EVALUATION SCHEME & SYLLABI

for

Master of Science in Mathematics

TWO-YEARS FULL-TIME PROGRAMME
(Effective from session 2026-2027)

Second Year

Department of Applied Sciences & Humanities

INVERTIS UNIVERSITY
Invertis Village
Bareilly-Lucknow NH-24, Bareilly-243123, India

M.Sc. Mathematics

The proposed PG course structure in mathematics along with detailed syllabus shall be governed by the department of Applied sciences and Humanities, Invertis University, Bareilly.

1. There shall be four semesters in the two-year M.Sc. course in Mathematics.
2. Each paper will be of 100 marks. This will include an internal assessment of 30 marks. Duration for examination of a paper will be 3hours.
3. Three lectures and one tutorial per week are to be allotted to each paper.
4. A Project work/Dissertation Examination of 100 marks will be held during Semester IV. The Board of Examiners will consist of one External and two internal examiners recommended for appointment by the BOS. The Chairman of the Board will be the senior-most from amongst the internal examiners.
5. There shall be 600 marks for I and II Sem. For III and IV semester there shall be 650 marks and 650 marks respectively Thus, for the entire course it comes out to be a total of 2500 marks.

The course prescribed for various semesters shall be the following and marks distribution is described in the table.

I Year (Mathematics)

I Year										
I Semester			Teaching Scheme			Marks Distribution				
PAPER	**CODE**	**SUBJECT**	**L**	**T**	**P**	**MSM**	**ESM**	**Total**	**Credit**
Paper 1	MMA101	Abstract Algebra	3	1	0	30	70	100	4
Paper 2	MMA102	Real Analysis and Measure Theory	3	1	0	30	70	100	4
Paper 3	MMA103	Advanced Differential Equations	3	1	0	30	70	100	4
Paper 4	MMA104	Fundamental of computer and c programming	3	1	0	30	70	100	4
Paper 5	MMA105	Numerical Methods	3	1	0	30	70	100	4
Paper 6	EPC001	AI Based English Proficiency Course-I	0	0	0	0	50	50	2
LAB 1	MMA151	C-Programming Lab	0	0	4	15	35	50	2
Total			**15**	**5**	**4**	**165**	**435**	**600**	**24**
II Semester									
PAPER	**CODE**	**SUBJECT**	**L**	**T**	**P**	**MSM**	**ESM**	**Total**	**Credit**
Paper 6	MMA201	Linear Algebra	3	1	0	30	70	100	4
Paper 7	MMA202	Complex Analysis	3	1	0	30	70	100	4
Paper 8	MMA203	Topology	3	1	0	30	70	100	4
Paper 9	MMA204	Statistical Methods and Data Analysis	3	1	0	30	70	100	4
Paper 10	MMA205	Operations Research	3	1	0	30	70	100	4
Paper 11	EPC001	AI Based English Proficiency Course – II	0	0	0	0	50	50	2
LAB 2	MMA251	Data Analytics Lab	0	0	4	15	35	50	2
Total			**15**	**5**	**4**	**165**	**435**	**600**	**24**

II Year (Mathematics)

III Semester			Teaching Scheme			Marks Distribution			
PAPER	**CODE**	**SUBJECT**	**L**	**T**	**P**	**MSM**	**ESM**	**Total**	**Credit**
Paper 1	MMA301	Python	3	1	0	30	70	100	4
Paper 2	MMA302	Functional Analysis	3	1	0	30	70	100	4
Paper 3	MMA303	Mathematical Methods	3	1	0	30	70	100	4
Paper 4	MMA304	Probability and Stochastic Processes	3	1	0	30	70	100	4
Paper 5	MMA031	DSE-I	3	1	0	30	70	100	4
Lab	MMA351	Python Lab	0	0	4	15	35	50	2
Lab	MMA 352	Field Project / Internship*	0	0	0	30	70	100	4
Total			**15**	**5**	**4**	**195**	**455**	**650**	**26**

IV Semester									
PAPER	**CODE**	**SUBJECT**	**L**	**T**	**P**	**MSM**	**ESM**	**Total**	**Credit**
Paper 6	MMA401	Mathematical Modeling	3	1	0	30	70	100	4
Paper 7	MMA041	DSE-II	3	1	0	30	70	100	4
Paper 8	MMA042	DSE- III	3	1	0	30	70	100	4
Paper 9	MMA043	DSE-IV	3	1	0	30	70	100	4
Lab	MMA451	MATLAB	0	0	4	15	35	50	2
Project	MMA452	Project work* / Dissertation	0	0	0	50	150	200	8
Total			**12**	**4**	**4**	**185**	**465**	**650**	**26**

*** Project will be given in end of III semester & submitted in IV semester and a Field project / Internship done by student during program will be evaluated in Third Semester.**

Effective from 2026-27

INVERTIS UNIVERSITY BAREILLY

Mathematics
Discipline Specific Elective (DSE)

