS	CO1	3	2	-	3	-	-	1	2	3	2	-
		CO2	3	2	-	3	-	-	1	2	3	2	-
		CO3	3	2	-	3	-	-	1	2	3	2	-
		CO4	3	2	-	2	-	-	1	2	3	2	-

Course Title/Code	MEASURE THEORY (MAH504B)	
Course Type	Core (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	To gain understanding of the abstract measure theory and definition and main properties of the integral. To construct Lebesgue's measure on the real line.	
Course Outcomes (COs)		**Mapping**
CO1	To demonstrate the underlying concepts of algebra's of sets, Measure Space, Lebesgue measure space, measurable and non-measurable functions.	**Skill Development**
CO2	To apply the basic concepts Lebesgue integral to solve related mathematical problems.	**Skill Development**
CO3	To describe and apply the notion of measurable functions and sets and use Lebesgue monotone and dominated convergence theorems and Fatou's Lemma.	**Skill Development**
CO4	To describe the construction of product measures and use of Fubini's theorem	**Skill Development**
Prerequisites (if any)	**N.A**	

SECTION A

Introduction of Measure Theory; Extension of Real Line, Semi algebra, Algebra, algebra, Borel field, Set function, Length function and their properties, Counting measure, Extension of measure, Outer measure. Finite, Semi-finite and finite measure, Measurable sets, Measurable space, Completeness of measure spaces.

SECTION B

Lebesgue measure and its properties, Cantor's Theory, non-measurable sets, characterization of Lebesgue measurable sets, Measurable functions and its properties, Convergence of measurable function, Littlewood's Three principles.

SECTION C

Lebesgue Integral of a Bounded functions over a set of Finite Measure, Fatou's Lemma, Monotone Convergence Theorem, Lebesgue Convergence Theorem and Convergence in Measure. Absolute continuity, Jensen Inequality Fundamental Theorem of Calculus for Lebesgue Integrals, Vitali's Lemma, Function of bounded variation.

SECTION D

Lebesgue Convergence Theorem and Convergence in Measure, Integration of complex valued function, Product measure, Fubini's Theorem, Signed Measures, Hahn Decomposition Theorem, Jordan decomposition, Radon-Nikodym Theorem, Lebesgue decomposition.

TEXTBOOKS

1. Real Analysis by H. L. Royden, PHI
2. An Introduction to Measure Theory by I. K. Rana. AMS and Narosa

REFERENCE BOOKS

1. Real Analysis by W. Rudin, TMH

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH504B	MEASURE THEORY	CO1	3	-	3	2	-	-	-	-	3	-	3
		CO2	3	-	3	2	-	-	-	-	3	-	3
		CO3	3	-	3	2	-	-	-	-	3	-	3
		CO4	3	-	3	2	-	-	-	-	3	-	3

Course Title/Code	MATHEMATICAL STATISTICS (MAH512B)	
Course Type	Core (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	To familiarize students with statistical tools and concepts that helps them in decision making.	
Course Outcomes (COs)		**Mapping**
CO1	Use and apply the concepts of probability mass/density functions for the problems involving single/bivariate random variables	**Skill Development**
CO2	Explain concept of Estimation and their properties	**Skill Development**
CO3	Apply testing of hypothesis, types of error and test of significance for different sample sizes.	**Skill Development**
CO4	Demonstrate an ability to apply statistical tools to solve problems.	**Skill Development**
Prerequisites (if any)	**Basic concept of Statistics**	

SECTION A

Random variable and probability functions: Multivariate Probability Distributions Random variables, joint, marginal and conditional distributions, conditional expectations, Moment generating functions, Multinomial and Bivariate Normal Distributions, Chi square, t and F Distributions and their properties.

SECTION B

Introduction to Statistical Inference: Point Estimation-Confidence intervals for means-Confidence intervals for differences of means- Confidence intervals for variances.Estimation and Testing: Basic concept of estimation, definition of a statistic, properties of a good estimator un-biasedness, efficiency, consistency and sufficiency, MVUE Estimator, Cramer Rao Inequality and applications, Maximum Likelihood Estimators.

SECTION C

Sampling Theory Random sampling with and without replacement, stratified sampling, cluster sampling, systematic sampling etc. Distribution of sample mean and variance

Testing: Null and Alternative Hypothesis, Type 1 and Type 2 Error, Z-test, t test, Chi-square, F-test

SECTION D

Analysis of Variance (ANOVA): one way classification and two way classification, Non Parametric Tests: Median Test and Mann Whitney U-Test.

TEXTBOOKS

Books: 1. R.V. Hogg & A.T. Craig: Introduction to Mathematical Statistics, Amerind Pub. Co. Pvt. Ltd. New Delhi, 1972.
2. SC Gupta, VK Kapoor: Fundamentals of Mathematical Statistics, Sultan Chand & Sons (2007)
3. Goon, A. M., Gupta, M. K. and Gupta, B. D. (1968)

REFERENCE BOOKS

1. Freund J.E., Mathematical Statistics, Prentice Hall of India.
2. Hogg, R.V. and Craig, A.T., Introduction to Mathematical Statistics, Pearson Education Limited-2014.
3. Speigel, M., Probability and Statistics, Schaum Outline Series.

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO11
MAH512B	MATHEMATICAL STATISTICS	CO1	1	2	3	2	-	1	2	2	3	3	1
		CO2	1	2	3	2	-	1	2	2	3	3	1
		CO3	1	2	3	2	-	1	2	2	3	3	1
		CO4	1	2	3	2	-	1	2	2	3	3	1

Course Title/Code	EXCEL WORKSHOP**(**MAW515B**)**	
Course Type	Core (Departmental)	
L-P Structure	0-2	
Credits	1	
Course Objective	The course aims to develop to analyze and present data in various formats and styles, summarize data as required by specific business problem.	
Course Outcomes (COs)		**Mapping**
CO1	Comprehend effective use of appropriate spreadsheet vocabulary.	**Skill Development**
CO2	Use critical thinking and problem solving skills in designing the spreadsheets for various business problems.	**Skill Development**
CO3	Assess the document for accuracy in the entry of data and creation of formulas, readability and appearance.	**Employment**
CO4	Develop efficiency with specific sets of skills through repetitive reinforcement to evaluate business problems	**Employment**
Prerequisites (if any)	**N.A**	

SECTION A

Introduction to Excel: Excel Introduction, Understanding Workbooks and Worksheets, Introducing the Ribbon, Using Shortcut Menus, Working with Dialog Boxes, Using the Task Pane, Creating Excel Worksheet, Entering and Editing Worksheet Data, Essential Worksheet Operations, Autosum functions, Working with Dates and Time.

SECTION B

Advanced Excel: Working with Cells and Ranges, Introducing Tables, Worksheet Formatting, Using Custom Number Formats, Understanding Excel Files, Using and Creating Templates, Financial functions, Logical functions, Creating Formulas That Look Up Values.

SECTION C

Creating Formulas for Financial Applications: Introducing Array Formulas, Visualizing Data Using Conditional Formatting, Using Data Validation, Creating Charts and Graphics 04, Understanding How Excel Handles Charts, Understanding Chart Types, Understanding Chart Elements, Modifying the Chart Area, Modifying the Plot Area, Working with Chart Titles, Working with a Legend.

SECTION D

Working with Gridlines, Working with Data Series, Creating Chart Templates, Analyzing Data with Excel, Introducing Pivot Tables, Analyzing Data with Pivot Tables, Understanding Slicers and Slicer properties.

TEXTBOOKS

1. John Walkenbach, Excel 2013 Bible, Wiley, PAP/CDR edition, 2013.

REFERENCE BOOKS

2. John Walkenbach, Excel 2013 Power Programming with VBA (Mr. Spreadsheet's Bookshelf) Wiley; PAP/CDR edition, 2013.

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAW515B	EXCEL WORKSHOP	CO1	-	-	-	2	3	-	1	-	-	3	-
		CO2	-	-	-	2	3	-	1	-	-	3	-
		CO3	-	-	-	2	3	-	1	-	-	3	-
		CO4	-	-	-	2	3	-	1	-	-	3	-

Course Title/Code	MATHEMATICS LAB-I (MAH506B)	
Course Type	Elective (Departmental)	
L-P Structure	0-2	
Credits	1	
Course Objective	Students would be able to understand the software Octave and use commands to perform various experiments.	
Course Outcomes (COs)		**Mapping**
CO1	To perform basic mathematical calculations, plotting the graphs and matrix operation using Mathematical software.	Skill Development
CO2	To evaluate derivative and its application using mathematical software.	Skill Development
CO3	To understand and apply concept of integration to evaluate area and volume using Mathematical software	Employment
CO4	To visualize and find the roots of quadratic, cubic & biquadratics equations and transformation of equations using mathematical software.	Skill Development
Prerequisites (if any)	N.A	

LAB EXERCISE

1. Introduction to OCTAVE and use of some simple OCTAVE commands.
2. To define matrices and compute matrix operations
3. Perform advanced operation on Matrices
4. Introduction to graphics: Basic Two-Dimensional Graphs, Labels, Multiple plots on the same axes, Line styles, Markers and color, Axis limits and Subplots.
5. To transform an equation using Octave
6. Find roots of cubic and bi-quadratic equations
7. To find limit & continuity of function of single variable
8. To find differentiability of function of single variable
9. To find limit & continuity of function of several variables

10. To find differentiability of function of several variables
11. Compute differentiation of function of single and several variables.
12. To find maxima and minima of function of several variables
13. To find integral of a given function
14. Application of integrals- To compute arch length and area under a given curve.
15. Multiple Integrals

TEXTBOOKS

1. Jesper Schmidt Hansen, GNU Octave Beginner's Guide.

REFERENCE BOOKS

1. Jason Lachniet, Introduction to Gnu Octave

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH506B	MATHS LAB-I	CO1	1	-	-	3	3	-	-	-	-	2	-
		CO2	1	-	-	3	3	-	-	-	-	2	-
		CO3	1	-	-	3	3	-	-	-	-	2	-
		CO4	1	-	-	3	3	-	-	-	-	2	-

Course Title/Code	PYTHON PROGRAMMING(CSH511B)	
Course Type	Elective (Allied)	
L-P Structure	0-2	
Credits	1	
Course Objective	The course is designed to provide Basic knowledge of **Python**. **Python** programming is intended for software engineers, system analysts, program managers and user support personnel who wish to learn the **Python** programming language.	
Course Outcomes (COs)		**Mapping**
CO1	Install and run the Python interpreter	**Skill Development**
CO2	Create and execute Python programs	**Skill Development**
CO3	Describe how to program using Python, by learning concepts like variables, flow controls, data types, type conversion	**Skill Development**
CO4	Implement python data structures	**Skill Development**
CO5	Understand the concepts of file I/O	**Skill Development**
CO6	Solve problems using functions, objects and classes	**Employment**
Prerequisites (if any)	**N.A**	

Section-A

Introduction : Introduction to Python, Components and Versions of Python, Difference between Python 2 and Python 3, Python Distributions, Python REPL, Python Syntax. **Basic Operators** – Arithmetic, Relational, Assignment, Logical, Membership and Identity operators, Variables and Data Types **Collections –** String, list, set, tuple, dictionary, Understanding Mutable and Immutable types. **Conditional Constructs -** Working with Loops – While & For, Effects of break, continue, pass & else statement in various construct.

Section-B

Implementing custom functions, Variable scope – Global vs. Local, Dealing with various function arguments – default, named and variable length

arguments, Understanding the concept of pass by value and pass by reference, Returning multiple values from a function, Recursive function.

Section-C

Understanding File Operations, Working with the File Object for reading & writing, Object oriented programming in Python, Understanding Classes & Objects, and Exploring different components of a Class

Section-D

Class inheritance & Method overriding, Working with multiple Inheritance, Understanding the Abstraction mechanism in Python, Built-in Class attributes, Exception handling.

LIST OF EXPERIMENTS: Tool Used: - Jupyter Notebook/ Spyder

1. Using Jupyter Notebook to create and execute Python Program.
2. Programming Constructs in Python – Hands- on - Practice
3. Control Structure - Hands- on - Practice
4. String & List : Hands- on - Practice
5. Operation on Tuples : Hands- on - Practice
6. Dictionary : Hands- on - Practice
7. Function – Pass by reference : Hands- on - Practice
8. Working with the File Object for reading & writing
9. Object Oriented Programming
10. Class inheritance & Method overriding : Hands- on – Practice
11. Exception handling : Hands- on - Practice

Text Books:

- Learn Python 3 the Hard Way: A Very Simple Introduction to the Terrifyingly Beautiful World of Computers and Code (Zed Shaw's Hard Way Series)
- Mark Lutz's, "Learning Python", O'Reilly, 2001

Reference Books:

- Sahana Kumaraswamy, Roy Antony Arnoid G, "Assignment for Object Oriented Programming using Python", Infosys, Dec 2015.

e-Resources (websites/Wikipedia pages/webtutorials/online courses, etc.)

- https://swayam.gov.in/nd1_noc19_cs59/preview

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11

CSH511B	PYTHON PROGRAMMING	CO1	1	-	-	-	3	-	-	-	-	-	-
		CO2	1	3	-	-	3	-	-	-	-	-	-
		CO3	1	3	2	1	-	-	-	-	-	-	-
		CO4	1	2	2	-	3	-	1	-	-	-	-
		CO5	1	2	3	-	2	-	-	-	-	-	-
		CO6	-	2	1	1	2	-	1	-	2	2	2

Course Title/Code	PROFESSIONAL COMPETENCY PG (CDO511)	
Course Type/Sem	Core	
L-P Structure	0-2	
Credits	1	
Course Objective	To familiarize students with the verbal ability, career planning & personality enhancement concepts.	
Course Outcomes (COs)		**Mapping**
CO1	Students will be able to recognize problems based on arithmetic & number systems.	**Skill Development**
CO2	Students will be able to solve problems based on verbal reasoning & simplification.	**Skill Development**
CO3	Students will be able to solve complex problems based on arithmetic reasoning.	**Skill Development**
CO4	Students will be able to plan their career meticulously by setting their time oriented goals.	**Skill Development**
Prerequisites (if any)	**N.A**	

SECTION A

Communication Accuracy: Relevance of Verbal Ability and preparatory guidelines, Functional Grammar – Subject Verb Agreement, Tenses – Perfect, Simple, Continuous, Common Errors and rectification, Idioms and Phrases.

SECTION B

Word Power Building Skills & Reading & Writing Skills: Words: Antonyms, Synonyms, Verbal Analogies, Root Word Technique for Prefixes & Suffixes, Word Power: 7 Tips for Learning New Words, Practice Vocabulary Exercises, Objectives of Reading, Definition & Types of Reading & Importance of Reading, Reading Techniques: SQ3R, Active Reading, Detailed, Speed Reading, Practice Exercises: Short & Medium Passages, Sentences, Phrases, Types of Sentences, Parts of Sentences, Paragraph Writing: Construction, Linkage & Cohesion, Email writing using given phrases

SECTION C

Career Planning & Personality Enhancement: Career planning Process - Self Assessment, Decision Making, Goal Setting: Relevance, SMART goals, The Dos & Don'ts, Stress Management: What is Stress, Types of Stress, Stress Response Example, Vulnerability to Stress, Why do we Stress out, Stress Warning Symbols, Suggestions for Reducing Stress, Time Management: Setting Priorities, Managing Time, Four Quadrants of Time Management.

SECTION D

Effective Communication: Situational English: Role Plays, Greetings & Introduction, Making Requests, Asking for & giving permission, Telephone Communications, Art of Small Talk.

TEXTBOOKS

6. A Modern Approach to Verbal& Non Verbal Reasoning: R S Aggarwal, S Chand & Company Pvt. Ltd, Edition 2018
7. College to Career: The Student Guide to Career and Life Navigation by Mark A Griffin

REFERENCE BOOKS

5. Verbal Ability and Reasoning for Competitive Examinations: P.A. Anand, Wiley
6. Effective Communication in the Workplace by Anthony Gutierez

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO11
CDO511	Professional Competency PG	CO1	--	--	--	-	-	--	--	3	--	2	1
		CO2	--	1	--	-	-	--	--	3	--	1	1
		CO3	--	1	--	-	-	--	--	3	--	2	1
		CO4	--	-	--	-	1	1	--	1	--	1	1

MAP-01- Semester-II

SUBJECT CODES	SUBJECT NAME	**OFFERING DEPARTMENT			L	P	NO. OF CONTACT HOURS PER WEEK	NO. OF CREDITS
MAH517B	MATHEMATICAL MODELING	MA	HARD	CORE	4	0	4	4
MAH508B	COMPLEX ANALYSIS	MA	HARD	CORE	4	0	4	4
MAH509B	FUNCTIONAL ANALYSIS	MA	HARD	CORE	4	0	4	4
MAH510B	DIFFERENTIAL GEOMETRY	MA	HARD	CORE	4	0	4	4
MAH604B	OPERATIONS RESEARCH	MA	HARD	CORE	4	0	4	4
MAH516B	MATHEMATICS LAB - II	MA						
CSW519B	PYTHON FOR DATA ANALYSIS	CS	HARD	ELECTIVE (ANY ONE)	0	2	2	1
RDO504	SCIENTIFIC RESEARCH - I	MA	NTCC	CORE	0	4	2	2
CDO503	PROFESSIONAL COMPETENCY PG-I	CDC	SOFT	AP/ AF	0	2	2	1
	TOTAL (L-P-O/CONTACT HOURS/CREDITS)				**20**	**8**	**26**	**24**
MAO513B	**Summer Internship**							**2**

DETAILED SYLLABUS
MAP01 – SEMESTER-II

Course Title/Code	MATHEMATICAL MODELING (MAH517B)	
Course Type	Core (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	To familiarize students with the concept of Mathematical Modeling and Simulation.	
Course Outcomes (COs)		**Mapping**
CO1	Understand various techniques of mathematical modeling	**Skill Development**
CO2	Apply mathematical models in different fields and situations	**Skill Development**
CO3	Understand and apply mathematical modeling through differential equations.	**Skill Development**
CO4	Analyze Stochastic models and their needs.	**Skill Development**
Prerequisites (if any)	**NA**	

SECTI ON A

Introduction and Process of Mathematical Modeling: Introduction to mathematical modelling.Classification of mathematical models. Formulation of mathematical modeling by different types of mathematical techniques. Some characteristic of mathematical models, Linear and Non-linear growth and decay models, Population growth models, Effects of Immigration and Emigration on Population size, A simple compartmental model (with case study) and other types of models.