MMA031 / MMA041 / MMA042 / MMA043				
S. No.	**Course Name**	**L-T-P**	**Credit**	**Contact Hrs.**
1.	Discrete Mathematics	4-0-0	4	40
2.	Data Analysis and Visualization	4-0-0	4	40
3.	Finite Element Method	4-0-0	4	40
4.	Numerical Linear Algebra	4-0-0	4	40
5.	Bio Mathematics	4-0-0	4	40
6.	Multivariable Calculus	4-0-0	4	40
7.	Introduction to Algebraic Geometry	4-0-0	4	40
8.	Theory of Analytic functions	4-0-0	4	40
9.	Fourier Analysis and applications	4-0-0	4	40
10.	Network Models	4-0-0	4	40
11.	Stochastic Programming and applications	4-0-0	4	40
12.	Differential Geometry	4-0-0	4	40
13.	Modern theory of PDE	4-0-0	4	40
14.	Fluid Mechanics	4-0-0	4	40
15.	Numerical Methods of PDE	4-0-0	4	40
16.	Tensors & Riemannian Geometry	4-0-0	4	40
17.	Number theory and Cryptography	4-0-0	4	40
18.	Integral Equation and Calculus of variations	4-0-0	4	40
19.	Financial Mathematics	4-0-0	4	40

Skill Enhancement Courses (SEC) for Pure Mathematics

S. No.	Course Name	Code	L-T-P	Credit	Contact Hrs.
1.	Artificial Intelligence and Machine Learning	MMA 104	**3-1-0**	4	40
2.	Fundamental of Computer and C Programming	MMA 044	**4-1-0**	4	40
3.	Data Analysis and Visualization	MMA 045	**4-1-0**	4	40
4.	Python Lab	MMA 351	**0-0-2**	2	20
5.	Advanced Mathematical Statistical Lab (R- Based)	MMA 251	**0-0-2**	2	20
6.	Statistical Methods and Data Analysis	MMA 204	**3-1-0**	4	40

Ability Enhancement Compulsory (AECC)

S. No.	Course Name	Code	L-T-P	Credit	Contact Hrs.
1.	Dissertation	MMA 452	**0-0-4**	4	40

INVERTIS UNIVERSITY BAREILLY

II Year (Data Science)

III Semester			Teaching Scheme			Marks Distribution			
PAPER	**CODE**	**SUBJECT**	**L**	**T**	**P**	**MSM**	**ESM**	**Total**	**Credit**
Paper 1	MMA301	Python	3	1	0	30	70	100	4
Paper 2	MMA304	Probability and Stochastic Processes	3	1	0	30	70	100	4
Paper 3	MMA305	Artificial Intelligence and Machine Learning	3	1	0	30	70	100	4
Paper 4	MMA306	Data Warehouse and Data Mining	3	1	0	30	70	100	4
Paper 5	MMA032	DSE-I	3	1	0	30	70	100	4
Lab	MMA353	Machine Learning with Python Lab	0	0	4	15	35	50	2
Lab	MMA352	Field Project/ Internship*	0	0	0	30	70	100	4
Total			**15**	**5**	**4**	**195**	**455**	**650**	**26**

IV Semester									
PAPER	**CODE**	**SUBJECT**	**L**	**T**	**P**	**MSM**	**ESM**	**Total**	**Credit**
Paper 6	MMA401	Mathematical Modeling	3	1	0	30	70	100	4
Paper 7	MMA402	Database Management System	3	1	0	30	70	100	4
Paper 8	MMA044	DSE-II	3	1	0	30	70	100	4
Paper 9	MMA045	DSE- III	3	1	0	30	70	100	4
Lab	MMA453	Database Management System Lab	0	0	4	15	35	50	2
Paper 10	MMA452	Project work* / Dissertation	0	0	0	50	150	200	8
Total			**12**	**4**	**4**	**185**	**465**	**650**	**26**

*** Project will be given in end of III semester & submitted in IV semester and a Field project /**

Internship done by student during program will be evaluated in Third Semester.

Data Science

Discipline Specific Elective (DSE)

MMA032 / MMA044 / MMA045				
S. No.	**Course Name**	**L-T-P**	**Credit**	**Contact Hrs.**
1.	Discrete Mathematics	4-0-0	4	40
2.	Big Data Analysis	4-0-0	4	40
3.	Software Reliability	4-0-0	4	40
4.	Statistical Inference	4-0-0	4	30
5.	Advance Machine Learning	4-0-0	4	30
6.	Portfolio Management	4-0-0	4	40
7.	Quality Management	4-0-0	4	40
8.	Data Structures & Algorithms	4-0-0	4	40
9.	Marketing Research	4-0-0	4	40
10.	Logistics and supply chain management	4-0-0	4	40
11.	Financial Management	4-0-0	4	40
12.	Reliability and Maintenance theory	4-0-0	4	40
13.	Recording and Analysis of Business Operations	4-0-0	4	40

Mathematics

MMA301: Python	
Teaching Scheme	**Examination Scheme**
Lectures:3hrs/Week	ClassTest-12Marks
Tutorials:1hr/Week	TeachersAssessment-6 Marks
	Attendance-12Marks
Credits:4	End Semester Exam–70marks

Course Objectives:

The course is designed to teach:

1. The Python environment, data types, operators used in Python.
2. The use of control structures and numerous native data types with their methods.
3. The design and implement user defined functions, modules, and packages.
4. Creating and handling files in Python
5. Object Oriented Programming (OOP) Concepts.

Detailed Syllabus

UNIT 1	Introduction to Python: Features of Python, Limitations, Major Applications of Python, Python Data Types & Input/Output: Keywords, Identifiers, Python Statement, Indentation, Documentation, Variables, Multiple Assignment,
UNIT 2	Understanding Data Type, Data Type Conversion, Python Input and Output Functions, Import command, Operators and Expressions: Operators in Python, Expressions, Precedence, Associativity of Operators, Non-Associative Operators, Interactive Mode and Script Mode, Order of Operations.
UNIT 3	Control Structures: Decision making statements, loops, control statements. Python Native Data Types: Numbers, Lists, Tuples, Sets, Dictionary, Functions & Methods of Dictionary
UNIT 4	Strings: String as a sequence, traversal with a for loop, string slices and dices, strings Are immutable, searching, looping and counting, string methods, the in operator, string comparison, string operations
UNIT 5	Python Functions: Function calls, type conversion functions, math functions, user defined functions - definitions and uses, parameters and arguments, variables and parameters Are Local, stack diagrams, fruitful functions and void functions, importing with from, return values, composition, Boolean functions, recursion, checking types

Text Books:

1. Pooja Sharma, Programming in Python, BPB Publications, 2017, ISBN: 978- 9386551276 2.
2. R. Nageswara Rao, Core Python Programming, Dreamtech Press, 3rd Edition, ISBN: 978-9390457151

Reference Books:

1. Dr. Marlapalli Krishna, S. Jaya Prakash, K. Varada Rajkumar, Basic Python Programming for Beginners, Bluerose Publishers Pvt. Ltd., 2021, ISBN: 978- 9354720604

2. Martin C. Brown, Python: The complete Reference, McGraw Hill Education, 2018, ISBN: 978-9387572942
3. Martelli A., A. Ravenscroft, S. Holden, Python in a Nutshell, OREILLY.
4. Reema Thareja, Python Programming, OUP India, Oxford University Press India, 2nd edition, 2023, ISBN: 978-9354973765
5. Christos Manola, Dimitrios Xanthidis, Han-I Wang, Ourania K. Xanthidou, Handbook of Computer Programming with Python, CRC Press; 1st edition, 2022, ISBN: 978- 0367687779

Course Outcomes:

At the end of the course, the student should be able to:

1. Understand Python features, syntax, variables, and basic input/output operations.
2. Apply operators, expressions, and type conversions to solve computational problems.
3. Implement control structures and native data types like lists, dictionaries, and tuples to manage data.
4. Manipulate and analyze string sequences using slicing, traversal, and built-in string methods.
5. Develop modular programs using user-defined functions, parameters, return values, and recursion.

MMA302 Functional Analysis	
Teaching Scheme	**Examination Scheme**
Lectures:3hrs/Week	ClassTest-12Marks
Tutorials:1hr/Week	TeachersAssessment-6 Marks Attendance– 12Marks
Credits:4	End Semester Exam–70marks

Course Objectives:

1. Understand the definitions, properties, and geometric characteristics of normed linear spaces.
2. Understand the definitions, properties of Banach spaces, and Hilbert spaces.
3. Analyze inner product spaces by utilizing the Projection Theorem and Orthonormal bases.
4. To understand generalized Fourier approximations like Bessel's inequality and Parseval's formula.
5. To understand the concepts of bounded operators Space of bounded operators and dual space.

Detailed Syllabus

UNIT 1	Normed linear spaces and its topological properties, Convergence in normed linear spaces, Cauchy sequences, Banach spaces with examples, Cauchy's inequality, Holder's and Minkowski's inequality, Quotient space of normed linear space, Equivalent norms.
UNIT 2	Continuous and bounded linear transformations Space of bounded linear transformations. Conjugate space (dual space), Functional, Hahn-Banach theorem for real and complex normed linear spaces, Applications of Hahn- Banach theorem, Heine Borel theorem, Riesz lemma.
UNIT 3	Open mapping theorem, Closed graph theorem, Baire category theorem, Uniform boundedness principle, Inner product spaces, Hilbert Spaces and basic properties, Cauchy-Schwarz's inequality, Projection theorem.
UNIT 4	Orthogonal complement, Orthonormal bases, Bessel's inequality, Parseval's Formula, Complete orthonormal sets and its characterization, Continuous linear functional on Hilbert space, Riesz representation theorem, Reflexivity of Hilbert space, Weak and strong convergence.
UNIT 5	Bounded operators, Space of bounded operators and dual space, Riesz representation theorem, Adjoint of operators on a Hilbert Space, Unbounded operators, Convergence of sequence of operators. Hahn Banach extension theorem, Uniform boundedness principle.

Text Books:

1. G. F. Simmons, Introduction to Topology and Modern Analysis, McGraw Hill,1963.
2. S. Ponnusamy, Foundations of Functional Analysis, Narosa Publishing House, New Delhi,2002.
3. M. T. Nair, Functional Analysis, A first course, Prentice Hall of India,2002.
4. B. V. Limaye, Functional Analysis, Second Edition, New Age International,1996.