SECTION B

Model and its Different Types: Mathematical modeling of epidemics, A simple epidemics model, A susceptible-infected-susceptible (SIS) model, SIS model with constant number of carriers, Simple epidemic model with carriers, Mathematical modeling in medicine, A model for diabetes mellitus and cancer tumor, Mathematical modeling in economics, Arms race and battles: Richardson model for arms race, Lamechester combat model.

SECTION C

Modeling with Differential Equations: Mathematical modeling through partial differential equations: Mass-balance Equations, Momentum balance Equations, Modeling for traffic on a highway, air pollution models. Hydrodynamic model. Case Studies: Heat diffusion, Wave vibration, Laplace equation.

SECTION D

Modeling with Decision Theory: 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.

TEXTBOOKS

1. S. L. Ross: Differential Equations, John Wiley and Sons, India, 2004.

2. Kapur J.N., Mathematical Modelling, New Age International Limited,2015

3. Kapur J.N., Mathematical Models in Biology and Medicine, Affiliated East-West Press (P) Ltd., 1985

REFERENCE BOOKS

1. Burghes D.N. and Wood A.D., Mathematical Models in the Social, Management and Life Sciences, John Wiley and Sons,1980

2. Andrews J.G. and Mclone R.R, Mathematical Modeling, Butterworths (Pub.) Inc., 1976
3. Clive L. Dym, Principles of Mathematical Modelling, Elsevier Press, Second Edition, 2004.
4. Edward A. Bender, An Introduction to Mathematical Modeling, Dover, 2000.
5. D Kincaid and W. Cheney, Numerical Analysis: Mathematics of Scientific Computing, Third Edition, American Mathematical Society, 2009.

SUGGESTED WEB SOURCES:

1. https://nptel.ac.in/
2. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=14
3. https://swayam.gov.in/

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO11

MAH517 B	Mathematical Modeling	CO1	1	2	3	2	-	1	2	2	3	3	1
		CO2	1	2	3	2	-	1	2	2	3	3	1
		CO3	1	2	3	2	-	1	2	2	3	3	1
		CO4	1	2	3	2	-	1	2	2	3	3	1

Course Title/Code	COMPLEX ANALYSIS **(**MAH508B**)**	
Course Type	Core (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	The objective of this course is to introduce the fundamental ideas for developing and understanding the concepts of Complex Analysis.	
Course Outcomes (COs)		**Mapping**
CO1	Understand the significance of continuity, differentiability and analyticity of complex functions	**Skill Development**
CO2	Demonstrate the use of Cauchy integral formula ,Taylor and Laurent series expansions.	**Skill Development**
CO3	Classify the nature of singularities, poles and residues and explain the application of Cauchy Residue theorem	**Skill Development**
CO4	Apply the consequences of analytic continuation, Schwarz reflection principle, Monodromy theorem and conformal mapping	**Skill Development**
Prerequisites (if any)	N.A	

SECTION A

Construction and Algebra of Complex number, Field of complex numbers, conjugate and absolute values, Topology of complex plane, Isometry, function of complex variable, Analytic Functions, power series, radius of convergence of power series, corves on complex plane.

SECTION B

Complex Integration, Fundamental Theorem of calculus, Homotopy of the curve, Cauchy-Goursat Theorem, Cauchy's Integral Theorem, Cauchy's Integral Formula and related results, Maximum modulus principle, Schwartz Lemma, Cauchy's Inequality, Liouville's theorem, Morera's Theorem.

SECTION C

Taylor & Laurent's Series Expansion, Singularities, Casorati-Weierstress theorem, Meromorphic functions, Zeros of complex functions, the argument principle, Rouche's theorem, Inverse function theorem. Residues, Cauchy's residue theorem, Evaluation of integrals.

SECTION D

Analytic continuation, Uniqueness of direct analytic continuation, Uniqueness of analytic continuation along a curve, Power series method of analytic continuation, Schwarz reflection principle, Monodromy theorem and its consequences. Mapping and transformations on complex plane.

TEXTBOOKS

1. S. Ponnusamy, Complex Analysis, Springer.
2. E. T. Copson, Complex Variables, Oxford University Press.

REFERENCE BOOKS

1. J. B. Conway, Functions of one complex variable, Narosa Publication House.
2. H.S. Kasana, Complex- Variable Theory and Applications, PHI Learning Pvt.
3. J. N. Sharma, Functions of a Complex- Variable, Krishna Prakashan Media (P) Ltd.

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH508B	COMPLEX ANALYSIS	CO1	1	2	3	2	-	2	-	2	2	2	2
		CO2	3	2	1	1	-	2	-	2	2	2	2
		CO3	3	2	2	1	-	2	-	2	2	2	2
		CO4	3	3	2	1	-	2	-	1	2	2	1

Course Title/Code	FUNCTIONAL ANALYSIS (MAH509B)	
Course Type	Core (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	To provide the student with the concept and the understanding in Banach spaces, Hilbert space and Banach Algebras.	
Course Outcomes (COs)		**Mapping**
CO1	Demonstrate the basic concepts, underlying the definition of the general Functional spaces like Norm Linear space, Quotient space, Banach space, Inner product spaces, Hilbert spaces.	**Skill Development**
CO2	Understand the concept associated with the dual of a linear space, point set topology, linear functional, linear operator, approximation theory.	**Skill Development**
CO3	Apply and understand the concept of Hahn-Banach Theorem and their applications, open mapping, closed graph theorems and weak topology.	**Skill Development**
CO4	Analysis the concept of orthonormal bases, complete orthonormal sets, Projection theorem, Riesz representation theorem, Riesz-Fischer theorem.	**Skill Development**
Prerequisites (if any)	**N.A**	

SECTION A

Normed linear spaces, Banach spaces, their examples including R^n, C^n, $l_p(n)$, c_0, c, l_p, $C[a, b]$. Subspaces, Quotient spaces of normed linear space and its completeness. Joint continuity of addition and scalar multiplication. Summable sequences and completeness, Continuous and bounded linear operators and their basic properties.

SECTION B

Normed linear space of bounded linear operators and its completeness. Isometric isomorphism, Topological isomorphism. Equivalent norms. Finite dimensional normed spaces and compactness. Riesz Theorem, Open mapping theorem and its simple consequences. Closed graph theorem. Uniform boundedness, Banach-Steinhaus theorem.

SECTION C

Bounded linear functionals Dual spaces. Form of dual spacesR^{n*}, C^{n*}, (n), c^*, c^*, l^* , $C^*[a, b]$., Hahn-Banach Theorem and its consequences, Embedding and Reflexivity of Normed linear spaces.

SECTION D

Adjoint of Bounded linear operators, Weak convergence and strong convergence. Hilbert spaces, orthogonal complements and direct sums, Bessel inequality, total orthonormal sets and sequences.

Recommended Books:

1. P. K. Jain and O P Ahuja, Functional Analysis, New age international publishers
2. S. Ponnusamy, Foundation of Functional Analysis, Springer
3. Walter Rudin, Functional Analysis, TMH Edition
4. V.S. Sunder, Functional Analysis spectral theory, Hindustan Book Agency, 1997

TEXTBOOKS

1. P. K. Jain and O P Ahuja, Functional Analysis, New age international publishers
2. S. Ponnusamy, Foundation of Functional Analysis, Springer

REFERENCE BOOKS

1. Walter Rudin, Functional Analysis, TMH Edition
2. V.S. Sunder, Functional Analysis spectral theory, Hindustan Book Agency, 1997

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH509B	FUNCTIONAL ANALYSIS	CO1	3	1	2	-	-	-	2	1	2	2	-
		CO2	3	2	2	-	-	-	2	2	3	3	-
		CO3	2	2	2	-	-	-	2	2	3	3	-
		CO4	3	2	3	-	-	-	2	2	3	3	-

Course Title/Code	DIFFERENTIAL GEOMETRY (MAH510B)	
Course Type	Core (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	To familiarize students with space curves, geodesics, intrinsic and non-intrinsic properties of a surface.	
Course Outcomes (COs)		**Mapping**
CO1	understand and evaluate mathematical problems based on the transformation of coordinate system, tensor Calculus	**Skill Development**
CO2	Understand, visualize and solve the problem related to Differentiable curves in R3 and their parametric representations	**Skill Development**
CO3	Visualize and apply the concepts of differential calculus to solve the problem related to Curvatures (Normal, Principal, Gaussian,Mean) and differential forms	**Skill Development**
CO4	Understand and apply the concept of different operators on surface to solve the problem related to Minimal & totally umbilical surface, Geodesics.	**Skill Development**
Prerequisites (if any)	**N.A**	

SECTION A

Co-ordinate transformation, Covariant, Contravariant and Mixed tensors, Tensors of higher rank, Symmetric and Skew- symmetric tensors, Tensor algebra, Contraction, Inner product, Riemannian metric tensor, Christoffel symbols, Covariant derivatives of tensors.

SECTION B

Differentiable curves in R^3 and their parametric representations, Vector fields, Tangent vector, Principal normal, Binormal, Curvature and torsion, Serret-Frenet formula, Frame fields, Covariant differentiation, Connection forms, The structural equations.

SECTION C

Surfaces, Differentiable functions on surfaces, Differential of a differentiable map, Differential forms, Normal vector fields, First fundamental form, Shape operator, Normal curvature, Principal curvatures, Gaussian curvature, Mean curvature, Second fundamental form.

SECTION D

Gauss equations, Weingarten equation, Codazzi-Mainardi equations, Totally umbilical surfaces, Minimal surfaces, Variations, First and second variations of arc length, Geodesic, Exponential map, Jacobi vector field, Index form of a geodesic.

TEXTBOOKS

1. Barett O' Neill, Elementary Differential Geometry, Academic Press, 2006.
2. Manfredo P. Do' Carmo, Differential Geometry of Curves and Surfaces, , Prentice Hall Inc.
3. S. Montiel and A. Ros, Curves and Surfaces , American Mathematical Society, 2005.

REFERENCE BOOKS

1. Somasundaram, Differential Geometry, A first course, Narosa Publication.
2. Zafar Ahsan, Tensor Calculus, Anamaya Publications, New Delhi.
3. U. C. De, Tensor Calculus, Narosa Publications, New Delhi.

e-Resources (websites/Wikipedia pages/webtutorials/online courses, etc.)

1. https://nptel.ac.in/courses/111104095

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH510B	DIFFERENTIAL GEOMETRY	CO1	1	-	3	2	-	-	-	-	2	2	-
		CO2	1	-	3	2	-	-	-	-	2	2	-
		CO3	1	-	3	2	-	-	-	-	2	2	-
		CO4	1	-	3	2	-	-	-	-	2	2	-

Course Title/Code	OPERATIONS RESEARCH **(**MAH604B)	
Course Type	Elective (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	To equip students with quantitative methods and techniques for effective decisions– making; model formulation and applications that is used in solving business decision problems.	
Course Outcomes (COs)		**Mapping**
CO1	Understand any real life system with limited constraints and depict it in a model form.	**Skill Development**
CO2	Demonstrate the problem on the basis of obtained solution of different problems of OR with real world limitations/applications.	**Skill Development**
CO3	Apply the different methods to solve OR problems & find the optimal solution.	**Skill Development**
CO4	Analyze and construct the mathematical models and learn to apply the restrictions on problems.	**Skill Development**
Prerequisites (if any)	**N.A**	

SECTION A

Convex set theory: Linear independence and dependence of vectors, Convex sets, Convex hull, Extreme points, convex polyhedron, Hyper planes and Half-spaces, Convex cones, supporting hyperplane, Linear programming problem, feasible solution of LPP, basic feasible solution, OR Introduction, Construction of OR Model, Linear programming problem, feasible solution of LPP, basic feasible solution, Graphical Method with cases.

SECTION B

Introduction to Linear Programming: Linear Programming Problem Formulation, Graphical solution, Simplex Algorithm, Artificial variables techniques: Two–phase method & Big-M method , Duality theory, Dual-simplex method.
Degeneracy, Alternate optimal solution. Integer Programming; Gomory's Fractional cut method, Mixed Integer Programming.

SECTION C

Transportation problem & Assignment problems: Formulation of Transportation problem, Optimal solution, Unbalanced transportation problem, Degeneracy, Formulation of Assignment problem, Optimal solution, Variants of Assignment Problem- Traveling Salesman problem.

SECTION D

Sequencing: Sequencing problems: Introduction, assumptions, processing of n - jobs through 2 machines, Processing of n - jobs through 3 machines. Processing of n - jobs through m- machines. Graphical method for sequencing.
Game Theory: Introduction, Two person zero sum game, Pure strategies, Maximin & minimax principle,Game with saddle points, Mixed strategies, Game without saddle points, Dominance rule. Matrix method, Method of oddment, Graphical, Linear programming approach.

TEXTBOOKS

1. H. A. Taha, Operations Research an introduction, Pearson India
2. J. K. Sharma, Operations Research theory & applications, 5th edition, Macmillian India Ltd-new Delhi

REFERENCE BOOKS

1. P.K. Gupta &D. S. Hira, Operations Research, S. Chand.

e-Resources (websites/Wikipedia pages/webtutorials/online courses, etc.)

1. **https://nptel.ac.in/courses/111107128**

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH604B	OPERATIONS RESEARCH	CO1	3	3	3	3	2	2	2	2	2	2	2
		CO2	3	3	3	3	2	2	2	2	2	2	2
		CO3	3	3	3	3	2	2	2	2	2	2	2
		CO4	3	3	3	3	2	2	2	2	2	2	2

Course Title/Code	MATHEMATICS LAB-II (MAH516B)	
Course Type	Elective (Departmental)	
L-P Structure	0-2	
Credits	1	
Course Objective	To familiarize students with script file and m files to perform various experiments using mathematical software.	
Course Outcomes (COs)		**Mapping**
CO1	Write programming codes using conditional statements for related mathematical problems.	**Skill Development**
CO2	Write programming codes using iterative statements (for loop, while loop) for related mathematical problems.	**Skill Development**
CO3	Successfully install LaTeX and its related components on a home/personal computer.	**Skill Development**
CO4	Use LaTeX and various templates acquired from the course to compose Mathematical documents, presentations, and reports	**Skill Development**
CO5	Write mathematical documents containing mathematical expressions & formulas via LaTeX.	**Skill Development**
CO6	Write articles in different journal styles.	**Skill Development**
CO7	Draws graphs and figures in LaTeX. Customize LaTeX documents.	**Skill Development**
CO8	Prepare presentations using LaTeX	**Employment**
Prerequisites (if any)	NA	

LAB EXERCISE: Software Octave/ SciLab/MATLAB/ Altair

1. Introduction to m file - basic programming.
2. Introduction to conditional Statements
3. Introduction to iteration-based programming

4. Introduction to function files
5. Functions calling through main program (script file)
6. Find the rank of a matrix & solution of simultaneous Linear equations
7. Eigen values and Eigen vector of a matrix
8. Orthogonalization of a Matrix
9. Diagonalization of a matrix
10. linear dependence and independence of vectors, basis and dimension
11. Matrix of Linear Transformation

TEXTBOOKS

1. **Jesper Schmidt Hansen, GNU Octave Beginner's Guide.**

REFERENCE BOOKS

1. Jason Lachniet, Introduction to Gnu Octave

CO-PO Mapping

Course Code	Course Name	Course Uotcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH511B	MATHEMATICS LAB-II	CO1	-	-	-	-	3	-	-	2	-	-	-
		CO2	-	-	-	-	3	-	-	2	-	-	-
		CO3	-	-	-	-	-	-	-	-	-	2	-
		CO4	-	-	-	-	3	-	-	2	-	2	-
		CO5	-	-	-	-	3	-	-	2	-	-	-
		CO6	-	-	-	-	3	-	-	2	-	2	-
		CO7	-	-	-	-	3	-	-	2	-	-	-
		CO8	-	-	-	-	3	-	-	2	-	2	-

Course Title/Code	PYTHON FOR DATA ANALYSIS **(**CSW519B)	
Course Type	Elective (Allied)	
L-P Structure	0-2	
Credits	1	
Course Objective	To familiarize students with the advance features of python programming using various libraries and packages for exploratory data analysis and visualization.	
Course Outcomes (COs)		**Mapping**
CO1	Understanding of advance features of python programming.	**Employment**
CO2	Apply advance features of python programming for explorateory Analysis.	**Skill Development**
CO3	Implemant the concepts in various real world proplems	**Employment**
CO4	Perform Analysis through visualization	**Employment**
Prerequisites (if any)	**N.A**	

Section-A

Jupyter and Numpy: The NumPy ndarray: A Multidimensional Array Object, Creating ndarrays, Data Types for ndarrays, Arithmetic with NumPy Arrays, Basic Indexing and Slicing, Boolean Indexing, Fancy Indexing, Transposing Arrays and Swapping Axes, **Universal Functions**: Fast Element-Wise Array Functions, **Array-Oriented Programming with Arrays :** Expressing Conditional Logic as Array Operations, Mathematical and Statistical Methods, Methods for Boolean Arrays, Sorting,Unique and Other Set Logic **File Input and Output with Arrays**

Section-B

Importing Dataset: Understanding the Data, Python Packages for Data Science, Importing and Exporting Data in Python
Pandas: Introduction to pandas Data Structures, Series, DataFrame, Index Objects, Reindexing
Dropping Entries from an Axis, Indexing, Selection, and Filtering, Integer Indexes, Arithmetic and Data Alignment, Function Application and Mapping, Sorting and Ranking,Axis Indexes with Duplicate Labels

Section-C

Summarizing and Computing Descriptive Statistics: Correlation and Covariance, Unique Values, Value Counts, and Membership

Data Cleaning and Preparation : Handling Missing Data, Filtering Out Missing Data, Filling In Missing Data **Data Transformation :** Removing Duplicates, Transforming Data Using a Function or Mapping, Replacing Values, Renaming Axis Indexes, Discretization and Binning, Detecting and Filtering Outliers, Permutation and Random Sampling, Computing Indicator/Dummy Variables

Section-D

Plotting and Visualization : Figures and Subplots, Colors, Markers, and Line Styles, Ticks, Labels, and Legends, Annotations and Drawing on a Subplot, Saving Plots to File, Line Plots, Bar Plots, Histograms and Density Plots, Scatter or Point Plots, Facet Grids and Categorical Data

Mini Project

Text Books:

1. McKinney, Wes. Python for data analysis: Data wrangling with Pandas, NumPy, and IPython. " O'Reilly Media, Inc.", 2012.
2. Mark Lutz's, "Learning Python", O'Reilly, 2001

Reference Books:

1. Lott, Steven. Functional Python Programming. Packt Publishing Ltd, 2015.
2. Matthes, Eric. Python crash course: a hands-on, project-based introduction to programming. No Starch Press, 2015.
3. https://pandas.pydata.org/

e-Resources (websites/Wikipedia pages/webtutorials/online courses, etc.)