Reference Books:

1. Kreyzig, E., Introduction to Functional Analysis with Applications, Wiley,1989.
2. Limaye, B. V., Functional analysis (3rd ed.). New Age International Publishers, 2014.
3. Conway, J. B., A course in functional analysis (2nd ed.). Springer, 2019.
4. Rudin, W., Functional analysis (2nd ed.). McGraw-Hill Education, 1991.
5. Brezis, H., Functional analysis, Sobolev spaces and partial differential equations. Springer, 2011.

Course Outcomes:

1. At the end of the course, the student should be able to:
2. Understand Banach spaces and Hilbert spaces.
3. Learn bounded operators and their properties.

4. Find orthonormal basis.
5. Use projection theorem.
6. Know the applications of closed graph theorem and open mapping theorem.

MMA 303: Mathematical Methods	
Teaching Scheme Lectures:3hrs/Week Tutorials:1hr/Week Credits:4	**Examination Scheme** ClassTest-12Marks Teachers Assessment-6 Marks Attendance-12Marks End Semester Exam–70marks

Course Objectives:

The course is designed to teach:

1. To understand the concepts and mathematical properties of Laplace and Fourier transforms.
2. To apply transform techniques in solving ordinary differential equations and boundary-value problems.
3. To learn Fourier series expansions for representing periodic, even, and odd functions.
4. To grasp the calculus of variations and utilize Euler's equations to find extremals.
5. To study orthogonal function sets and the properties of Sturm-Liouville boundary-value problems.

Detailed Syllabus

UNIT 1	**Laplace Transform:** Definition, Existence and Linearity of Laplace Transform. First Shifting Theorem, Laplace Transform of the derivatives and of the Integrals of a function, Derivatives and Integrals of Transforms, Inverse Laplace transform, Convolution theorem, Applications of Laplace transform to solve ordinary differential equations.
UNIT 2	**Fourier Transform:** Fourier Integrals, Fourier Cosine and Sine Integrals, Inverse Fourier Transform, Fourier Cosine and Sine Transform, Complex form of the Fourier Transform, Linearity of the Fourier Transform.
UNIT 3	**Calculus of Variations:** Functionals and extremals, Variation and its properties, Euler equations, Cases of several dependent and independent variables, Functionals dependent on higher derivatives, Parametric forms, Simple applications.
UNIT 4	**Fourier Series:** Periodic functions, Trigonometric series, Fourier series, Euler formulas, Functions having arbitrary periods, Even and Odd functions, Half-range expansions, Determination of Fourier coefficients without integration, Approximation by trigonometric polynomials, Square error.

UNIT 5	**Boundary-value problems and Transforms:** Orthogonal and Orthonormal sets of functions, Generalized Fourier series, Sturm-Liouville problems, Examples of Boundary-value problems which are not Sturm- Liouville problems,

Textbooks & Reference Books:

1. Advanced Engineering Mathematics – Erwin Kreyszig (Wiley)
2. Higher Engineering Mathematics – B.S. Grewal (Khanna Publishers)
3. Elements of Partial Differential Equations – Ian N. Sneddon (McGraw-Hill)
4. Calculus of Variations – I. M. Gelfand and S. V. Fomin (Dover Publications)
5. Operational Mathematics – Ruel V. Churchill (McGraw-Hill)

Course Outcomes:
At the end of the course, the student should be able to:

1. Effectively solve linear ordinary differential equations using Laplace and inverse Laplace methods.
2. Analyze and compute Fourier, sine, and cosine transforms for mathematical and engineering applications.
3. Represent complex periodic and non-periodic functions using Euler's formulas and half-range expansions.
4. Find extremals of functionals involving single, multiple, or higher-order derivatives.
5.Analyze orthogonal function sets and solve both standard and non-Sturm-Liouville boundary problems.

MMA304: Probability and Stochastic Processes	
Teaching Scheme	**Examination Scheme**
Lectures:3hrs/Week	ClassTest-12Marks
Tutorials:1hr/Week	TeachersAssessment-6 Marks Attendance– 12Marks
Credits:4	End Semester Exam–70marks

Course Objectives:

1. To introduce the concepts of probability and stochastic processes
2. To illustrate these concepts with real applications.
3. Explanations and expositions of probability and stochastic processes.
4. To introduce the concepts of stochastic process in research
5. Theoretical concepts pertaining to handling various stochastic modeling

Detailed Syllabus

UNIT 1	Basic Probability: Introduction, definitions, Sample space, discrete probability, independent events, Laws, Conditional & Total probability, Bayes theorem, Concept of Random Variable, Some common discrete and continuous distributions, Distribution of Functions of Random Variables