On line Course:

1. Python for Data Science: https://swayam.gov.in/nd1_noc19_cs59/preview
2. Data Analysis with Python: https://www.coursera.org/learn/data-analysis-with-python

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CSH519B	PYTHON FOR DATA ANALYSIS	CO1	1	3	-	-	3	-	-	-	-	-	-
		CO2	1	3	2	1	-	-	-	-	-	-	-
		CO3	1	2	2	-	3	-	1	-	-	-	-
		CO4	1	2	3	-	2	-	-	-	-	-	-

Course Title/Code	SCIENTIFIC RESEARCH-I (RDO504)	
Course Type	CORE	
L-P Structure	0-4	
Credits	2	
Course Objective	To acquaint the researcher with the tools of research by exposing them to the mechanics of writing a research report/ research paper/ thesis/ dissertation.	
Course Outcomes (COs)		**Mapping**
CO1	Describe research and its impact.	**Employment**
CO2	Identify broad area of research, analyze, the processes and procedures to carryout research.	**Skill Development**
CO3	Use different tools for literature survey	**Employment**
CO4	Understand and adopt the ethical practice that are to be followed in the research activities.	**Employment**
CO5	work in groups with guidance	
Prerequisites (if any)	**N.A**	

Unit 1: What is Research and its impact?

1.1 Capturing the current research trends
1.2 Insight about scientific research performed by renowned experts in the related field (case studies)
1.3 Do's and Don'ts pertaining to research

Unit 2: Identification of Broad Area of research

2.1 Identification of thrust area of research for deciding broad area
2.2 Framing the research questions and hypothesis
2.3 Identification of the research gap based on feasibility of problem

2.4 Exploration of in-house and commercially available facilities related to broad area

Unit 3: Understanding the tools for Literature Survey

3.1 Finding research papers related to a topic
3.2 Understanding the different aspects of Literature search
3.3 Usage of different sources like Google scholar, WoS, SCI/ SCIE, PubMed, Scopus, ABDC, EBSCO etc.
3.4 Search for online journals relevant to research area
3.5 Indexing of Journals
3.5 Usage of scholarly networking sites like Research Gate, Mendeley, and Academia.edu etc.
3.6 Demo sessions on the usage of above mentioned sources

Unit 4: Review of research papers pertaining to broad area and specific area of research

4.1 Selection of relevant papers
4.2 Finding specific research problem from broad area of research
4.3 Literature survey and justification of specific research problem
4.4 Experimentation and data cleaning and verification
4.5 Understanding and selection of the research domain
4.6 Seeking information through published work w.r.t the problem
4.7 Reading & categorizing the downloaded/referred papers and structuring of the idea
4.8 Model design about framing the research questions

Unit 5: Report Writing and Presentation skill Development

5.1 Report making on the surveyed literature to cater the basic idea of the research papers
5.2 Compiling and analyzing the published results to justify and understand the proposed ideas Usage of MS-PowerPoint and other technical resources for the presentation
5.3 Development of presentation skills and group addressing
5.4 Scientific/technical writing and ethical practice, project report

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
RDO504	SCIENTIFIC RESEARCH-I	CO1	3	-	-	-	-	-	-	-	3	3	3
		CO2	3	2	3	3	2	-	-	-	3	3	3
		CO3	3	-	-	-	-	-	-	-	3	2	2

		CO4	-	-	-	-	-	3	-	-	3	2	1

Course Title/Code	PROFESSIONAL COMPETENCY PG - I (CDO503)	
Course Type/Sem	Core (Departmental)/2	
L-P Structure	0-2	
Credits	1	
Course Objective	To familiarize students with the Quantitative Aptitude & Logical reasoning.	
Course Outcomes (COs)		**Mapping**
CO1	Students will be able to recognize problems based on arithmetic & number systems.	**Skill Development**
CO2	Students will be able to solve problems based on verbal reasoning & simplification.	**Skill Development**
CO3	Students will be able to solve complex problems based on arithmetic reasoning.	**Skill Development**
CO4	Students will be able to plan their career meticulously by setting their time oriented goals.	**Skill Development**
Prerequisites (if any)	**N.A**	

SECTION A

Number System, Numbers, Types of numbers and number tree, Divisibility Rule, HCF & LCM, Factors and Multiples, Unit Digits & Cyclicity, Remainders, Factorials

SECTION B

Average, Percentages, Profit & Loss, Basic terminology & Formulae, Error in Weights, Marked Price and Discounts, Interest, Simple Interest, Compound Interest, Relation between SI & CI

SECTION C

Ratio & Proportion, Proportionality, Variations, Partnership, Problem on Ages & Numbers, Time & Work, Time and Work, Chain Rule, Work & Wages, Pipes & Cisterns, Data Interpretation, Table and Bar graph, Line and Pie Charts, Mixed Charts and Caselets

SECTION D

Logical Reasoning, Direction Sense Test, Blood Relation Test, Coding and Decoding

TEXTBOOKS

1. A Modern Approach to Verbal& Non Verbal Reasoning: R S Aggarwal, S Chand & Company Pvt. Ltd, Edition 2018

REFERENCE BOOKS

2. Logical & Non Verbal Reasoning: Arun sharma, Edition 2018

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO11
CDO503	Professional Competency PG-1	CO1	3	2	2	2	1	1	--	--	1	--	--
		CO2	--	--	--	2	1	--	--	--	--	1	--
		CO3	2	3	1	1	2	1	--	--	1	--	--
		CO4	--	-	--	-	1	1	--	1	--	1	1

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MAP01 -Semester-III

SUBJECT CODES	SUBJECT NAME	**OFFERING DEPARTMENT	*COURSE NATURE (Hard/Soft/ Workshop/ NTCC)	COURSE TYPE (Core/Elective / University Compulsory)	L	P	NO. OF CONTACT HOURS PER WEEK	NO. OF CREDITS
MAH601B	INTEGRAL EQUATIONS & CALCULUS OF VARIATION	MA	HARD	CORE	4	0	4	4
MAH602B	FLUID MECHANICS	MA	HARD	CORE	4	0	4	4
MAH607B	FOURIER ANALYSIS							
MAH507B	FIELD THEORY							
MAH608B	DIFFERENTIABLE MANIFOLDS							
MAH606B	DESIGN OF EXPERIMENTS							
MAH623B	ADVANCED NUMERICAL ANALYSIS	MA	HARD	ELECTIVE (ANY ONE)	4	0	4	4
MAH614B	ADVANCED OPERATIONS RESEARCH							
MAH625B	FUZZY SETS AND APPLICATIONS							
MAH605B	GRAPH THEORY							
MAH609B	WAVELETS							
MAH610B	TOPOLOGY - II	MA	HARD	ELECTIVE (ANY ONE)	4	0	4	4
RDO604	SCIENTIFIC RESEARCH - II	MA	NTCC	CORE	0	4	2	2
CDO603	PROFESSIONAL COMPETENCY PG-II	CDC	SOFT	AP/ AF	0	2	2	1

	TOTAL (L-P-O/CONTACT HOURS/CREDITS)				**16**	**6**	**20**	**19**

DETAILED SYLLABUS

MAP01 - SEMESTER III

Course Title/Code	INTEGRAL EQUATIONS & CALCULUS OF VARIATION(MAH601B)	
Course Type	Core (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	The objective of this course is to introduce the fundamental ideas for developing and understanding the concepts of Integral Equations and Calculus of variation.	
Course Outcomes (COs)		**Mapping**
CO1	Acquire sound knowledge of different types of Integral equations: Fredholm and Volterra integral equations.	**Skill Development**
CO2	Deduce & solve integral equation from differential equation arising in different engineering branches	**Skill Development**
CO3	Construct Green function in solving boundary value problem by converting it to an integral equation	**Skill Development**
CO4	Identify functional and its applications in engineering problem.	**Skill Development**
CO5	Use the Euler-Lagrange equation or its first integral to find differential equations for stationary paths and solve, subject to boundary conditions.	**Skill Development**
Prerequisites (if any)	**NA**	

SECTION A

Introduction to Integral equation, Linear Integral equations, Some basic identities, Differentiation of function under an integral sign, 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. Resolvent kernel as a series. Solution of a Volterra integral equation of the first kind.

SECTION B

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 as a sum of series. Fredholm resolvent kernel as a ratio of two series. Fredholm equations with separable kernels. Approximation of a kernel by a separable kernel, Fredholm Alternative, Non-homogeneous Fredholm equations with degenerate Kernels.

SECTION C

Green function, Use of method of variation of parameters to construct the Green function for a non homogeneous 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.

SECTION D

Introduction to calculus of Variation, Variation of Functionals, Euler's equation, Euler – Lagrange equation, Solutions of Euler's Equation, Necessary and sufficient condition for Extrema. Several dependent variables, Functional involving higher order derivatives, Variational methods for boundary value problems in ordinary and partial differential equations.

TEXTBOOKS

1. William Vernon Lovitt, Linear Integral equations, Dover Publications, INC Mineola, New York.
2. Rainer Kress, Linear Integral equations, Springer
3. Ram P. Kanwal, Linear Integral equations, Academic Press, New York and London.

REFERENCE BOOKS

1. Shanti Swarup, Shiv Raj Singh, Linear Integral equations , Krishna Prakashan Media (P) Ltd.
2. D.C Sharma, M.C Goyal, Linear Integral equations, PHI Learning PVT Delhi.
3. A.S.Gupta, Calculus of Variations with Applications, PHI Learning PVT Delhi.
4. I.M Gelfand, S. V Fomin, Calculus of Variations with Applications, Prentice Hall.

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH601B	INTEGRAL EQUATIONS & CALCULUS OF VARIATION	CO1	3	1	1	3	-	-	-	-	2	2	2
		CO2	2	2	3	2	-	-	-	-	2	1	1
		CO3	3	3	2	3	-	-	-	-	1	-	2
		CO4	2	3	2	3	-	-	-	-	2	1	2
		CO5	3	2	2	3	-	-	-	-	2	1	2

Course Title/Code	FLUID MECHANICS(MAH602B)	
Course Type	Core (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	To familiarize students with basic concepts of fluid mechanics.	
Course Outcomes (COs)		**Mapping**
CO1	Describe the continuum model of fluid flow and classify fluid/flows based on physical properties of a fluid/flow along with Eulerian and Lagrangian descriptions of fluid motion.	**Skill Development**
CO2	Demonstrate an ability to apply the concepts of Steady viscous flow and Conservation of Momentum for solving real world problems."	**Skill Development**
CO3	Apply the concepts of Irrotational/rotational Motion for solving real world problems.	**Skill Development**
CO4	Construct and Analyse mathematically the nature of Laminar/non laminar flow.	**Skill Development**
Prerequisites (if any)	**N.A**	

SECTION A

Concept of fluids, Physical Properties of fluids, Continuum Hypothesis, density, specific weight, specific volume, Kinematics of Fluids: Eulerian and Lagrangian methods of description of flows, Equivalence of Eulerian and Lagrangian method, General motion of fluid element, integrability and compatibility conditions, strain rate tensor, streamline, path line, streak lines, stream function, vortex lines, circulation.

SECTION B

Stresses in Fluids: Stress tensor, symmetry of stress tensor, transformation of stress components from one co-ordinate system to another, principle axes and principle values of stress tensor Conservation Laws: Equation of conservation of mass (continuity equation), equation of conservation of momentum, Navier Stokes equation, Euler's equation of motion, equation of moments of momentum, Equation of energy.

SECTION C

Irrotational and Rotational Flows: Bernoulli’s equation, Bernoulli’s equation for irrotational flows, Two dimensional irrotational incompressible flows, Circle theorem, sources and sinks, sources sinks and doublets in two dimensional flows, methods of images.

SECTION D

Approximate (analytical) solutions of Navier Stoke Equation, Order of magnitude analysis, Use of similarity variables in analytical solution techniques, Solutions of some benchmark problems like; Couette Flow, Axi-symmetric Flows, Creeping flows.

TEXTBOOKS

1. Dr.H.K.Pathak ,J.P.Chauhan Fluid Dynamics,Shree Shiksha Sahitya Prakashan.

REFERENCE BOOKS

1. O'Neil, M. E., and Chorlton, F. Ideal and Incompressible Fluid Dynamics.John Wiley & Sons, 1986.
2. Kundu, P.K., Cohen, I.M. and Dowling, R. David. Fluid Mechanics, 6th edition, Academic Press, 2015.
3. Yuan, S.W. Foundations of Fluid Mechanics. Prentice Hall of India Private Limited, New Delhi, 1976.
4. Besaint, W.H. and Ramsey, A.S. A Treatise on Hydromechanics, Part II.CBS Publishers, Delhi, 1988.
5. Curle, N. & Davies, H. J. Modern Fluid Dynamics.Vol 1, D Van Nostrand Company Ltd, London, 1968.

e-Resources :

- **https://nptel.ac.in/courses/101103004**

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH602B	Fluid Mechanics	CO1	3	-	3	3	-	-	2	2	1	1	1
		CO2	3	3	3	3	-	-	2	2	1	1	1
		CO3	3	3	3	3	-	-	2	2	1	1	1
		CO4	3	3	3	3	-	-	2	2	1	1	1

Course Title/Code	FOURIER ANALYSIS(MAH607B**)**	
Course Type	Elective (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	To familiarize students with Fourier series, orthogonality, completeness, Fourier Transform, tempered distributions.	
Course Outcomes (COs)		**Mapping**
CO1	Understand the basic properties of Fourier series	**Skill Development**
CO2	Use concept of separation of variables Sturm-Liouville Theorem to solve related problem	**Skill Development**
CO3	Apply the concepts of distributions and Fourier transform to solve related problem	**Skill Development**
CO4	Understand the application of Fourier transform	**Skill Development**
Prerequisites (if any)	Functional Analysis (MAH509B)	

SECTION A

Basic Properties of Fourier series: Uniqueness of Fourier Series, Convolutions, Cesaro and Abel Summability, Fejer's theorem, Poisson Kernel and Dirichlet problem in the unit disc, Mean square Convergence, Example of Continuous functions with divergent Fourier series.

SECTION B

L2-theory: Orthogonality, Completeness, ON systems, Applications to partial differential equations, Separation of variables, Something about Sturm-Liouville theory and Eigen function expansions.

SECTION C

Distributions and Fourier Transforms: Calculus of Distributions, Schwartz class of rapidly decreasing functions, Fourier transforms of rapidly decreasing functions, Riemann Lebesgue lemma, Fourier Inversion Theorem, Fourier transforms of Gaussians.

SECTION D

Tempered Distributions: Fourier transforms of tempered distributions, Convolutions, Applications to PDEs (Laplace, Heat and Wave Equations), Schrodinger-Equation and Uncertainty principle. Paley-Wienner Theorems, Poisson Summation Formula: Radial Fourier transforms and Bessel's functions, Hermite functions.

TEXTBOOKS

1. R. Strichartz, A Guide to Distributions and Fourier Transforms, CRC Press
2. E.M. Stein and R. Shakarchi, Fourier Analysis: An Introduction, Princeton University Press, Princeton 2003.

REFERENCE BOOKS

1. Fourier Analysis by Javier Duoandicoetxea. AMS Graduate Studies in Mathematics Volume 29, 2001
2. Classical and Modern Fourier Analysis by Loukas Grafakos. Prentice Hall 2003

e-Resources (websites/Wikipedia pages/webtutorials/online courses, etc.)

1. https://nptel.ac.in/courses/111101164

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH607B	FOURIER ANALYSIS	CO1	3	-	1	2	-	-	-	-	-	1	-
		CO2	3	-	2	2	-	-	-	-	-	1	-
		CO3	3	3	2	2	-	-	2	-	1	2	-
		CO4	3	3	3	3	1	-	2	-	2	2	-

Course Title/Code	FIELD THEORY (MAH507B)	
Course Type	Core (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	To familiarize students with the Field Theory & its applications.	
Course Outcomes (COs)		**Mapping**
CO1	Explain the fundamental concepts of field extensions and its role in modern mathematics and applied contexts	**Skill Development**
CO2	Demonstrate the application of Galois theory.	**Skill Development**
CO3	Illustrate about Galois fields, Cyclotomic extension and polynomials	**Skill Development**
CO4	Solve polynomial equations by radicals along with the understanding of ruler and compass	**Skill Development**
Prerequisites (if any)	**N.A**	

SECTION - A

Extension of fields: Elementary properties, Simple Extensions, Algebraic and transcendental Extensions. Factorization of polynomials, Splitting fields, Algebraically closed fields, Separable extensions, Perfect fields.

SECTION - B

Galios theory: Automorphism of fields, Monomorphisms and their linear independence, Fixed fields, Normal extensions, Normal closure of an extension, The fundamental theorem of Galois theory, Norms and traces.

SECTION - C

Cyclotomic extensions: Normal basis, Galios fields, Cyclotomic extensions, Cyclotomic polynomials, Cyclotomic extensions of rational number field, Cyclic extension, Wedderburn theorem.

SECTION - D

Geometrical Constructions & Radicals: Ruler and compasses construction, Solutions by radicals, Extension by radicals, Generic polynomial, Algebraically independent sets, Insolvability of the general polynomial of degree $n \geq 5$ by radicals.

TEXTBOOKS

1. I.S. Luther and I.B.S.Passi, Algebra, Vol. IV-Field Theory, Narosa Publishing House, 2012.
2. Ian Stewart, Galios Theory, Chapman and Hall/CRC, 2004.
3. Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House, 1999.
4. P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul, Basic Abstract Algebra (2nd Edition),

REFERENCE BOOKS

5. I.S. Lang, Algebra, 3rd editioin, Addison-Wesley, 1993.
6. Ian T. Adamson, Introduction to Field Theory, Cambridge University Press, 1982.
7. I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd., New Delhi, 1975.

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH507B	Field Theory	CO1	3	2	-	-	-	2	-	2	3	2	-
		CO2	3	2	-	-	-	2	-	2	2	2	-
		CO3	3	2	-	-	-	2	-	2	2	2	-
		C04	3	2	1	1		2	-	2	2	2	2

Course Title/Code	DIFFERENTIABLE MANIFOLDS (MAH608B)	
Course Type	Elective (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	To familiarize students with tangent vectors, cotangent vectors, immersion, submersions, connections, geodesicness in differential Manifolds	
Course Outcomes (COs)		**Mapping**
CO1	Able to use concepts of tangent vectors and normal vectors to investigate intrinsic and extrinsic properties of differential manifolds	**Skill Development**
CO2	Able to apply properties Lie bracket , Jacobian , transformation to establish results on differentiable manifolds.	**Skill Development**
CO3	Able to apply the concepts of immersion and submersion to study geometry of differential manifolds	**Entrepreneurship**
CO4	Apply the concepts covariant derivative , curvature, connectedness to geometry of differential manifolds	**Skill Development**
Prerequisites (if any)	Differential Geometry(MAH510B)	

SECTION A

Differentiable manifolds, Definition and examples, Smooth maps between two smooth manifolds, Tangent vector and tangent space at a point on a manifold, Tangent bundle of manifold.

SECTION B

Vector fields, Lie bracket, Jacobian of a smooth map, One parameter group of transformation, Integral curves on manifolds, Involutive distribution, Lie derivative

SECTION C

Cotangent space, Differential forms, Pullback of 1-form, Tensor fields, Exterior derivatives, Immersions, Submersions and submanifolds examples.

SECTION D

Connections, Geodesics, Covariant differentiations, Torsion, curvature, Structure equations of Cartan, Bianchi identities, Riemannian metric,

Riemannian manifold, Riemannian connection, Riemannian curvature, Sectional curvature, Ricci curvature and Scalar curvature.

TEXTBOOKS

1. B.O. Neill, Elementary Differential Geometry, Academic Publishers, 2006.
2. U.C. De and A. Shaikh, Differentiable Manifolds, Narosa Publications, 2007.
3. S. Kumaresan, A Course in Differential Geometry and Lie Groups, Hindustan Book Agency, 200

REFERENCE BOOKS

1. Boothby, An Introduction to Differentiable Manifolds and Riemannian Geometry, Academic Press, 2002.
2. Gerardo F. Torres del Castillo, Differentiable Manifolds, Birkhauser, 2012.
3. M. P. DoCarmo, Riemannian Geometry, Brikhauser, 2013.

e-Resources (websites/Wikipedia pages/webtutorials/online courses, etc.)

1. **https://nptel.ac.in/courses/111108134**

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH608B	DIFFERENTIABLE MANIFOLDS	CO1	1		2						2	2	
		CO2	1		2						1	1	
		CO3	1		2						2	2	
		CO4	1		2						2	2	

Course Title/Code	DESIGN OF EXPERIMENTS **(**MAH606B**)**	
Course Type	Core (Departmental)	
L-P-O Structure	4-0	
Credits	4	
Course Objective	To equip students with the tool of designing experiments in a valid, efficient and economical way.	
Course Outcomes (COs)		**Mapping**
CO1	understand the issues and principles of Design of Experiments (DOE)	**Skill Development**
CO2	understand experimentation is a process	**Skill Development**
CO3	list the guidelines for designing experiments	**Skill Development**
CO4	construct BIBD	**Skill Development**
Prerequisites (if any)	**N.A**	

SECTION – A

Review of linear estimation and basic designs: ANOVA: Fixed effect models (2-way classification with unequal and proportional number of observations per cell), Random and Mixed effect models (2-way classification with m (>1) observations per cell).

SECTION – B

Incomplete Block Designs: Incomplete Block Designs, Concepts of Connectedness, Orthogonality and Balance. Intrablock analysis of General Incomplete Block design. B.I.B designs with and without recovery of interblock information. Elimination of heterogeneity in two directions.

SECTION – C

Factorial Experiments: Symmetrical factorial experiments (sm, where s is a prime or a prime power), Confounding in sm factorial experiments, sk-p fractional factorial where s is a prime or a prime power. Split-plot experiments.

SECTION – D

Construction of B.I.B.D: Finite fields, Finite Geometries- Projective geometry and Euclidean geometry. Construction of complete set of mutually

orthogonal latin squares.
Construction of B.I.B.D. using finite Abelian groups, MOLS, finite geometry and method of differences.

TEXTBOOKS

1. Chakrabarti, M.C. (1962). Mathematics of Design and Analysis of Experiments, Asia Publishing House, Bombay.
2. Das, M.N. and Giri, N.C. (1986). Design and Analysis of Experiments, Wiley Eastern Limited.
3. Dean, A. and Voss, D. (1999). Design and Analysis of Experiments, Springer. First Indian Reprint 2006. 4. Dey, A. (1986). Theory of Block Designs, John Wiley & Sons.

REFERENCE BOOKS

1. Hinkelmann, K. and Kempthorne, O. (2005). Design and Analysis of Experiments, Vol. 2: Advanced Experimental Design, John Wiley & Sons.
2. John, P.W.M. (1971). Statistical Design and Analysis of Experiments, Macmillan Co., New York.
3. Kshirsagar, A.M. (1983). A Course in Linear Models, Marcel Dekker, Inc., N.Y.
4. Montgomery, D.C. (2005). Design and Analysis of Experiments, Sixth Edition, John Wiley & Sons.

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH606B	DESIGN OF EXPERIMENTS	CO1	1	2	-	-	-	-	3	2	-	-	-
		CO2	1	2	-	-	-	-	3	2	-	-	-
		CO3	1	2	-	-	-	-	3	2	-	-	-
		CO4	1	2	-	-	-	-	3	2	-	-	-

Course Title/Code	ADVANCED NUMERICAL ANALYSIS(MAH623B)	
Course Type	Core (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	This course considers the high-end numerical methods, which are often required to get the numerical results from research studies in applied sciences and engineering.	
Course Outcomes (COs)		**Mapping**
CO1	To Learn about errors which arise during computation due to roundoff or truncation or number representation and the high-end numerical methods for solving transcendental and polynomial equations.	**Skill Development**
CO2	Attain the skills of solving system of linear equations using direct and iterative schemes and analysis of such schemes. Know to apply finite difference schemes/operators for numerical differentiation.	**Skill Development**
CO3	Learn advanced numerical methods to evaluate integrals for solving linear/non-linear first/second order IVP/BVP involving ODEs.	**Skill Development**
CO4	Understand the finite difference methods for solving parabolic, elliptic and hyperbolic PDEs and attain capability to use such methods in scientific problem solving.	**Skill Development**
Prerequisites (if any)	N.A	

SECTION A

Error Analysis: Errors, Absolute, relative and percentage errors; Significant digits and numerical instability, Propagation of errors in arithmetic operations, Significant errors, Representation of numbers in computer, Normalized floating point representation and its effects.

Solution of Polynomial and Transcendental Equations: Iteration methods; First order, second order and higher order methods, Acceleration of the

convergence, Efficiency of a method, Newton-Raphson method for multiple roots, Modified Newton-Raphson method, Muller method and Chebyshev method, Birge-Vieta method, Bairstow method, Graeffe's root squaring method, Solutions of systems of non-linear equations.

SECTION B

Systems of Linear Equations: Matrix inverse methods, Triangularization method, Cholesky Method, Matrix partition method, Operation count, Ill-conditioned linear systems, Moore-Penrose inverse method, Least square solutions for inconsistent systems. Iteration methods Successive over relaxation (SOR) method, Convergence analysis. Eigen values and eigen vectors, bounds on eigen values, Given's method, Rutishauser method, Householder's method for symmetric matrices, Power method.

Numerical Differentiation based on difference formulae, Richardson's extrapolation method, Cubic spline method, Method of undetermined coefficients.

SECTION C

Numerical Integration: Weddle's rule, Newton-Cotes method, Gauss-Legendre, Gauss-Chebyshev, Gauss-Laguerre, and Gauss-Hermite integration methods. Composite integration method, Euler-Maclaurin's formula, Romberg Integration, Double integration.

Numerical Solution of Ordinary Differential Equations: Estimation of local truncation error of Euler and single step methods. Bounds of local truncation error and convergence analysis of multistep methods, Predictor-Corrector methods; Adams-Bashforth methods, Adams-Moulton formula, Milne-Simpson method, System of Differential Equations. Finite difference method for solving second order IVPs and BVPs, Shooting method for boundary value problems.

SECTION D

Solving Partial Differential Equations: Finite difference approximations to partial derivatives, solving parabolic equations using implicit and explicit formulae, C-N scheme and ADI methods; solving elliptic equations using Gauss-elimination, Gauss-Seidel method, SOR method, and ADI method , solving hyperbolic equations using method of characteristics, explicit and implicit methods, Lax-Wendroff's method.

TEXTBOOKS

1. Gupta, R. S., Elements of Numerical Analysis, Cambridge Univ. Press, 2015.
2. Jain, M. K., Iyengar, S.R.K. and Jain, R.K., Numerical Methods for Scientific and Engineering Computation, 6th Edition, New Age International Publishers, 2012.
3. Pal, M., Numerical Analysis for Scientists and Engineers, Narosa Publishing House Pvt. Ltd., 2008.

REFERENCE BOOKS

4. Gourdin, A. and Boumahrat, M., Applied Numerical Methods, PHI Learning Private Ltd., 2004.

e-Resources (websites/Wikipedia pages/webtutorials/online courses, etc.)

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO11
MAH623B	Advanced Numerical Analysis	CO1	3	--	3	-	-	1	2	1	3	3	1
		CO2	3	-	3	-	-	1	2	1	3	3	1
		CO3	3	-	3	-	-	1	2	1	3	3	1
		CO4	3	-	3	-	-	1	2	1	3	3	1

Course Title/Code	ADVANCED OPERATIONS RESEARCH**(**MAH614B**)**	
Course Type	Elective (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	To apply and familiarize students with the concepts of advanced operations research with its theoretical aspects and its applications in the real world.	
Course Outcomes (COs)		**Mapping**
CO1	Understanding of advance operations research techniques , methodologies and tools.	**Skill Development**
CO2	Analyze and solve of the fundamental concepts and techniques used in Network Analysis.	**Skill Development**
CO3	Develop mathematical skills to analyze and solve OR models like Queueing, Replacement, etc and apply them for optimization.	**Skill Development**
CO4	Conduct and interpret post-optimal and sensitivity analysis and explain the primal -dual relationship.	**Skill Development**
Prerequisites (if any)	Operations Research (MAH604B)	

SECTION A

Project management- PERT & CPM: Significance, Phases of project management, PERT /CPM Network components and precedence relationship, Critical path analysis, Forward and backward pass methods, Slack of an activity and event, Project scheduling with uncertain activity times, Estimation of project completion time, Project time–cost trade off, Updating of the project progress. Types of floats and applications.

SECTION B

Replacement: Introduction, Replacement of items that deteriorate with time – when money value is not counted and counted–Replacement of items that fail completely, Group replacement, Staffing problem, Equipment renewal problem.
Dynamic Programming: Bellman's principle of optimality, Allocation Problem, Cargo loading problem, Employment smoothening problem. Cargo loading problem, Reliability, Nonlinear Programming

SECTION C

Queuing Theory: Introduction, Single Channel, Poisson arrivals, Exponential service times – with infinite population and finite population models, Multichannel, Poisson arrivals, exponential service times with infinite population single channel Poisson arrivals.

SECTION D

Sensivity Analysis: Post Optimal Analysis: In cost and requirement vector, optimality conditions. Karush-Kuhn-Tucker optimality conditions.
Quadratic Programming: Wolfe's method, Complementary pivot algorithm, Duality in quadratic programming, Separable Programming, Applications.

TEXTBOOKS

1. H. A. Taha, Operations Research an introduction, Pearson India
2. J. K. Sharma, Operations Research theory & applications, 5th edition, Macmillian India Ltd-new Delhi.

REFERENCE BOOKS

1. P.K. Gupta &D. S. Hira, Operations Research, S. Chand.

e-Resources (websites/Wikipedia pages/webtutorials/online courses, etc.)

1. **https://nptel.ac.in/courses/111107128**

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH614B		CO1	3	3	3	3	2	2	2	2	2	2	2
		CO2	3	3	3	3	2	2	2	2	2	2	2

	ADVANCED OPERATIONS RESEARCH	**CO3**	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**2**
		CO4	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**2**

Course Title/Code	FUZZY SETS AND APPLICATIONS (MAH625B)	
Course Type	Elective (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective		
Course Outcomes (COs)		**Mapping**
CO1	Understand the concept of fuzziness involved in various systems and fuzzy set theory	**Skill Development**
CO2	Apply the concepts of fuzzy relation to solve related problem	**Skill Development**
CO3	Use the concepts of fuzzy measure to understand physical problem related to different classes of fuzzy measures	**Skill Development**
CO4	Analyze the application of fuzzy logic control to real time systems.	**Skill Development**
Prerequisites (if any)	N.A	

SECTION A

Crisp sets and Fuzzy sets - Introduction, crisp sets an overview, the notion of fuzzy sets basic concepts of fuzzy sets, membership functions, methods of generating membership functions, defuzzification methods- operations on fuzzy sets- fuzzy complement, fuzzy union, fuzzy intersection, combinations of operations, general aggregation operations.

SECTION B

Fuzzy arithmetic and Fuzzy relations: Fuzzy numbers- arithmetic operations on intervals- arithmetic operations on fuzzy numbers- fuzzy equations, Fuzzy relations: binary relations, binary relations on a single set, equivalence and similarity relations, compatibility or tolerance relations.

SECTION C

Fuzzy Logic and Fuzzy control systems Introduction – An overview of fuzzy logic, approximate reasoning- other forms of implication operations - other forms of the composition operations, Fuzzy control structure - Modelling and control parameters – If….and….then rules – Rule evaluation – Conflict resolution – Defuzzification – Fuzzy controller with matrix Representation – Exercises.

SECTION D

Applications Fuzzy Control in Washing Machine – Fuzzy Decision making in forecasting – Fuzzy decision Making in industrial problems – Fuzzy control in traffic control – Fuzzy relational equation in medicine.

Text Books

1. First Course on Fuzzy Theory and Applications, Kwang H. Lee, Springer, 2005.
2. Fuzzy Set Theory and Its Applications, Fourth Edition, H.-J. Zimmermann, 2001.

Reference Books

1. George J. Klir and Tina A. Folger, Fuzzy Sets, Uncertainty and Information, Prentice-Hall of India 1993.
2. Witold Pedrycz & Fernando Gomide, An introduction to Fuzzy Set, Prentice-Hall of India, New Delhi.2005.
3. James J. Buckely, Esfandiar Eslami, An introduction to Fuzzy Logic and Fuzzy Sets, Springer 2002.
4. Abraham Kandel and Gideon Langholz, Fuzzy Control Systems, CRC Press, USA 1994.

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH625B	FUZZY SETS AND APPLICATIONS	CO1	3	-	1	2	-	-	-		-	1	-
		CO2	3	-	2	2	-	-	-		-	1	-
		CO3	3	3	3	2	-	-	2		1	2	-
		CO4	3	3	3	3	1	-	2		2	2	-

Course Title/Code	GRAPH THEORY **(**MAH605B)	
Course Type	Elective (Departmental)	
L-P-O Structure	4-0	
Credits	4	
Course Objective	To familiarize students with the main concepts of graph theory, graph representations and the basic classes of graphs.	
Course Outcomes (COs)		**Mapping**
CO1	Apply the concepts of path, walk , circuit to study different types of graph	**Skill Development**
CO2	Apply concepts of tree to find the problem related to distance, spanning tree or minimal spanning tree	**Skill Development**
CO3	Apply the concepts of shortest distance in graph to find the solution of problem of travelling saleman	**Skill Development**
CO4	Understand the concept of coloring and planar graph	**Skill Development**
Prerequisites (if any)	**N.A**	

SECTION A

Graphs: Basic concepts in graph theory, walks, paths and circuits in a graph, connected graphs and components, degrees, operations on graphs, special graphs, isomorphic graphs, blocks, cut-points, bridges and blocks, block graph sand cut-point graphs.

SECTION B

Trees: Elementary properties of trees, minimally connected graph, distance, centers and centroids in a tree, radius and diameter, spanning trees, rank and nullity, block-cut point trees, independent cycles and co-cycles.

SECTION C

Connectivity and Traversability: Connectivity and line connectivity, Menger's theorems, Eulerian graph, Hamiltonian graphs, travelling salesman

problem, shortest path.

SECTION D

Planarity and Coloring: Planar graphs, outer planar graphs, Euler's formula, Kuratowski's theorem, dual graphs, self dua graphs, chromatic number, five color theorem, chromatic polynomial.

TEXTBOOKS

1. R. Balakrishnan and K. Ranganathan, A Text Book of Graph Theory, Springer, 2000.
2. B. Bollobas, Modem Graph Theory, Springer,2002.

REFERENCE BOOKS

1. G. Chartrand and L. Lesniak, GraphsandDigraphs,4th Edit., Chapman &Hall (CRC),2005.
2. F. Iarary, GraphTheory, Narosa Publishing House, NewDelhi,200l.

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH605B	GRAPH THEORY	CO1	2	1	-	-	-	-	1	-	2	-	-
		CO2	2	1	-	-	-	-	2	-	2	-	-
		CO3	2	1	-	-	-	-	2	-	2	-	-
		CO4	2	1	-	-	-	-	2	-	2	-	-

Course Title/Code	WAVELETS **(**MAH609B**)**	
Course Type	Elective (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	The student would be able to apply the concepts of theory of wavelets for solving problems in mathematics and image & signal processing.	
Course Outcomes (COs)		**Mapping**
CO1	understand STFT, windowed Fourier transform, FT, IFT and difference between windowed Fourier transform and wavelet transforms.	**Skill Development**
CO2	analyse and apply wavelet basis and characterize continuous and discrete wavelet transforms.	**Skill Development**
CO3	construct wavelets by multiresolution analysis and identify various wavelets and evaluate their time-frequency resolution properties.	**Skill Development**
CO4	Characterize Wavelets, MRA wavelets, Scaling function Low-pass filter & High Pass filter, MSF wavelets.	**Skill Development**
Prerequisites (if any)	Measure Theory (MAH504B) and Functional Analysis(MAH509B)	

SECTION A

Fourier Transform in $L^1(R)$, $L^2(R)$ **and Discrete Fourier Transform:** Stationary and non-stationary signals, Signal representation using basis and frames, Brief introduction to Fourier transform in $L^1(R)$ and $L^2(R)$, Inverse Fourier Transform on R, Properties of Fourier transform, parseval's relation, plancherel formula, convolution, Discrete Fourier Transform in $l^2(Z_N)$ and its properties, Fast Fourier transform, sampling theorem, Uncertainty Principle.