UNIT 2	Sample space, discrete probability, independent events, Bayes theorem. Random variables and distribution functions, expectation and moments. Independent random variables, marginal and conditional distributions. Characteristic functions.
UNIT 3	Moments, Generating functions, Characteristics function, Two and higher dimensional distributions, Joint distributions, multivariate and multinomial distributions
UNIT 4	Conditional distributions, conditional expectation, correlation, covariance, Limit theorems: Modes of convergences, Modes of convergence, weak and strong laws of large numbers, Central limit theorem, Stochastic processes: Classification, properties, Simple stochastic processes
UNIT 5	Markov chains with finite and countable state space, classification of states, limiting behaviour of n-step transition probabilities, stationary distribution, Discrete time Markov chains, Continuous time Markov chains, Renewal process in continuous time Markov chain, Poisson and Birth and death processes, Simple Markovian Queuing models

Text Books:

1. J. Mehdi, "Stochastic Process" New age international publishers
2. V.K. Rohatgi & A.K. Md. E. Saleh, An Introduction to Probability and Statistics, Wiley

Reference Books:

1. Papoulis, S. U. Pillai, "Probability, Random Variables and Stochastic Processes", Tata McGraw Hill
2. S L Miller, D Childers, "Probability and Random Processes", Academic press.
3. Kishor S. Trivedi, Probability and Statistics with Reliability, Queueing and Computer Science Applications, second edition, Wiley, 2001.
4. Sheldon M. Ross, Introduction to Probability Models, 9th edition, Academic Press, 2000.
5. Liliana Blanco Castaneda, Viswanathan Arunachalam, S. Dharmaraja, Introduction to Probability and Stochastic Processes with Applications, Wiley, 2012.

Course Outcomes

On the successful completion of the course, student will be able:

1. Solve problems based on probability
2. Explain probability and probability distribution
3. Describe the moments and generating function
4. Explain the stochastic process and their properties
5. Explain the Markov chain and different types of state space

<table>
<tr><th colspan="2">MMA351- Python Lab</th></tr>
<tr><td>Teaching Scheme
Lab: 2Hrs/Week
Tutorials: 0 Hrs./Week</td><td>Examination Scheme
Internal-15Marks
External- 35 Marks</td></tr>
</table>

Credits: 2	

Course Objectives:

The course is designed to teach:

1. Describe the core syntax and semantics of Python programming language.
2. Discover the need for working with the strings and functions.
3. Illustrate the process of structuring the data using lists, dictionaries, tuples and sets.
4. Infer the Object-oriented Programming concepts in Python.
5. Creating and handling files in Python

List of Experiments/Programs

Program 1	Write a program to perform addition, subtraction, multiplication, division, and modulus of two numbers.
Program 2	Write a program to calculate Simple Interest and Compound Interest.
Program 3	Write a program to swap two numbers with and without using a third variable.
Program 4	Write a program to find the largest of three numbers using conditional statements.
Program 5	Write a program to check whether a number is prime.
Program 6	Write a function to calculate the square root of a number.
Program 7	Write a function to find the Least Common Multiple (LCM) of two numbers.
Program 8	Write a recursive function to calculate the factorial of a number.
Program 9	Write a program to check whether a string is a palindrome.
Program 10	Write a program to perform string operations (concatenation, slicing, searching, replacing, splitting, joining).
Program 11	Write a program to count the frequency of each character in a string.
Program 12	Write a program to perform list operations (append, insert, remove, pop, reverse, sort).
Program 13	Write a program to demonstrate tuple operations and tuple unpacking.
Program 14	Write a program to create, write, read, and append data to a text file.
Program 15	Write a program to create and import a user-defined module to perform arithmetic operations.

Course Outcomes:

On the successful completion of the course, student will be able:

1. Solve problems using various control statements, functions and strings in Python
2. Make use of Python lists, set, tuples, dictionaries.
3. Describe the fundamental elements of relational database management systems.
4. Explain the concepts of transaction processing, basic database storage structures and access techniques

MMA352: Internship / Field Work	
Teaching Scheme	**Examination Scheme**

Credits: 4	Internal Assessment - 30 Marks End Semester Exam - 70 Marks

Course Objectives:

1. **Provide students with practical exposure** to professional, industrial, research, or field environments related to mathematics and allied disciplines.
2. **Enable students to apply theoretical knowledge and practical skills** to real-world problems and professional situations.
3. **Develop professional competencies**, including teamwork, communication, time management, documentation, and technical report writing.
4. **Familiarize students with career opportunities** in industry, research, higher education, and other interdisciplinary fields.

Scope / Guidelines:

1. Students shall undertake an internship of **a minimum duration of 2–4 weeks or equivalent field work** in a research laboratory, industry, academic institution, or reputed organisation related to Mathematics, Data Science, or an allied area. Alternatively, students may undertake supervised field work, community-based activities, or a survey-based study under the guidance of a faculty mentor.
2. The internship or field work shall be **approved in advance by the Department** in consultation with the faculty mentor and, where applicable, the host organisation.
3. Students shall maintain a **work diary/logbook** documenting their activities, learning experiences, tasks performed, and skills acquired during the internship or field work.
4. Students shall follow the **professional, safety, ethical, and academic guidelines** of the host organisation or field activity.
5. At the completion of the internship/field work, students shall submit a **certificate from the host organisation**, wherever applicable, along with a comprehensive report in the format prescribed by the Department.
6. Students shall present their experience and learning outcomes through a **seminar/presentation** and appear for a viva-voce as part of the final evaluation.