SECTION B

Time Frequency Analysis and Wavelet Transforms: Localization/Isolation in time and frequency Time-frequency analysis, Short Time Fourier Transform (STFT) and windowed Fourier Transform, Wavelets, Wavelet transform-A first level introduction, Continuous Wavelet Transform, Properties of wavelets used in continuous wavelet transform, Continuous versus discrete wavelet transform, Discrete Wavelet Transform

SECTION C

Wavelets & MRA:
Wavelets on R: $L^1(R)$&$L^2(R)$, Orthonormal Wavelets, Characterization of Orthonormal Wavelets, Some standard Wavelets (Haar Wavelets, Shannon Wavelets, Journe's Wavelets, Meyer Wavelets, Daubechies' family of wavelets in detail), Multiresolution Analysis, Father Wavelets & Mother Wavelets, Construction of Wavelets through MRA, Scaling function.

SECTION D

Characterization of Wavelets: Characterization of Scaling function, Low-pass filter & High Pass filter, Characterizations of Low & High pass filter, Band limited Wavelets, Compactly Supported Wavelets, Minimally- Supported Frequency (MSF) Wavelets, Wavelet Sets, Characterization of MSF wavelets & Wavelet Sets, Dimension Functions, Characterization of MRA Wavelets.

TEXTBOOKS

1. Michael W. Frazier, An Introduction to Wavelets through Linear Algebra, Springer
2. Hernandez & Weiss, A First Course of Wavelets, CRC Press
3. Charles K. Chui, An Introduction to Wavelets.

REFERENCE BOOKS

1. George Bachman, Lawrence Narici, Edward Beckenstein, Fourier and Wavelet Analysis, springer.
2. C. S. Burrus, Ramose and A. Gopinath, Introduction to Wavelets and Wavelet Transform, Prentice Hall Inc.

e-Resources (websites/Wikipedia pages/webtutorials/online courses, etc.)

1. http://users.rowan.edu/~polikar/WAVELETS/WTtutorial.html
2. http://www.wavelet.org/
3. http://www.math.hawaii.edu/~dave/Web/Amara's%20Wavelet%20Page.htm

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH609B	WAVELETS	CO1	3	3	3	3	2	2	2	2	2	2	2
		CO2	3	3		3	2	2	2	2	3	3	3
		CO3	3	3	3	3	-	2	2	2	3	3	3
		CO4	3	3	3	3	-	2	2	2	3	3	3

Course Title/Code	TOPOLOGY-II **(**MAH610B**)**	
Course Type	**Elective (Departmental)**	
L-P Structure	**4-0**	
Credits	**4**	
Course Objective	To familiarize students with concepts of topological spaces, separation Axioms, nets and filters	
Course Outcomes (COs)		**Mapping**
CO1	Understand the product of two topological spaces and their properties	**Skill Development**
CO2	Apply the concepts nets and filter to solve related problems	**Skill Development**
CO3	Uses the notion of compactness to solve related problem	**Skill Development**
CO4	Apply the concept of paracompactness to study properties of product manifolds	**Skill Development**
Prerequisites (if any)	Topology-I (MAH502B)	

SECTION A

Tychonoff product topology in term of standard sub-base and its characterizations, Projection maps, Separation axioms and product spaces, Connectedness, Compactness, Countability of product spaces.

SECTION B

Nets and filters, Topology and convergence of nets, Housdorffness and nets , Compactness, Nets Filter and their Convergence.

SECTION C

Canonical way of converting nets to filters and vice-versa, ultra filters and compactness. Stone-Cech compactification. Application of Urysohn's Lemma, The Stone–Cech Compactification, The Stone–Weierstrass Theorems.

SECTION D

Homotopy of paths, Fundamental group, Covering spaces, The fundamental group of the circle and fundamental theorem of algebra. Covering of a space, local finiteness, paracompact spaces, Mchaell theorem on characterisation of paracompactness in regular space, Paracompactness as normal,

Nagata-Smirnov Metrization theorem.

TEXTBOOKS

1. James R. Munkres, Topology (2ndEdition) Pearson Education Pvt. Ltd., Delhi-2002
2. J. Dugundji , Topology , Prentice Hall of India, New Delhi, 1975

REFERENCE BOOKS

1. George F.Simmons, Introduction to Topology and Modern Analysis, McGraw Hill Book Co.

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH610B	TOPOLOGY-II	CO1	3	2	-	-	-	1	2	1	3	3	2
		CO2	3	2	-	-	-	1	2	1	3	3	2
		CO3	3	2	3	-	-	1	2	1	3	3	2
		CO4	3	2	3	-	-	1	2	1	3	3	2

Course Title/Code	SCIENTIFIC RESEARCH –II **(**RDO604)	
Course Type	**Core (Departmental)**	
L-P-O Structure	**0-4**	
Credits	**2**	
Course Objective	The students will be able to critically evaluate the work done by various researchers relevant to the research topic and integrate the relevant theory and practices followed in a logical way and draw appropriate conclusions	
Course Outcomes (COs)		**Mapping**
CO1	Able to critically evaluate the work done by various researchers relevant to the research topic.	**Skill Development**
CO2	Integrate the relevant theory and practices followed in a logical way and draw appropriate conclusions.	**Skill Development**
CO3	Understand the research methodologies/approaches/techniques used in the literature.	**Skill Development**
CO4	Structure and organize the collected information or findings through an appropriate abstract, headings, reference citations and smooth transitions between sections.	**Skill Development**
Prerequisites (if any)	SCIENTIFIC RESEARCH -I(RDO503)	

Section-A

Literature Survey (LS)/Design of Experiment

1.1 Collection of research papers related to previously identified gap/problem (15 papers or more)

1.2 Comprehend and arrange the literature based on the idea framed

1.3 Presenting the collected data and inferring it with the further scope of expansion and Designing the experiment wherever applicable.

Section-B

Structuring of Review Paper and setting up of experimental facility

2.1 Analysis of different approach/methodology adopted by various researchers

2.2 Listing out the components of the paper/ setting up experimental facility w.r.t the problem
2.3 Identification of suitable Journal or Conference
2.4 Formatting/Styling the paper according to the respective template

Section-C

Planning of experiments

3.1 Formulate experimental procedures with Modification of the experimental set-up, if required
3.2 Procurement of materials

Execution of experiments/simulations

4.1 Conduct experiments/ build prototype
4.2 Tabulating and recording data
4.3 Analysis and interpretation of the data
4.4 Comparison of the results with other reported experiments
4.5 Interpretation of observations
4.6 Integration of relevant theory, findings in a structured way and draw appropriate conclusions

Section-D

Departmental Presentation

5.1 Structuring and preparation of PPT
5.2 Mock presentation
5.3 Review on presentation skills and content delivered both
5.4 Incorporating the review comments in the slides

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
RDO604	SCIENTIFIC RESEARCH -II	CO1	3	1	2	-	-	-	-	-	3	3	-
		CO2	3	2	2	-	-	-	-	-	3	3	-
		CO3	3	3	2	-	-	-	-	-	3	3	-
		CO4	3	-	2	-	-	-	-	-	3	3	-

Course Title/Code	PROFESSIONAL COMPETENCY PG - II (CDO603)	
Course Type/Sem	Core	
L-P Structure	0-2	
Credits	1	
Course Objective	To familiarize students with the problem solving, develop leadership ability & manage interviews.	
Course Outcomes (COs)		**Mapping**
CO1	Students will be able to demonstrate problem solving and leadership skills required to participate in a stimulated environment.	**Skill Development**
CO2	Students will be able to face real life challenges using critical reasoning skills.	**Skill Development**
CO3	Prepare for placements and manage interviews effectively.	**Skill Development**
CO4	Enhance their ability to write, read, comprehend and communicate effectively to increase the productivity of business.	**Skill Development**
Prerequisites (if any)	**N.A**	

SECTION A

Problem Solving and Critical Thinking: Problem Solving skills: Defining Problem, Generating alternative solutions and root cause analysis, Critical thinking: Determine the importance and relevance of arguments and ideas, Critical thinking process and components, Decision-making and productivity.

SECTION B

Personal Effectiveness & Managing Interviews - I: Accountability, Adaptability for Success, Building Your Self Esteem and Assertiveness Skills, Building Relationships for Success, Self Mastery – A Plan for Personal Success, Boosting Your Confidence, Public Speaking and Performance, How to Set Goals When Everything Feels Like a Priority, Developing the employability mindset, Preparing for Self –Introduction, Researching the employer, Portfolio Management, Types of Interviews & Interview etiquette.

SECTION C

Advanced Vocabulary and Sentence Construction & Syntax: Synonyms, Antonyms, One Word Substitution, Ordering of Words, Sentence

Improvement, Spotting Errors, Ordering of Sentences, Change of Voice/ Direct & Indirect speech, Completing Statements/Sentences.

SECTION D

Reading Comprehension & Reasoning-II: Strategic Reading, Eliminating Poor Reading Habits, Techniques to increase speed reading, comprehension and recall, Solving Sample RC Passages, Para Jumbles

TEXTBOOKS

1. The 7 Habits of Highly Effective People: Stephen R. Covey
2. Personal Effectiveness: Alexander Murdock, Carol N. Scutt, 3rd Edition

REFERENCE BOOKS

1. Verbal Ability and Reasoning for Competitive Examinations: P.A. Anand, Wiley
2. Great Work, Great Career: How to Create your ultimate job and make extraordinary contribution by Stephen R. Covey, Jennifer Colosimo

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO11
CDO603	Professional Competency PG-II	CO1		2	--	1	1	2	3	--	1	1	1
		CO2	--	2	--	2	1	1	--	--	--	1	1
		CO3	--	--	--	--	--	--	--	3	--	1	1
		CO4	--	-	--	-	--	--	1	3	1	2	1

MAP01- Semester-IV

SUBJECT CODES	SUBJECT NAME	**OFFERING DEPARTMENT	*COURSE NATURE (Hard/Soft/ Workshop/ NTCC)	COURSE TYPE (Core/Elective / University Compulsory)	L	P	NO. OF CONTACT HOURS PER WEEK	NO. OF CREDITS
MAH621B	DYNAMICS OF RIGID BODY							
MAH612B	COMPUTATIONAL FLUID DYNAMICS							
MAH613B	GENERALIZED FUZZY SET THEORY							
MAH624B	ADVANCED DISCRETE MATHEMATICS							
MAH618B	LIGHTLIKE MANIFOLDS							
MAH616B	STOCHASTIC PROCESSES	MA	HARD	ELECTIVE (ANY ONE)	4	0	4	4
MAH617B	HARMONIC ANALYSIS							
MAH615B	CODING THEORY							
MAH619B	WAVELETS & IT's APPLICATIONS							
MAH620B	ALGEBRAIC TOPOLOGY	MA	HARD	ELECTIVE (ANY ONE)	4	0	4	4
MAN626B	PROJECT	MA	NTCC	CORE	0	16	2	8
	TOTAL (L-P-O/CONTACT HOURS/CREDITS)				**8**	**16**	**10**	**16**
							GRAND TOTAL OF CREDITS	**84**

DETAILED SYLLABUS
MAP01 – SEMESTER-IV

Course Title/Code	DYNAMICS OF RIGID BODY(MAH621B)	
Course Type	Elective (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	The course aims to develop an understanding of Lagrangian and Hamiltonian which allow simplified treatments of many problems in classical mechanics. The course aims to provide the foundation for the modern understating of dynamics.	
Course Outcomes (COs)		**Mapping**
CO1	To demonstrate that they can apply the concept of system of particle in finding moment of inertia, D' Alembert's Principle and consequently know the inertia constants for a rigid body and the equation of momental ellipsoid together with the idea of principal axes and principal moments of inertia.	**Skill Development**
CO2	To apply the concept of the dynamics involving a single particle like projectile motion, Simple harmonic motion, pendulum motion and related problems so that they can use these methods to solve real world problems.	**Skill Development**
CO3	To demonstrate an ability to apply the concepts of motion of rigid body in two & three dimensions, system of Euler's dynamical equations for studying rigid body motions for solving real world problems.	**Skill Development**
CO4	To analyze the derivation of Lagrange's Equations . Extension of Hamilton's principle to non-holonomic systems. Distinguish the concept of the Hamilton Equations of motion and the Principle of Least Action.	**Skill Development**
Prerequisites (if any)	**N.A**	

SECTION A

Moments and products of inertia, The momental ellipsoid, Equimomental systems Principal axes, D'Alembert's principle, The general equation of motion of a rigid body, Motion of Centre of inertia and motion relative to the centre of inertia.

SECTION B

Motion about the fixed axis, The compound pendulum, Centre of Percussion, Motion of rigid body in two dimensions under finite and impulsive forces.

SECTION C

Conservation of Momentum and Energy for finite as well as impulsive forces, Initial motions, Motion in three dimensions with reference to Euler's dynamics and geometrical equations .

SECTION D

Lagrange's equation, of motion, Energy equation for conservative field, Small oscillations, Hamiltons's principle, Hamilton's equation of motion, Variational principle of least action.

TEXTBOOKS

1. P. P. Gupta & G.S. Malik, Rigid Dynamics, Krishna's Publishers

REFERENCE BOOKS

1. S.L. Loney, An elementary Treatise on the dynamics of particle and rigid bodies, Cambridge University Press.
2. D. Greenwood, Classical Dynamics, Prentice Hall of India, New Delhi, 1985.
3. H. Goldstein, Classical Mechanics, (2ndEdition) Narosa Publishing House, New Delhi.

e-Resources

1. https://nptel.ac.in/courses/112101096

CO-PO Mapping

Course Code	Course Name	Course Uotcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
		CO1	3	3	2	3	-	-	2	1	3	-	3

MAH621B	DYNAMICS OF RIGID BODY	**CO2**	**3**	**3**	**2**	**3**	**-**	**-**	**2**	**1**	**3**	**-**	**3**
		CO3	**3**	**3**	**2**	**3**	**-**	**-**	**2**	**1**	**3**	**-**	**3**
		CO4	**3**	**3**	**2**	**3**	**-**	**-**	**2**	**1**	**3**	**-**	**3**

Course Title/Code	COMPUTATIONAL FLUID DYNAMICS(MAH612B)	
Course Type	**Elective (Departmental)**	
L-P Structure	**4-0**	
Credits	**4**	
Course Objective	To familiarize students with basic concepts of computational fluid dynamics.	
Course Outcomes (COs)		**Mapping**
CO1	Demonstrate an ability to recognize the type of fluid flow that is occurring in a particular physical system and to use the appropriate model equations to investigate the flow.	**Skill Development**
CO2	Demonstrate the ability to simplify a real fluid-flow system into a simplified model problem, to select the proper governing equations for the physics involved in the system, to solve for the flow, to investigate the fluid-flow behavior, and to understand the results.	**Skill Development**
CO3	Demonstrate the ability to analyze a flow field to determine various quantities of interest, such as flow rates, heat fluxes, pressure drops, losses, etc., using flow visualization and analysis tools.	**Skill Development**
Prerequisites (if any)	**N.A**	

SECTION A

Governing Equations and Boundary Conditions: Basics of computational fluid dynamics – Governing equations of fluid dynamics – Continuity, Momentum and Energy equations – Chemical species transport – Physical boundary conditions – Time-averaged equations for Turbulent Flow – Turbulent–Kinetic Energy Equations – Mathematical behaviour of PDEs on CFD – Elliptic, Parabolic and Hyperbolic equations.

SECTION B

Finite Difference and Finite Volume Methods for Diffusion: Derivation of finite difference equations – Simple Methods – General Methods for first and second order accuracy – Finite volume formulation for steady state One, Two and Three - dimensional diffusion problems –Parabolic equations – Explicit and Implicit schemes – Example problems on elliptic and parabolic equations – Use of Finite Difference and Finite Volume methods.

SECTION C

Finite Volume Method for Convection Diffusion: Steady one-dimensional convection and diffusion – Central, upwind differencing schemes properties of discretization schemes – Conservativeness, Boundedness, Tran sportiveness, Hybrid, Power-law, QUICK Schemes.

SECTION D

Flow Field Analysis: Finite volume methods -Representation of the pressure gradient term and continuity equation – Staggered grid – Momentum equations – Pressure and Velocity corrections – Pressure Correction equation, SIMPLE algorithm and its variants – PISO Algorithms.
Turbulence Models and Mesh Generation: Turbulence models, mixing length model, Two equation (k-Є) models – High and low Reynolds number models – Structured Grid generation – Unstructured Grid generation – Mesh refinement – Adaptive mesh – Software tools.

TEXTBOOKS

1. Versteeg, H.K., and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The finite volume Method", Pearson Education Ltd.Second Edition, 2007.
2. Ghoshdastidar, P.S., "Computer Simulation of flow and heat transfer", Tata McGraw Hill Publishing Company Ltd., 1998.
3. Patankar, S.V. "Numerical Heat Transfer and Fluid Flow", Hemisphere Publishing Corporation, 2004.

REFERENCE BOOKS

1 Chung, T.J. "Computational Fluid Dynamics", Cambridge University, Press, 2002.
1. Ghoshdastidar P.S., "Heat Transfer", Oxford University Press, 2005
2. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer",Narosa Publishing House, New Delhi, 1995.
3. Prodip Niyogi, Chakrabarty, S.K., Laha, M.K. "Introduction to Computational Fluid Dynamics", Pearson Education, 2005.
4. Anil W. Date "Introduction to Computational Fluid Dynamics" Cambridge University Press, 2005.

1.

e-Resources

1. **https://nptel.ac.in/courses/112105045**

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH612B	COMPUTATIONAL FLUID DYNAMICS	CO1	3	3	3	3			2	2	1	1	1
		CO2	3	3	3	3		3	2	2	1	1	1
		CO3	3	3	3	3			2	2	1	1	1

Course Title/Code	GENERALISED FUZZY SET THEORY (MAH613B)	
Course Type	Elective (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	The students would be able to understand the concepts of Generalized set structures such as Fuzzy sets, Multisets, Rough sets,Soft sets, Rough multisets, Genuine sets Information systems	
Course Outcomes (COs)		***Mapping***
CO1	Explain the concept of advanced level of Generalized fuzzy set.	**Skill Development**
CO2	Relate the concepts of soft sets, rough multisets.	**Skill Development**
CO3	Apply structures such as Multisets, Rough sets.	**Skill Development**
CO4	Solve and analyze real world problems using advanced level fuzzy techniques.	**Skill Development**
Prerequisites (if any)	**Fuzzy Sets & Fuzzy Logic(MAH603B)**	

SECTION A

An overview of basic operations on Fuzzy sets and Multisets, Multiset relations, Compositions, equivalence multiset relations and partitions of multisets, Multiset functions, Fuzzy Multisets.

SECTION B

Rough sets, Approximations of a set, Properties of Approximations, Rough membership function, Rough sets and Reasoning from data: Information systems, Decision tables, Dependency of attributes, Reduction of attributes, Indiscernibility matrices and functions.

SECTION C

Soft sets, Tabular representation of a soft set, Operations with Soft sets: soft subset, complement of a soft set, null and absolute soft sets, AND and OR operations, Union and intersection of soft sets, De-Morgan laws, Applications and soft analysis.

SECTION -D

Fuzzy soft sets, Operations on fuzzy soft sets, Soft fuzzy sets and its properties, Fuzzy rough sets and rough fuzzy sets, Rough multisets, Genuine sets, Applications.

Recommended Books:

5. Bing-Yuan Cao, Fuzzy Information and Engineering, Springer, 2007.
6. K. P. Girish & J. J.Sunil, Relations and Functions in Multiset context, Information Sciences' 179 (2009) 758 - 768.
7. J. F. Peters & A. Skowron, Transactions on Rough Sets I, Springer, 2004.
8. L. Polkowski, Rough Sets: Mathematical Foundations, Springer, 2002.
9. M. Demirci, Genuine Sets, Fuzzy Sets and Systems, 105 (1999) 377-384.
10. H.J. Zimmerman, Fuzzy set Theory and its Applications, Allied Publishers Ltd., 2000.

TEXTBOOKS

1.H.J. Zimmerman, Fuzzy set Theory and its Applications, Allied Publishers Ltd., 2000.

REFERENCE BOOKS

1. Bing-Yuan Cao, Fuzzy Information and Engineering, Springer, 2007.
2. K. P. Girish & J. J.Sunil, Relations and Functions in Multiset context, Information Sciences' 179 (2009) 758 - 768.
3. J. F. Peters & A. Skowron, Transactions on Rough Sets I, Springer, 2004.
4. L. Polkowski, Rough Sets: Mathematical Foundations, Springer, 2002.
5. M. Demirci, Genuine Sets, Fuzzy Sets and Systems, 105 (1999) 377-384.

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH613B	GENERALISED FUZZY SET THEORY	CO1	3	-	1	2	-	-	-		-	1	-
		CO2	3	-	2	2	-	-	-		-	1	-
		CO3	3	3	3	2	-	-	2		1	2	-
		CO4	3	3	3	3	1	-	2		2	2	-

Course Title/Code	ADVANCED DISCRETE MATHEMATICS (MAH624B)	
Course Type	ELECTIVE (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	To acquire basic understanding Mathematical Logic: Propositional logic, logic gates minimizations of circuits by using Boolean identities and K-map, logical arguments using grammar, the automata theory and finite set of machines, Eulerian paths and circuits in undirected graphs, Euler's formula for planar graphs, minimal spanning tree for the undirected graphs.	
Course Outcomes (COs)		**Mapping**
CO1	Conceptual understanding of Mathematical Logic: Propositional logic.	**Skill Development**
CO2	Analyse the minimizations of circuits by using Boolean identities and K-map.	**Skill Development**
CO3	Construct and express logical arguments using grammar and to work in abstract or general term to increase the clarity and efficiency of analysis.	**Skill Development**
CO4	Introduce the automata theory and finite set of machine to determine the decidability and intractability of computational problem	**Skill Development**
CO5	Discuss Euler and Hamilton paths and circuits and Evaluate minimal spanning tree for the undirected graphs.	**Skill Development**
Prerequisites (if any)	**Basic concept of Statistics**	

SECTION-A

Mathematical Logic: Propositional logic, Propositional equivalences, Predicates and Quantifiers, Rule of inference, direct proofs, proof by contraposition, proof by contradiction. Boolean Algebra: Boolean functions and its representation, logic gates, minimizations of circuits by using Boolean identities and K-map.

SECTION-B

Grammar and Languages — Phrase Structure Grammars. Rewriting Rules. Derivations Sentential Forms. Language generated by Grammar. Regular, Context Free, and Context Sensitive Grammar and Languages. Regular sets, Regular Expressions and the Pumping Lemma, Kleene's Theorem. Notions of Syntax Analysis. Polish Notations. Conversion of Infix Expressions to Polish Notations. The Reverse Polish Notation.

SECTION-C

Introductory Computability Theory – Finite state machines and their transition table diagrams. Equivalence of finite state machines. Reduced Machines, Homomorphism. Finite automata. Acceptors. Non-deterministic finite automata and Equivalence of its power to that of Deterministic Finite Automata. Moore and Mealy Machines.

SECTION-D

Graphs: Graphs definitions, graph terminology, types of graphs, representing graphs, graph isomorphism, connectivity of graphs, Euler and Hamilton paths and circuits, Dijkstra's algorithm to and shortest path, planar graphs { Euler's formula and its applications, graph coloring and its applications. Trees: Trees definitions { properties of trees, applications of trees {BST, Haffman Coding, tree traversals : pre-order, in – order, post-order, prefix, infix, postfix notations, spanning trees {DFS, BFS, Prim's, Kruskal's algorithms}

Text Books:

1. Kenneth H.Rosen "Discrete Mathematics and its Applications", fourth edition, Tata McGraw Hill Publishing company.

Reference Books:

1. Discrete and Combinatorial Mathematics by Ralph P.Grimaldi.
2. Discrete Mathematics for Computer Scientists by Stein, Drysdale, Bogart.
3. Discrete Mathematical Structures with Applications to Computer Science by J.P.Tremblay, R.Manohar.
4. Discrete Mathematics for Computer Scientists and Mathematicians by Joe L.Mott, Abraham Kandel, Theoder P. Baker 5.

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO11

MAH624B	**ADVANCED DISCRETE MATHEMATICS**	CO1	1	2	3	2	-	1	2	2	3	3	1
		CO2	1	2	3	2	-	1	2	2	3	3	1
		CO3	1	2	3	2	-	1	2	2	3	3	1
		CO4	1	2	3	2	-	1	2	2	3	3	1
		CO5	1	2	3	2	-	1	2	2	3	3	1

Course Title/Code	LIGHTLIKE MANIFOLDS (MAH618B)	
Course Type	Elective (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	To familiarize students with the concept of indefinite metric, semi-Riemannian manifolds, lightlike manifolds.	
Course Outcomes (COs)		**Mapping**
CO1	Demonstrate the ability to aply the concepts of of metric tensor, isometries, curvature and geodesic of a semi-Riemannian manifolds to prove the theorem and mathematical problem based on these topics	**Skill Development**
CO2	Explain connection, normal connection totally geodesic , hypersurfaces and solve related mathematical problems	**Skill Development**
CO3	Apply the concept of lightlike hypersurfaces to rove results on screen conformal hypersurfaces, induced scalar curvature , Einstein hypersurface	**Skill Development**
CO4	Prove results on half lighlike submanifolds, screen conformal submanifolds	**Skill Development**
Prerequisites (if any)	Differentiable Manifolds (MAH608B)	

SECTION A

Semi- Riemannian manifolds: Metric tensors and isometries, Parallel transport, connections, and derivative operators ·
Curvature: Riemannian, Ricci, sectional, scalar, Geodesics, Cartan's Structure Equations.

SECTION B

Semi-Riemannian Manifolds: Tangent and normals**,** induced connections, geodesic, totally geodesic.
Hypersurfaces: Hyperquadrics, codazzi equations, totally umbilical hypersurfaces, Normal connection, congruence theorem, isometric immersion.

SECTION C

Lightlike Hypersurfaces: Basic general results, Screen conformal hyper surfaces, Unique existence of screen distributions, Induced scalar curvature, Lightlike Einstein hypersurfaces, Semi-symmetric hypersurfaces.

SECTION D

Lightlike Submanifolds: Half lightlike submanifolds- Unique existence of screen distributions, Totally umbilical submanifolds, Screen conformal submanifolds, lightlike Submanifolds of indefinite Kaehler manifolds, lightlike submanifolds of Sasakian manifolds.

TEXTBOOKS

1. K. L. Duggal and A. Bejancu, Lightlike Submanifolds of Semi-Riemannian Manifolds and Applications, vol. 364 of Mathematics and Its Applications, Kluwer Academic Publishers, Dordrecht, The Netherlands, 1996.
2. D. N. Kupeli, Singular Semi-Riemannian Geometry, vol. 366 of Mathematics and Its Applications, Kluwer Academic Publishers, Dordrecht, The Netherlands, 1996.

REFERENCE BOOKS

1. K. L. Duggal and A. Bejancu, Lightlike submanifolds of semi-Riemannian manifolds and applications, vol. 364 of Mathematics and its Applications, Kluwer Academic Publishers Group, Dordrecht, 1996.

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH618B	LIGHTLIKE MANIFOLDS	CO1	3		2	1	-	-	-	-	3	-	3
		CO2	3	-	2	1	-	-	-	-	3	-	3
		CO3	3	-	2	1	-	-	-	-	3	-	3
		CO4	3	-	2	1	-	-	-	-	3	-	3

Course Title/Code	STOCHASTIC PROCESSES (MAH616B)	
Course Type	**Elective (Departmental)**	
L-P Structure	**4-0**	
Credits	**4**	
Course Objective	To familiarize students with mathematical theory of random variables and random processes and applications.	
Course Outcomes (COs)		**Mapping**
CO1	Illustrate and formulate fundamental probability distribution and density functions, as well as functions of random variables	**Skill Development**
CO2	Analyze continuous and discrete-time random processes	**Skill Development**
CO3	Apply the theory of stochastic processes to analyze linear systems	**Skill Development**
CO4	Apply the above knowledge to solve basic problems in filtering, prediction and smoothing	**Skill Development**
Prerequisites (if any)	**N.A**	

SECTION A

Poisson process, Brownian motion process, Thermal noise, Markov-shot noise, Two-valued processes. Model for system reliability.

SECTION B

Mean value function and covariance kernel of the Wiener and Poisson processes. Increment process of a Poisson process, Stationary and evolutionary processes. Compound distributions, Total progeny in branching processes.

SECTION C

Time series as discrete parameter stochastic process. Auto covariance and auto correlation functions and their properties. Detailed study of the stationary processes: Moving average (MA), Auto regressive (AR), ARMA and ARIMA models. Box-Jenkins models. Discussion (without proof) of estimation of mean, auto covariance and auto correlation functions under large sample theory.

SECTION D

Choice of AR and MA periods. Estimation of ARIMA model parameters. Smoothing spectral analysis of weakly stationary process. Periodo gram

and correlogram analysis. Filter and transfer functions. Problems associated with estimation of spectral densities. Forecasting: Exponential and adaptive Smoothing methods.

TEXTBOOKS

1. Bhat, B.R. (2000). Stochastic Models- Analysis and Applications, New Age International Publishers.
2. Judge, G.C., Hill, R,C. Griffiths, W.E., Lutkepohl, H. and Lee, T-C. (1988). Introduction to the Theory and Practice of Econometrics, Second Edition, John Wiley & Sons.
3. Kendall, M.G. and Stuart, A. (1968). The Advanced Theory of Statistics (Vol. III), Second Edition, Charles Griffin.

REFERENCE BOOKS

1. Kmenta, J. (1986). Elements of Econometrics, Second Edition, Mac millan.
2. Medhi, J. (1994). Stochastic Processes, Second Edition, Wiley Eastern, New Delhi
3. Montgomery, D.C. and Johnson, L.A. (1976). Forecasting and Time Series Analysis, Mc Graw Hill, New York .

e-Resources (websites/Wikipedia pages/webtutorials/online courses, etc.)

1. **https://nptel.ac.in/courses/111102014**

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH616 B	STOCHASTIC PROCESSES	**CO1**	**3**	**2**	**1**					**2**		**2**	**1**
		CO2	**3**	**2**	**1**					**2**		**2**	**1**
		CO3	**3**	**2**	**1**					**2**		**2**	**1**
		CO4	**3**	**2**	**1**					**2**		**2**	**1**

Course Title/Code	HARMONIC ANALYSIS (MAH617B)	
Course Type	Elective (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	This module brings together methods learned in algebra, group theory and analysis courses to introduce the students to harmonic analysis. Harmonic analysis extends key ideas of Fourier analysis from Euclidean spaces to general topological groups.	
Course Outcomes (COs)		**Mapping**
CO1	Explain the concept of Haar measure and identify Haar measures for the group of the integers, the reals under addition and multiplication, the torus, and the ax+b group.	**Skill Development**
CO2	Use the Gelfand-Naimark it to identify the C* algebra of the groups R_nand Z_n.	**Skill Development**
CO3	Explain the concept of Pontryagin duality and the connection with the Fourier series and Fourier transform.	**Skill Development**
CO4	Use the Pontryagin duality to identify duals of examples of locally compact abelian groups	**Skill Development**
Prerequisites (if any)	Functional Analysis (MAH509B), Fourier Analysis(MAH607B)	

SECTION A

Groups and Homogenous spaces, linear Lie groups, Computation of Haar measures on some known examples, Convolution Various function spaces.

SECTION B

Harmonic Analysis over Torus and Euclidean spaces. Generalities about locally compact abelian groups, which includes Fourier Inversion Formula, Bochner’s theorem.

SECTION C

Basic Representation Theory, Induced representations, Positive Definite functions, Schur's lemma, Naimark Theorem. Peter-Weyl Theory of compact groups- Examples: Unitary groups, Orthogonal groups.

SECTION D

Abstract Theory of Gelfand Paris, Spherical Fourier Transforms, Plancherel-Godement Theorem, Inverse Sperical Fourier Transforms, Compact Gelfand Pair. Representation Theory of Heisenberg group, Gelfand pair consisting of Heisenberg group and Unitary group. Associated Plancherel-Godment Theorem, Special functions.

TEXTBOOKS

1. J. Faraut. Analysis on Lie Groups: An Introduction. Cambridge Studies in Advanced Mathematics. Cambridge University Press, 2008.
2. G. Folland, A course in abstarct harmonic analysis, CRC Press, 1994.
3. Y. Katznelson: Introduction to Harmonic Analysis J. Wiley and Sons, 1968

REFERENCE BOOKS

1. Fourier Analysis by Javier Duoandicoetxea. AMS Graduate Studies in Mathematics Volume 29, 2001
2. Classical and Modern Fourier Analysis by Loukas Grafakos. Prentice Hall 2003
3. Harmonic Analysis. Real-variable methods, orthogonality, and oscillatory integrals by E. Stein. Princeton University Series 43, 1993.

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH617B	HARMONIC ANALYSIS	CO1	3	-	3	2	-	-	-	-	3	-	3
		CO2	3	-	3	2	-	-	-	-	3	-	3
		CO3	3	-	3	2	-	-	-	-	3	-	3
		CO4	3	-	3	2	-	-	-	-	3	-	3

Course Title/Code	CODING THEORY (MAH615B)	
Course Type	Elective (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	To equip students with fundamental theories and laws of information theory and coding theory with reference to the application in modern communication and computer systems	
Course Outcomes (COs)		**Mapping**
CO1	The student will be able to demonstrate simple ideal statistical communication models.	Skill Development
CO2	The student will be able to explain the development of codes for transmission and detection of information.	Skill Development
CO3	The student will be able to utilize various error control encoding and decoding techniques.	Skill Development
CO4	The student will be able to apply information theory and linear algebra in source coding and channel coding	Skill Development
CO5	The student will be able to analyze the performance of error control codes.	Skill Development
Prerequisites	**N.A**	

(if any)	

Section A

Information Theory & Source Coding: Introduction, Self-information, Extension of zero memory source, Entropy of a source with memory, Entropy of a source with memory, Types of codes (Block Codes, Non -Singular codes), Types of codes (uniquely decodable codes, instantaneous codes, optimal codes), Prefix codes, source coding theorem, Shannon's first Encoding theorem, Shannon's -Fano Encoding algorithm, Huffman codes, Extended Huffman codes, Arithmetic coding, Lempel-Ziv Algorithm, run length encoding .

Section B

Information Channels: Channel matrix, Joint probability matrix, Binary symmetric channel, System entropies, Mutual information, Mutual information, Shanon -Hartely Theorem, Channel Capacity, Information Redundancy, Channel capacity with binary symmetric channel, Channel capacity with binary erasure channel, Muroga's theorem, Continuous channel, Entropy of a continuous signal, Mutual information and capacity of a continuous Noisy channel, Introduction of Error control coding, Need of error control coding, Types of codes, Coding gain.

Section C

Error Control Coding -I: Linear block codes, Parity check matrix, Encoding Circuit for an (n, k) LBC, Syndrome calculation and error detection Distance properties of a LBC, Error detection and error correction capabilities of a LBC, Standard array decoding of an (n, k) LBC, General decoding for an (n, k) LBC, The Hamming codes, bounds on codes (Hamming Bound), Bunds on codes (Plotkin Bound), Bounds on codes (other bounds), Probability of an undetected error Pattern for an LBC over BSC.

Section D

Error Control Coding -II: Cyclic codes, Algebraic description of cyclic codes, Nonsystematic cyclic codes, systematic cyclic codes, generator and parity check matrices, encoding of cyclic codes using (n-k) shift registers, encoding of an (n, k) code using k shift registers, syndrome calculation and error detection, decoding of cyclic codes

Golay codes, shortened cyclic codes, Burst error correcting codes, product codes, fire codes, BCH codes, Non binary BCH codes.

TEXTBOOKS

1. **Bose R. , Information Theory, Coding and Cryptography , Tata McGraw-Hill, 2008.**
2. Robert B. Ash, (2014). Information Theory. Dover Publications.

REFERENCE BOOKS

Recommended Books:

1. Thomas M. Cover & Joy A. Thomas (2013). Elements of Information Theory (2nd edition). Wiley India Pvt. Ltd.
2. Joseph A. Gallian (2017). Contemporary Abstract Algebra (9th edition), Cengage.
3. Fazlollah M. Reza, (2003). An Introduction to Information Theory. Dover Publications.
4. Ron M. Roth (2007). Introduction to Coding Theory. Cambridge University Press.

e-Resources (websites/Wikipedia pages/webtutorials/online courses, etc.)