Evaluation Scheme:

1. Internal Assessment (30 Marks): work-diary/log book, mentor's assessment and a mid-term presentation.

2. End Semester Examination (70 Marks): submission of the internship/field-work report and a viva-voce examination before a departmental committee.

Course Outcomes:

After completing the course, students will be able to:

CO1.	**Recall** relevant concepts and principles of Mathematics applicable to the assigned internship or field-work activities.

CO2.	**Explain** the tasks, procedures, tools, and professional practices encountered during the internship or field work.
CO3.	**Apply** theoretical knowledge and practical skills to address real-world problems and perform assigned professional or field-based tasks.
CO4.	**Analyse** observations, work experiences, technical information, or field data using appropriate scientific and analytical methods.
CO5.	**Evaluate** the outcomes of the internship or field work and critically reflect on the skills acquired, challenges encountered, and possible improvements.
CO6.	**Develop** professional competencies and effectively communicate the internship/field-work experience through a structured report, presentation, and viva-voce.

MMA401-Mathematical Modelling	
Teaching Scheme	**Examination Scheme**
Lectures:3hrs/Week	ClassTest-12Marks
Tutorials:1hr/Week	TeachersAssessment-6 Marks Attendance– 12Marks
Credits:4	End Semester Exam–70marks

Course Objectives:

1. To introduce the fundamental concepts, principles, and methodology of mathematical modelling for solving real-world problems.
2. To develop mathematical models using ordinary differential equations and analyze their applications in population dynamics, epidemiology, and other scientific fields.
3. To formulate and solve discrete mathematical models using difference equations for applications in economics, finance, genetics, and population studies.
4. To formulate and solve optimization problems using linear programming techniques, including transportation and assignment models.
5. To develop the ability to interpret, validate, and evaluate mathematical models and apply computational tools for modelling and decision-making.

Detailed Syllabus

UNIT 1	**Introduction to Mathematical Modelling:** Introduction to mathematical modelling, concept, objectives, scope, importance, and applications of mathematical models. Steps

	involved in the modelling process, classifications of mathematical models, characteristics, assumptions, limitations, validation and verification of models. Illustrative examples of mathematical modelling in physical sciences, biological sciences, environmental sciences, engineering, economics, and social sciences.
UNIT 2	**Mathematical Modelling through Ordinary Differential Equations**: Formulation of mathematical models using first-order ordinary differential equations, linear and nonlinear growth and decay models, logistic growth model, compartmental models, applications to population dynamics and epidemic modelling. Introduction to systems of ordinary differential equations, equilibrium points, and basic concepts of stability analysis.
UNIT 3	**Mathematical Modelling through Difference Equations:** Introduction to discrete mathematical models, formulation of discrete-time models, linear difference equations with constant coefficients, solution techniques, and applications to economics, finance, population dynamics, genetics, and other real-life problems.
UNIT 4	**Mathematical Modelling through Linear Programming**: Formulation of linear programming problems, graphical method of solution, transportation models, assignment models, and applications to production planning, resource allocation, forest management, logistics, and industrial optimization.
UNIT 5	**Applications and Case Studies in Mathematical Modelling:** Development and analysis of mathematical models for real-world problems arising in environmental sciences, epidemiology, engineering, agriculture, economics, and operations research. Interpretation of model results, model validation, sensitivity analysis (introductory concepts), limitations of models, and use of mathematical software/tools for modelling and simulation.

Text Books:

1. J. N. Kapur, Mathematical Modelling, 2nd Edition, New Age International (P) Ltd., Publishers, New Delhi, 1988.
2. Frank R. Giordano, William P. Fox and Steven B. Horton, A First Course in Mathematical Modeling, 5th Edition, Cengage Learning, Boston, 2014.
3. Edward A. Bender, An Introduction to Mathematical Modeling, Dover Publications, New York, 2000.
4. J. D. Murray, Mathematical Biology I: An Introduction, 3rd Edition, Springer-Verlag, New York, 2002.

Reference Books:

1. J. D. Murray, Mathematical Biology II: Spatial Models and Biomedical Applications, 3rd Edition, Springer-Verlag, New York, 2003.
2. N. Gerstenfeld, The Nature of Mathematical Modeling, Cambridge University Press, Cambridge, 1999.
3. Sandip Banerjee, Mathematical Modeling: Models, Analysis and Applications, CRC Press, Boca Raton, 2014.
4. Mark M. Meerschaert, Mathematical Modeling, 4th Edition, Academic Press, Elsevier, Amsterdam, 2013.
5. F. S. Hillier and G. J. Lieberman, Introduction to Operations Research, 10th Edition, McGraw-Hill Education, New York, 2015.

Course Outcomes:

At the end of the course, the student should be able to:

1. Explain the concepts, principles, classifications, assumptions, validation, and limitations of mathematical models and identify appropriate modelling techniques for real-life problems.
2. Formulate and analyze mathematical models using ordinary differential equations and interpret their applications in biological, environmental, and engineering systems.
3. Develop and solve discrete mathematical models using difference equations for applications in economics, finance, genetics, and population dynamics.
4. Formulate and solve optimization problems using linear programming techniques, transportation models, and assignment models for effective resource allocation and decision-making.
5. Analyze, validate, and interpret mathematical models using appropriate analytical and computational techniques, and apply them to interdisciplinary research and industrial applications.