1. https://onlinecourses.nptel.ac.in/noc22_ee49/preview#:~:text=Information%20Theory%20answers%20two%20fundamental,some%20practice%20source%20compression%20algorithms.

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH615 B	CODING THEORY	CO1	3	-	1	2	-	-	-	-	-	1	-
		CO2	3	-	2	2	-	-	-	-	-	1	-
		CO3	3	3	2	2	-	-	2	-	1	2	-
		CO4	3	3	3	3	1	-	2	-	2	2	-
		CO5	3	3	3	3	-	-	2	-	2	2	1

Course Title/Code	WAVELETS AND ITS APPLICATIONS**(**MAH619B**)**	
Course Type	Elective (Departmental)	
L-P Structure	4-0	
Credits	4	
Course Objective	The student would be able to understand the fundamental concepts which has applications in the development of tools and techniques which may be used in signal theory, communication techniques, graphical algorithms and numerical analysis.	
Course Outcomes (COs)		**Mapping**
CO1	Recognise the importance of discrete wavelet transform and MRA	**Skill Development**
CO2	Analyse and construct alternative wavelet representations	**Skill Development**
CO3	Understand the fundamental concepts of wavelets which has application in development of tools and techniques which may be used in signal theory, image processing, communication techniques, graphical algorithms and numerical analysis.	**Skill Development**
CO4	Apply the concepts of theory of wavelets for solving problems in mathematics, signal & image processing.	**Skill Development**
Prerequisites (if any)	Wavelets(MAH609B)	

SECTION A

Discrete Wavelet Transform and Relation to Filter Banks:
Signal decomposition (Analysis), Relation with filter banks, Frequency response, Signal reconstruction: Synthesis from coarse scale to fine scale, Upsampling and filtering, Perfect reconstruction filters, QMF conditions, Computing initial $sj+1$ coefficients, Concepts of Multi-Resolution Analysis

(MRA) and Multi-rate signal processing.

SECTION B

Alternative Wavelet Representations:
Introduction, Bi-orthogonal wavelet bases, Filtering relationship for bi-orthogonal filters, Examples of bi-orthogonal scaling functions and wavelets. 2-D wavelets.

SECTION C

Non-separable multidimensional wavelets:
Non-separable multidimensional wavelets, wavelet packets. Wavelets Transform and Data Compression: Introduction, transform coding, DTWT for image compression (i) Image compression using DTWT and run-length encoding

SECTION D

Applications of Wavelets:
Signal and Image compression, Detection of signal changes, analysis and classification of audio signals using CWT, Wavelet based signal de-noising and energy compaction, Wavelets in adaptive filtering, Adaptive wavelet techniques in signal acquisition, coding and lossy transmission, Digital Communication and Multicarrier Modulation, Trans multiplexers, Image fusion, Edge Detection and object isolation.

TEXTBOOKS

1. A Wavelet Tour of Signal Processing, 2nd edition, S. Mallat, Academic Press, 1999.
2. Wavelets and Sub band Coding, M. Vetterli and J. Kovacevic, Prentice Hall, 1995.
3. Wavelet transforms: Introduction, Theory and applications, Raghuveer rao and Ajit S.Bopardikar, Pearson Education Asia, 2000.
4. Fundamentals of Wavelets: Theory, Algorithms, and Applications, J.C. Goswami and A.K. Chan, 2nd ed., Wiley, 2011.

REFERENCE BOOKS

1. Wavelets and their Applications, Michel Misiti, Yves Misiti, Georges Oppenheim, Jean-Michel Poggi, John Wiley & Sons, 2010 .
2. A premier on Wavelets and their scientific applications, J S Walker, CRC press, 2002.
3. Wavelets and signal processing: An application-based introduction, Stark, Springer, 2005.
4. A friendly guide to Wavelets, Gerald keiser, Springer, 2011.

e-Resources (websites/Wikipedia pages/webtutorials/online courses, etc.)

1. http://users.rowan.edu/~polikar/WAVELETS/WTtutorial.html
2. http://www.wavelet.org/
3. http://www.math.hawaii.edu/~dave/Web/Amara's%20Wavelet%20Page.htm

CO-PO Mapping

Course Code	Course Name	Course Uotcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH619 B	WAVELETS AND ITS APPLICATIONS	CO1	3	3	2	3	1	1	2	2	3	2	2
		CO2	3	3	2	3	1	1	2	2	3	3	2
		CO3	3	3	2	3	3	1	2	2	3	3	3
		CO4	3	3	2	3	3	1	2	2	3	3	3

Course Title/Code	ALGEBRAIC TOPOLOGY (MAH620B)	
Course Type	Elective (Departmental)	
L-P-O Structure	4-0-0	
Credits	4	
Course Objective	To familiarize students with topological groups, Homotopies, Deck transform etc.	
Course Outcomes (COs)		**Mapping**
CO1	Explain the fundamental concepts of algebraic topology and their role in modern mathematics and applied contexts.	**Skill Development**
CO2	Demonstrate accurate and efficient use of algebraic topology techniques.	**Skill Development**
CO3	Demonstrate capacity for mathematical reasoning through analyzing, proving and explaining concepts from algebraic topology.	**Skill Development**
CO4	Apply problem-solving using algebraic topology techniques applied to diverse situations in physics, engineering and other mathematical contexts.	**Skill Development**
Prerequisites (if any)	Topology I (MAH502B) & Topology II (MAH610B)	

SECTION A

Introduction, Topological groups, Paths, Homotopies and the fundamental group, Categories and functors, Functorial properties of the fundamental group, Brouwer's theorem and its applications.

SECTION B

Homotopies of maps, Deformation retracts, Fundamental group of the circle, covering projections, Lifting of paths and Homotopies, Action of Π1(X, x0) on the fibers p^{-1}(x0), The lifting criterion.

SECTION C

Deck transformations, Orbit spaces, Fundamental groups of SO(3, R) and SO(4, R), Coproducts and push-outs, Adjunction spaces, The Seifert Van

Kampen theorem.

SECTION D

Homology theory, Singular complex of a topological space, The homology groups and there functoriality, Homotopy invariance of homology, Small simplicies, The Mayer Vietoris sequence, Abelianization of the fundamental group, The Mayer Vietoris sequence, Maps of spheres, Relative homology, Excision theorem, Inductive limits, Jordan Brouwer separation theorem.

TEXTBOOKS

1. Allen Hatcher, Algebraic Topology. Cambridge, UK: Cambridge University Press
2. William S. Massey, A Basic Course in Algebraic Topology. New York, NY: Springer-Verlag Glen Bredon, Topology and Geometry

REFERENCE BOOKS

1. James R. Munkres, Topology (2ndEdition) Pearson Education Pvt.. Ltd., Delhi-2002.

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1
MAH620B	ALGEBRAIC TOPOLOGY	CO1	3	-	3	2	-	-	-	-	3	-	3
		CO2	3	-	3	2	-	-	-	-	3	-	3
		CO3	3	-	3	2	-	-	-	-	3	-	3
		CO4	3	-	3	2	-	-	-	-	3	-	3

Course Title/Code	PROJECT(MAN626B)
Course Type	Core(Departmental)
L-P Structure	0-20
Credits	10
Course Objective	To impart understanding of research papers/articles in specific areas, improve the communication skills by presentation on specific subjects, improve the team work and improve the research and practical approach

Course Outcomes (COs)		**Mapping**
CO1	Understand the basic concepts & broad principles of research projects	**Skill Development**
CO2	Get capable of self education and clearly understand the value of achieving perfection in project implementation & completion.	**Skill Development**
CO3	Apply the theoretical concepts to solve problems with teamwork and multidisciplinary approach.	**Skill Development**
CO4	Demonstrate professionalism with ethics; present effective communication skills and relate issues to broader societal context.	**Skill Development**
Prerequisites (if any)	**N.A**	

CO-PO Mapping

Course Code	Course Name	Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAN626B	Project	**CO1**	3	2	3	1	2	2	-	-	3	2	-
		CO2	3	3	3	2	3	-	-	-	3	2	1
		CO3	3	2	3	2	2	-	2	3	3	3	2
		CO4	-	-	-	-	-	3	2	3	-	2	2

CO-PO Mapping

Courses Code	Courses		CO Statement	PO 1	PO 2	PO3	PO 4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH514B	ABSTRACT ALGEBRA	**CO1**	To elaborate the algebraic structure with two binary operations such as Ring and Fields.	3	-	3	-	-	1	2	1	3	3	1
		CO2	To characterize the polynomials over ring and fields.	3	-	3	-	-	1	2	1	3	3	1
		CO3	To identify and construct example of modules and their application to finitely generated abelian groups.	3	-	3	-	-	1	2	1	3	3	1
		CO4	To define and characterize Notherian, Artinian module, and their applications in structure theorem.	3	-	3	-	-	1	2	1	3	3	1
MAH502B	TOPOLOGY-I	**CO1**	Understand terms, definitions and theorems related to topology.	3	2	-	-	-	1	2	1	3	3	2
		CO2	Demonstrate concepts of topological space such as open and closed sets, interior, closure and boundary.	3	2	-	-	-	1	2	1	3	3	2

		CO3	Create new topological spaces by using subspace, product and quotient topologies.	3	2	3	-	-	1	2	1	3	3	2
		CO4	Use continuous functions and homeomorphisms to understand structure of topological spaces.	3	2	3	-	-	1	2	1	3	3	2
		CO5	Apply theoretical concepts of topology to real world applications.	3	2	3	2	-	1	2	1	3	3	2
MAH503B	DIFFERENTIAL EQUATIONS	**CO1**	Illustrate the basic concepts differential equations	3	2	-	3	-	-	1	2	3	2	-
		CO2	Explain the various techniques to solve the different types of differential equations	3	2	-	3	-	-	1	2	3	2	-
		CO3	To understand and apply concept of power series techinque to solve the differetinal equations	3	2	-	3	-	-	1	2	3	2	-
		CO4	Apply the concepts of differential equations in various physical problems (heat equations, wave equations**)**	3	2	-	2	-	-	1	2	3	2	-
MAH504B	MEASURE THEORY	**CO1**	Demonstrate the underlying concepts of algebra’s of sets, Measure Space, Lebesgue measure	3	-	3	2	-	-	-	-	3	-	3

			space, measurable and non-measurable functions.											
		CO2	Appply the basic concepts Lebesgue integral to solve related mathematical Problems .	3	-	3	2	-	-	-	-	3	-	3
		CO3	Describe and apply the notion of measurable functions and sets and use Lebesgue monotone and dominated convergence theorems and Fatous Lemma.	3	-	3	2	-	-	-	-	3	-	3
		CO4	Describe the construction of product measures and use of Fubini's theorem	3	-	3	2	-	-	-	-	3	-	3
MAH512B	MATHEMATICAL STATISTICS	**CO1**	Use and apply the concepts of probability mass/density functions for the problems involving single/bivariate random variables	1	2	3	2	-	1	2	2	3	3	1
		CO2	Explain concept of Estimation and their properties	1	2	3	2	-	1	2	2	3	3	1
		CO3	Apply testing of hypothesis, types of error and test of significance for different sample sizes.	1	2	3	2	-	1	2	2	3	3	1
		CO4	Demonstrate an ability to apply statistical tools to solve problems.	1	2	3	2	-	1	2	2	3	3	1

MAW515B	EXCEL WORKSHOP	**CO1**	Comprehend effective use of appropriate spreadsheet vocabulary.	-	-	-	2	3	-	1	-	-	3	-
		CO2	Use critical thinking and problem solving skills in designing the spreadsheets for various business problems.	-	-	-	2	3	-	1	-	-	3	-
		CO3	Assess the document for accuracy in the entry of data and creation of formulas, readability and appearance.	-	-	-	2	3	-	1	-	-	3	-
		CO4	Develop efficiency with specific sets of skills through repetitive reinforcement to evaluate business problems	-	-	-	2	3	-	1	-	-	3	-
MAH506B	MATH LAB-I	**CO1**	To perform basic mathematical calculations, plotting the graphs and matrix operation using Mathematical software.	1	-	-	3	3	-	-	-	-	2	-
		CO2	To evaluate derivative and its application using mathematical software.	1	-	-	3	3	-	-	-	-	2	-
		CO3	To understand and apply concept of integration to evaluate area and volume using Mathematicalsoftware	1	-	-	3	3	-	-	-	-	2	-

		CO4	To visualize and find the roots of quadratic, cubic & biquadratics equations and transformation of equations using mathematical software.	1	-	-	3	3	-	-	-	-	2	-
CSH511 B	PYTHON PROGRAMMING	**CO1**	Install and run the Python interpreter	1	-	-	-	3	-	-	-	-	-	-
		CO2	Create and execute Python programs	1	3	-	-	3	-	-	-	-	-	-
		CO3	Describe how to program using Python, by learning concepts like variables, flow controls, data types, type conversion	1	3	2	1	-	-	-	-	-	-	-
		CO4	Implement python data structures	1	2	2	-	3	-	1	-	-	-	-
		CO5	Understand the concepts of file I/O	1	2	3	-	2	-	-	-	-	-	-
		CO6	Solve problems using functions, objects and classes	-	2	1	1	2	-	1	-	2	2	2
CDO511	PROFESSIONAL COMPETANCY PG	**CO1**	Students will be able to recognize problems based on arithmetic & number systems.	3	2	2	2	1	1	--	--	1	--	--
		CO2	Students will be able to solve problems based on verbal reasoning & simplification.	--	--	--	2	1	--	--	--	--	1	--

		CO3	Students will be able to solve complex problems based on arithmetic reasoning.	2	3	1	1	2	1	--	--	1	--	--
		CO4	Students will be able to plan their career meticulously by setting their time oriented goals.	--	-	--	-	1	1	--	1	--	1	1
SEMESTER-II														
Courses Code	**Courses**	**Course Outcomes**	**CO Statement**	PO1	PO 2	PO3	PO 4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH517B	MATHEMATICAL MODELING	**CO1**	Understand various techniques of mathematical modeling	1	2	3	2	-	1	2	2	3	3	1
		CO2	Apply mathematical models in different fields and situations	1	2	3	2	-	1	2	2	3	3	1
		CO3	Understand and apply mathematical modeling through differential equations.	1	2	3	2	-	1	2	2	3	3	1
		CO4	Analyze Stochastic models and their needs.	1	2	3	2	-	1	2	2	3	3	1
MAH508B	COMPLEX ANALYSIS	**CO1**	Understand the significance of continuity, differentiability and analyticity of complex functions	1	2	3	2	-	2	-	2	2	2	2
		CO2	Demonstrate the use of Cauchy integral formula	3	2	1	1	-	2	-	2	2	2	2

			,Taylor and Laurent series expansions.										
		CO3	Classify the nature of singularities, poles and residues and explain the application of Cauchy Residue theorem	3	2	2	1	-	2	-	2	2	2	2
		CO4	Apply the consequences of analytic continuation, Schwarz reflection principle, Monodromy theorem and conformal mapping	3	3	2	1	-	2	-	1	2	2	1
MAH509B	FUNCTIONAL ANALYSIS	**CO1**	demonstrate the basic concepts, underlying the definition of the general Functional spaces like Norm Linear space, Quotient space, Banach space, Inner product spaces, Hilbert spaces.	3	1	2	-	-	-	2	1	2	2	-
		CO2	understand the concept associated with the dual of a linear space, point set topology, linear functional, linear operator, approximation theory.	3	2	2	-	-	-	2	2	3	3	-
		CO3	apply and understand the concept of Hahn-Banach Theorem and their applications, open mapping, closed graph theorems and weak topology.	2	2	2	-	-	-	2	2	3	3	-

		CO4	analysis the concept of orthonormal bases, complete orthonormal sets, Projection theorem, Riesz representation theorem, Riesz-Fischer theorem.	3	2	3	-	-	-	2	2	3	3	-
MAH510B	DIFFERENTIAL GEOMETRY	**CO1**	understand and evaluate mathematical problems based on the transformation of co-ordinate system, tensor Calculus	1	-	3	2	-	-	-	-	2	2	-
		CO2	understand, visualize and solve the problem related to Differentiable curves in R3 and their parametric representations	1	-	3	2	-	-	-	-	2	2	-
		CO3	visualize and apply the concepts to solve the problem related to Curvatures(Normal, Principal,Gaussian,Mean) and differential forms	1	-	3	2	-	-	-	-	2	2	-
		CO4	Understand and apply the concept of different operators on surface to solve the problem related to Minimal & totally umbilical surface, Geodesics.	1	-	3	2	-	-	-	-	2	2	-
MAH604B	OPERATIONS RESEARCH	**CO1**	Understand any real life system with limited	3	3	3	3	2	2	2	2	2	2	2

			constraints and depict it in a model form.											
		CO2	demonstrate the problem on the basis of obtained solution of different problems of OR with real world limitations/applications.	3	3	3	3	2	2	2	2	2	2	2
		CO3	apply the different methods to solve OR problems & find the optimal solution.	3	3	3	3	2	2	2	2	2	2	2
		CO4	analyse and construct the mathematical models and learn to apply the restrictions on problems.	3	3	3	3	2	2	2	2	2	2	2
MAH516B	MATHEMATICS LAB-II	**CO1**	Write programming codes using conditional statements for related mathematical problems.	-	-	-	-	3	-	-	2	-	-	-
		CO2	Write programming codes using iterative statements (for loop, while loop) for related mathematical problems.	-	-	-	-	3	-	-	2	-	-	-
		CO3	Successfully install LaTeX and its related components on a home/personal computer.	-	-	-	-	-	-	-	-	-	2	-

		CO4	Use LaTeX and various templates acquired from the course to compose Mathematical documents, presentations, and reports	-	-	-	-	3	-	-	2	-	2	-
		CO5	Write mathematical documents containing mathematical expressions & formulas via LaTeX.	-	-	-	-	3	-	-	2	-	-	-
		CO6	Write articles in different journal styles.	-	-	-	-	3	-	-	2	-	2	-
		CO7	Draws graphs and figures in LaTeX. Customize LaTeX documents.	-	-	-	-	3	-	-	2	-	-	-
		CO8	Prepare presentations using LaTeX	-	-	-	-	3	-	-	2	-	2	-
CSW519 B	PYTHON FOR DATA ANALYSIS	**CO1**	Understanding of advance features of python programming .	1	3	-	-	3	-	-	-	-	-	-
		CO2	Apply advance features of python programming for explorateory Analysis.	1	3	2	1	-	-	-	-	-	-	-
		CO3	Implemant the concepts in various real world proplems	1	2	2	-	3	-	1	-	-	-	-
		CO4	Perform Analysis through visualization	1	2	3	-	2	-	-	-	-	-	-