MMA451: Matlab Laboratory	
Teaching Scheme	**Examination Scheme**
Lab: 2 hrs/Week	Internal:15Marks
Tutorials:0 hr/Week	External: 35 Marks
Credits:2	

Course Objectives:

1. To familiarize students with the MATLAB environment and advanced programming concepts.
2. To develop computational skills for solving mathematical problems using MATLAB.
3. To implement algorithms related to linear algebra, numerical methods, differential equations, and optimization.
4. To visualize mathematical functions, data, and solutions using two- and three-dimensional graphical tools.
5. To apply MATLAB for solving advanced mathematical problems and conducting computational experiments.

Detailed Syllabus

Program 1	Introduction to MATLAB environment, variables, matrices, vectors, arrays, scripts, user-defined functions, control statements, loops, logical operations, symbolic toolbox, and file handling.
Program 2	Matrix computations and Linear Algebra: matrix operations, inverse, determinant, rank, eigenvalues, eigenvectors, LU decomposition, QR decomposition, Singular Value Decomposition (SVD), and solving systems of linear equations.
Program 3	Numerical computations using MATLAB: root-finding techniques, interpolation, numerical differentiation, numerical integration, curve fitting, and polynomial approximation using built-in MATLAB functions.

Program 4	Differential Equations using MATLAB: symbolic solution using dsolve, numerical solution using ode45, ode23, ode15s, ode113, systems of ordinary differential equations, phase portraits, and introductory partial differential equations using MATLAB PDE tools.
Program 5	Optimization and Data Visualization: optimization using fminbnd, fmin search, linprog, quadprog, contour plots, surface plots, mesh plots, animations, and graphical presentation of computational results. A mini-project involving computational investigation of a mathematical problem using MATLAB.

Course Outcomes:

At the end of course, the student will be able to

1. Demonstrate proficiency in MATLAB programming for mathematical computing.
2. Solve linear algebra and numerical computation problems using MATLAB.
3. Solve ordinary and introductory partial differential equations using MATLAB built-in functions.
4. Visualize and interpret mathematical models and computational results using MATLAB graphics.
5. Apply MATLAB to investigate advanced mathematical problems and present computational results effectively.

Suggested Text Books:

1. Brian R. Hunt, Ronald L. Lipsman, and Jonathan M. Rosenberg, *A Guide to MATLAB*, Cambridge University Press.
2. Cleve Moler, *Experiments with MATLAB*, MathWorks.
3. Amos Gilat, *MATLAB: An Introduction with Applications*, Wiley.
4. Desmond J. Higham and Nicholas J. Higham, *MATLAB Guide*, SIAM.

Reference Books:

1. Steven C. Chapra, *Applied Numerical Methods with MATLAB for Engineers and Scientists*, McGraw-Hill.
2. Kendall E. Atkinson, *An Introduction to Numerical Analysis*, Wiley.
3. Gilbert Strang, *Introduction to Linear Algebra*, Wellesley-Cambridge Press.
4. William E. Boyce and Richard C. DiPrima, *Elementary Differential Equations and Boundary Value Problems*, Wiley.
5. MATLAB Documentation, MathWorks.

MMA452: Project Work	
Teaching Scheme	**Examination Scheme**
Credits: 8	Internal Assessment - 50 Marks End Semester Exam - 150 Marks

Course Objectives:

1. **Provide students with an opportunity to undertake an independent or guided project** in theoretical, experimental, computational, or interdisciplinary areas of Mathematics.

2. **Develop research skills** including literature review, problem formulation, methodology selection, data collection, analysis, and interpretation of results.
3. **Develop scientific communication skills** through systematic project documentation, report writing, oral presentation, and defence of the project work.
4. **Familiarize students with research ethics and academic practices** and prepare them for higher studies, research, and professional careers.

Scope / Guidelines:

1. Each student, or a small group as decided by the Department, shall undertake a project under the supervision of a faculty member in an area of Mathematics or an interdisciplinary field.
2. The project may be **experimental, theoretical, computational, or interdisciplinary**, and shall involve appropriate components such as literature survey, problem formulation, methodology, data collection or theoretical derivation, analysis, results, discussion, and conclusions.
3. Students shall submit a **project proposal/synopsis** at the beginning of the semester and present their progress periodically before the supervisor or departmental committee.
4. Students shall maintain appropriate records of their project work and follow accepted standards of **academic integrity, research ethics, and scientific documentation**.
5. A **final project report** in the prescribed format shall be submitted at the end of the semester, followed by a seminar/presentation and viva-voce examination.

Evaluation Scheme:

1. Internal Assessment (50 Marks): progress reviews, regularity, project synopsis and the supervisor's assessment of the work carried out.

2. End Semester Examination (100 Marks): submission of the project report, an open seminar/presentation, and a viva-voce examination before a departmental committee.