CDO503	PROFESSIONAL COMPETANCY PG-I	**CO1**	Students will be able to recognize problems based on arithmetic & number systems.	3	2	2	2	1	1	--	--	1	--	--
		CO2	Students will be able to solve problems based on verbal reasoning & simplification.	--	--	--	2	1	--	--	--	--	1	--
		CO3	Students will be able to solve complex problems based on arithmetic reasoning.	2	3	1	1	2	1	--	--	1	--	--
		CO4	Students will be able to plan their career meticulously by setting their time oriented goals.	--	-	--	-	1	1	--	1	--	1	1
RDO504	SCIENTIFIC RESEARCH -I	**CO1**	describe research and its impact.	3	-	-	-	-	-	-	-	3	3	3
		CO2	identify broad area of research, analyze, the processes and procedures to carryout research.	3	2	3	3	2	-	-	-	3	3	3
		CO3	use different tools for literature survey	3	-	-	-	-	-	-	-	3	2	2
		CO4	understand and adopt the ethical practice that are to be followed in the research activities.	-	-	-	-	-	3	-	-	3	2	1

		CO5	work in groups with guidance.	-	-	-	-	-	-	3	-	3	2	-
SEMESTER-III														
Courses Code	**Courses**	**Course Outcomes**	**CO Statement**	PO1	PO 2	PO3	PO 4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH60 1B	INTEGRAL EQUATIONS & CALCULUS OF VARIATION	**CO1**	Acquire sound knowledge of different types of Integral equations: Fredholm and Volterra integral equations.	3	1	1	3	-	-	-	-	2	2	2
		CO2	Deduce & solve integral equation from differential equation arising in different engineering branches	2	2	3	2	-	-	-	-	2	1	1
		CO3	Construct Green function in solving boundary value problem by converting it to an integral equation	3	3	2	3	-	-	-	-	1	-	2
		CO4	Identify functional and its applications in engineering problem.	2	3	2	3	-	-	-	-	2	1	2
		CO5	Use Euler-Lagrange equation or its first integral to find & solve differential equations for stationary paths subject to boundary conditions.	3	2	2	3	-	-	-	-	2	1	2

MAH602B	FLUID MECHANICS	**CO1**	Describe a continuum model of fluid flow and classify fluid/flows based on physical properties of a fluid/flow along with Eulerian and Lagrangian descriptions of fluid motion.	3	-	3	3	-	1	2	2	1	1	1
		CO2	Demonstrate an ability to apply the concepts of Steady viscous flow and Conservation of Momentum for solving real world problems	3	3	3	3	-	-	2	2	1	1	1
		CO3	Apply the concepts of rotational/rotational Motion for solving real world problems.	3	3	3	3	-	-	2	2	1	1	1
		CO4	Construct and Analyse mathematically the nature of Laminar/Non Laminar flow.	3	3	3	3	-	-	2	2	1	1	1
MAH607B	FOURIER ANALYSIS	**CO1**	Understand the basic properties of Fourier series	3	-	1	2	-	-	-	-	-	1	-
		CO2	Use concept of separation of variables Sturm-Liouville Theorem to solve related problem	3	-	2	2	-	-	-	-	-	1	-
		CO3	Apply the concepts of distributions and Fourier transform to solve related problem	3	3	2	2	-	-	2	-	1	2	-

		CO4	Understand the application of Fourier transform	3	3	3	3	1	-	2	-	2	2	-
MAH507B	FIELD THEORY		Explain the fundamental concepts of field extensions and its role in modern mathematics and applied contexts	3	2	-	-	-	2	-	2	3	2	-
			Demonstrate the application of Galois theory.	3	2	-	-	-	2	-	2	2	2	-
			Illustrate about Galois fields, Cyclotomic extension and polynomials	3	2	-	-	-	2	-	2	2	2	-
			Solve polynomial equations by radicals along with the understanding of ruler and compass	3	2	1	1		2	-	2	2	2	2
MAH608B	DIFFERENTIABLE MANIFOLDS	**CO1**	Able to use concepts of tangent vectors and normal vectors to investigate intrinsic and extrinsic properties of differential manifolds	1	-	2	-	-	-	-	-	2	2	-
		CO2	Able to apply properties Lie bracket , Jacobian , transformation to establish results on differentiable manifolds.	1	-	2	-	-	-	-	-	1	1	-
		CO3	able to apply the concepts of immersion and submersion to study	1	-	2	-	-	-	-	-	2	2	-

			geometry of differential manifolds											
		CO4	apply the concepts covariant derivative , curvature, connectedness to geometry of differential manifolds	1	-	2	-	-	-	-	-	2	2	-
MAH606B	DESIGN OF EXPERIMENTS	**CO1**	understand the issues and principles of Design of Experiments (DOE)	1	2	-	-	-	-	3	2	-	-	-
		CO2	understand experimentation is a process	1	2	-	-	-	-	3	2	-	-	-
		CO3	list the guidelines for designing experiments	1	2	-	-	-	-	3	2	-	-	-
		CO4	construct BIBD	1	2	-	-	-	-	3	2	-	-	-
MAH623B	ADVANCED NUMERICAL ANALYSIS	**CO1**	To Learn about errors which arise during computation due to roundoff or truncation or number representation and the high-end numerical methods for solving transcendental and polynomial equations.	3	--	3	-	-	1	2	1	3	3	1
		CO2	Attain the skills of solving system of linear equations using direct and iterative schemes and analysis of such schemes. Know to apply	3	-	3	-	-	1	2	1	3	3	1

			finite difference schemes/operators for numerical differentiation.											
		CO3	Learn advanced numerical methods to evaluate integrals for solving linear/non-linear first/second order IVP/BVP involving ODEs.	3	-	3	-	-	1	2	1	3	3	1
		CO4	Understand the finite difference methods for solving parabolic, elliptic and hyperbolic PDEs and attain capability to use such methods in scientific problem solving.	3	-	3	-	-	1	2	1	3	3	1
MAH614B	ADVANCED OPERATIONS RESEARCH	**CO1**	Understanding of advance operations research techniques , methodologies and tools.	3	3	3	3	2	2	2	2	2	2	2
		CO2	Analyze and solve of the fundamental concepts and techniques used in Network Analysis.	3	3	3	3	2	2	2	2	2	2	2
		CO3	Develop mathematical skills to analyze and solve OR models like Queueing, Replacement, etc and apply them for optimization.	3	3	3	3	2	2	2	2	2	2	2

		CO4	Conduct and interpret post-optimal and sensitivity analysis and explain the primal -dual relationship.	3	3	3	3	2	2	2	2	2	2	2
MAH625B	FUZZY SETS AND APPLICATIONS	**CO1**	Understand the concept of fuzziness involved in various systems and fuzzy set theory	3	-	1	2	-	-	-		-	1	-
		CO2	Apply the concepts of fuzzy relation to solve related problem	3	-	2	2	-	-	-		-	1	-
		CO3	Use the concepts of fuzzy measure to understand physical problem related to different classes of fuzzy measures	3	3	3	2	-	-	2		1	2	-
		CO4	Analyze the application of fuzzy logic control to real time systems.	3	3	3	3	1	-	2		2	2	-
MAH605B	GRAPH THEORY	**CO1**	Apply the concepts of path, walk , circuit to study different types of graph	2	1	-	-	-	-	1	-	2	-	-

		CO2	Apply concepts of tree to find the problem related to distance, spanning tree or minimal spanning tree	2	1	-	-	-	-	2	-	2	-	-
		CO3	Apply the concepts of shortest distance in graph to find the solution of problem of travelling saleman	2	1	-	-	-	-	2	-	2	-	-
		CO4	Understand the concept of coloring and planar graph	2	1	-	-	-	-	2	-	2	-	-
		CO1	understand STFT, windowed Fourier transform, FT, IFT and difference between windowed Fourier transform and wavelet transforms.	3	3	3	3	2	2	2	2	2	2	2

MAH609 B	WAVELETS	**CO2**	analyse and apply wavelet basis and characterize continuous and discrete wavelet transforms.	3	3	-	3	2	2	2	2	3	3	3
		CO3	construct wavelets by multiresolution analysis and identify various wavelets and evaluate their time-frequency resolution properties.	3	3	3	3	-	2	2	2	3	3	3
		CO4	Characterize Wavelets, MRA wavelets, Scaling function Low-pass filter & High Pass filter, MSF wavelets.	3	3	3	3	-	2	2	2	3	3	3
		CO1	Understand the product of two topological spaces and their properties	3	2	-	-	-	1	2	1	3	3	2
		CO2	Apply the concepts nets and filter to solve related problems	3	2	-	-	-	1	2	1	3	3	2

MAH610 B	TOPOLOGY-II	**CO3**	Uses the notion of compactness to solve related problem	3	2	3	-	-	1	2	1	3	3	2
		CO4	Apply the concept of paracompactness to study study properties of product manifolds	3	2	3	-	-	1	2	1	3	3	2
CDO603	PROFESSIONAL COMPETENCY PG-II	**CO1**	Students will be able to demonstrate problem solving and leadership skills required to participate in a stimulated environment.		2	--	1	1	2	3	--	1	1	1
		CO2	Students will be able to face real life challenges using critical reasoning skills.	--	2	--	2	1	1	--	--	--	1	1
		CO3	Prepare for placements and manage interviews effectively.	--	--	--	--	--	--	--	3	--	1	1
		CO4	Enhance their ability to write, read, comprehend and communicate effectively to increase the productivity of business.	--	-	--	-	--	--	1	3	1	2	1
		CO1	able to critically evaluate the work done by various researchers relevant to the research topic.	3	1	2	-	-	-	-	-	3	3	-

RDO604	SCIENTIFIC RESEARCH - II	**CO2**	integrate the relevant theory and practices followed in a logical way and draw appropriate conclusions.	3	2	2	-	-	-	-	-	3	3	-
		CO3	understand the research methodologies/approaches/ techniques used in the literature.	3	3	2	-	-	-	-	-	3	3	-
		CO4	structure and organize the collected information or findings through an appropriate abstract, headings, reference citations and smooth transitions between sections.	3	-	2	-	-	-	-	-	3	3	-
SEMESTER-IV														
Courses Code	**Courses**	**Course Outcomes**	**CO Statement**	PO1	PO 2	PO3	PO 4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
MAH62 1B	DYNAMICS OF RIGID BODY	**CO1**	To demonstrate that they can apply the concept of system of particle in finding moment of inertia, D'Alembert's Principle and consequently know the inertia constants for a rigid body and the equation of momental ellipsoid together with the idea of principal axes and principal moments of inertia	3	3	2	3	-	-	2	1	3	-	3

		CO2	To apply the concept of the dynamics involving a single particle like projectile motion, Simple harmonic motion, pendulum motion and related problems so that they can use these methods to solve real world problem	3	3	2	3	3	2	3	-	-	2	1
		CO3	To demonstrate an ability to apply the concepts of motion of rigid body in two & three dimensions, system of Euler's dynamical equations for studying rigid body motions for solving real world problems.	3	3	2	3	-	-	2	1	3	-	3
		CO4	To analyze the derivation of Lagrange's Equations . Extension of Hamilton's principle to non-holonomic systems. Distinguish the concept of the Hamilton Equations of motion and the Principle of Least Action.	3	3	2	3	-	-	2	1	3	-	3
MAH612B	COMPUTATIONAL FLUID DYNAMICS	**CO1**	Demonstrate an ability to recognize the type of fluid flow that is occurring in a particular physical system and to use the appropriate	3	3	3	3	-	-	2	2	1	1	1

			model equations to investigate the flow.											
		CO2	Demonstrate the ability to simplify a real fluid-flow system into a simplified model problem, to select the proper governing equations for the physics involved in the system, to solve for the flow, to investigate the fluid-flow behavior, and to understand the results.	3	3	3	3	-	-	2	2	1	1	1
		CO3	Demonstrate the ability to analyze a flow field to determine various quantities of interest, such as flow rates, heat fluxes, pressure drops, losses, etc., using flow visualization and analysis tools.	3	3	3	3	-	3	2	2	1	1	1
MAH613B	GENERALIZED FUZZY SET THEORY	**CO1**	Explain the concept of advanced level of Generalized fuzzy set.	3	-	1	2	-	-	-	-	-	1	-
		CO2	Relate the concepts of soft sets, rough multisets.	3	-	2	2	-	-	-	-	-	1	-
		CO3	Apply structures such as Multisets, Rough sets.	3	3	3	2	-	-	2	-	1	2	-
		CO4	Solve and analyze real world problems using	3	3	3	3	1	-	2	-	2	2	-

			advanced level fuzzy techniques.											
MAH624B	ADVANCED DISCRETE MATHEMATICS	**CO1**	Conceptual understanding of Mathematical Logic: Propositional logic.	1	2	3	2	-	1	2	2	3	3	1
		CO2	Analyse the minimizations of circuits by using Boolean identities and K-map.	1	2	3	2	-	1	2	2	3	3	1
		CO3	Construct and express logical arguments using grammar and to work in abstract or general term to increase the clarity and efficiency of analysis.	1	2	3	2	-	1	2	2	3	3	1
		CO4	Introduce the automata theory and finite set of machine to determine the decidability and intractability of computational problem	1	2	3	2	-	1	2	2	3	3	1
		CO5	Discuss Euler and Hamilton paths and circuits and Evaluate minimal spanning tree	1	2	3	2	-	1	2	2	3	3	1

			for the undirected graphs.											
MAH618B	LIGHTLIKE MANIFOLDS	**CO1**	Demonstrate the ability to aply the concepts of of metric tensor, isometries, curvature and geodesic of a semi-Riemannian manifolds to prove the theorem and mathematical problem based on these topics	3	-	2	1	-	-	-	-	3	-	3
		CO2	Explain connection, normal connection totally geodesic , hypersurfaces and solve related mathematical problems	3	-	2	1	-	-	-	-	3	-	3
		CO3	Apply the concept of lightlike hypersurfaces to rove results on screen conformal hypersurfaces, induced scalar curvature , Einstein hypersurface	3	-	2	1	-	-	-	-	3	-	3
		CO4	Prove results on half lighlike submanifolds, screen conformal submanifolds	3	-	2	1	-	-	-	-	3	-	3
MAH616B	STOCHASTIC PROCESSES	**CO1**	Illustrate and formulate fundamental probability distribution and density functions, as well as	1	1	1	1	1	1	1	1	1	-	-

			functions of random variables											
		CO2	Analyze continuous and discrete-time random processes	1	2	2	1	1	1	1	1	2	1	1
		CO3	Apply the theory of stochastic processes to analyze linear systems	1	2	2	1	2	1	1	1	2	1	1
		CO4	Apply the above knowledge to solve basic problems in filtering, prediction and smoothing	1	2	2	1	2	1	1	1	2	1	2
MAH617B	HARMONIC ANALYSIS	**CO1**	Explain the concept of Haar measure and identify Haar measures for the group of the integers, the reals under addition and multiplication, the torus, and the ax+b group.	3	-	3	2	-	-	-	-	3	-	3
		CO2	Use the Gelfand-Naimark it to identify the C* algebra of the groups R_nand Z_n.	3	-	3	2	-	-	-	-	3	-	3
		CO3	Explain the concept of Pontryagin duality and the connection with the Fourier series and Fourier transform.	3	-	3	2	-	-	-	-	3	-	3

		CO4	Use the Pontryagin duality to identify duals of examples of locally compact abelian groups	3	-	3	2	-	-	-	-	3	-	3
MAH615B	CODING THEORY	**CO1**	Demonstrate simple ideal statistical communication models.	3	-	1	2	-	-	-	-	-	1	-
		CO2	Explain the development of codes for transmission and detection of information.	3	-	2	2	-	-	-	-	-	1	-
		CO3	Utilize various error control encoding and decoding techniques	3	3	2	2	-	-	2	-	1	2	-
		CO4	Apply information theory and linear algebra in source coding and channel coding	3	3	3	3	1	-	2	-	2	2	-
		CO5	Analyze the performance of error control codes.	3	3	3	3	-	-	2	-	2	2	1
MAH619B	WAVELETS & IT'S APPLICATIONS	**CO1**	Recognise the importance of discrete wavelet transform and MRA	3	3	2	3	1	1	2	2	3	2	2
		CO2	Analyse and construct alternative wavelet representations	3	3	2	3	1	1	2	2	3	3	2
		CO3	understand the fundamental concepts of wavelets which has applications in the development of tools and techniques which	3	3	2	3	3	1	2	2	3	3	3

			may be used in signal theory, image processing, communication techniques, graphical algorithms and numerical analysis.											
		CO4	apply the concepts of theory of wavelets for solving problems in mathematics, signal & image processing.	3	3	2	3	3	1	2	2	3	3	3
MAH620B	ALGEBRAIC TOPOLOGY	**CO1**	Explain the fundamental concepts of algebraic topology and their role in modern mathematics and applied contexts.	3	-	3	2	-	-	-	-	3	-	3
		CO2	Demonstrate accurate and efficient use of algebraic topology techniques.	3	-	3	2	-	-	-	-	3	-	3
		CO3	Demonstrate capacity for mathematical reasoning through analyzing, proving and explaining concepts from algebraic topology.	3	-	3	2	-	-	-	-	3	-	3
		CO4	Apply problem-solving using algebraic topology techniques applied to diverse situations in physics, engineering and other mathematical contexts.	3	-	3	2	-	-	-	-	3	-	3

MAN626B	PROJECT	**CO1**	Understand the basic concepts & broad principles of research projects	3	2	3	1	2	2	-	-	3	2	-
		CO2	Get capable of self-education and clearly understand the value of achieving perfection in project implementation & completion.	3	3	3	2	3	-	-	-	3	2	1
		CO3	Apply the theoretical concepts to solve problems with teamwork and multidisciplinary approach.	3	2	3	2	2	-	2	3	3	3	2
		CO4	Demonstrate professionalism with ethics; present effective communication skills and relate issues to broader societal context.	-	-	-	-	-	3	2	3	-	2	2