Course Outcomes:

After completing the course, students will be able to:

1. Formulate a research problem in Mathematics and carry out a systematic literature survey.

2. Plan and execute an experimental, theoretical or computational investigation using an appropriate methodology.

3. Analyse and interpret data/results and draw valid scientific conclusions.

4. Prepare a well-structured project report and defend the work through an oral presentation and viva-voce.

CO1.	**Recall** relevant concepts, principles, and scientific literature related to a selected project topic in Mathematics.
CO2.	**Explain** the background, objectives, methodology, and scientific significance of the selected project problem.

CO3.	**Apply** appropriate theoretical, experimental, computational, or analytical methods to investigate a defined problem.
CO4.	**Analyse** experimental data, computational results, or theoretical findings using suitable scientific and mathematical techniques.
CO5.	**Evaluate** the results critically, draw valid scientific conclusions, and identify limitations and possible future scope of the work.
CO6.	**Develop** a structured project report and effectively communicate and defend the project findings through scientific presentation and viva-voce.

Discipline Specific Elective (Mathematics) **MMA031/ MMA041/ MMA042/ MMA043** **(DISCRETE MATHEMATICS)**	
Teaching Scheme	**Examination Scheme**
Lectures:3hrs/Week	ClassTest-12Marks
Tutorials:1hr/Week	TeachersAssessment-6 Marks Attendance– 12Marks
Credits:4	End Semester Exam–70marks

Course Objectives:

1. To build formal logical reasoning and proof skills using mathematical induction and first-order logic.
2. To apply combinatorics, generating functions, and binary relations to model structural connections in data.
3. To analyze the time and space complexity of recursive and sorting algorithms using recurrence relations.
4. To utilize lattices, algebraic systems, and Boolean algebra to optimize digital logic circuits and expressions.
5. To implement classic graph and tree algorithms to solve network routing, searching, and optimization problems.

Detailed Syllabus

UNIT 1	**Mathematical Logic, Set Theory, and Induction:** Combinations of sets, Finite and infinite sets, Uncountably infinite sets, Propositions, Fundamentals of logic, first order logic, Principle of inclusion and exclusion, Mathematical induction, Ordered sets.

UNIT 2	**Combinatorics, Relations, and Functions:** Permutations, Combinations, Numeric functions, Generating functions, Properties of binary relations, Equivalence relations and partitions, Partial and total ordering relations, Transitive closure, Wars hall's algorithm.
UNIT 3	**Recurrence Relations and Recursive Algorithms:** Recurrence relations, Linear recurrence relations with constant coefficients, Solution by the method of generating functions, Recursive algorithms, Sorting algorithms
UNIT 4	**Lattices and Boolean Algebra:** Chains, Lattices and algebraic systems, Principle of duality, Basic properties of algebraic systems, Distributive and complemented lattices, Boolean lattices and algebras, Uniqueness of finite Boolean algebras, Boolean expressions and functions.
UNIT 5	**Graph Theory and Tree Algorithms:** Basic terminology of graphs, Multigraphs and weighted graphs, Paths and circuits, Shortest paths in weighted graphs, Eulerian paths and circuits, Hamiltonian paths and circuits, Colourable graphs, Chromatic numbers, Five-colour theorem, Four-colour problem, Trees, Rooted trees, Path lengths in rooted trees, Spanning trees, BFS and DFS algorithms, Minimum spanning trees, Prim's and Kruskal's algorithms.

Text Books:

1. C.L. Liu: Elements of Discrete Mathematics, McGraw Hill,1985.
2. J.P. Tremblay and R Manohar: Discrete Mathematical Structures with applications to Computer Science, McGraw Hill Book Co., New Delhi1975.

Reference Books:

1. J. L. Mott, A. Kandel and T. P. Baker: Discrete Mathematics for Computer Scientists, Reston Pub. Co,1983.
2. K.D. Joshi: Foundations in Discrete Mathematics, New Age International,1989.

Course Outcomes:

At the end of the course, the student should be able to:

1. Students will be able to construct formal mathematical proofs using first-order logic, set theory, and the principle of mathematical induction.
2. Students will be able to compute complex counting combinations and analyze properties of equivalence and partial ordering relations.
3. Students will be able to solve linear recurrence relations using generating functions to determine the efficiency of recursive and sorting algorithms.
4. Students will be able to apply properties of lattices and minimize boolean expressions for digital circuit design optimization.
5. Students will be able to execute graph coloring methods and tree traversal algorithms like BFS, DFS, Prim's, and Kruskal's for network optimization.

DATA ANALYSIS AND VISUALIZATION

Course Objectives:
The course is designed to teach:
1. To understand about data and representation
2. To learn about data analysis
3. To learn about machine learning
4. To learn about data mining and analysis
5. To learn about data visualization

Detailed Syllabus

Unit-1: Data Representation: Data Objects and Attribute Types: Nominal, Binary, Ordinal, Numeric, Discrete and Continuous, Types of data: Record, Temporal, Spatial Temporal, Graph, Unstructured and Semi structured data, Basic Statistical Descriptions of Data.
Unit-2: Introduction to Data Analysis: Probability and Random Variables, Correlation, Regression.
Unit-3: Data Analysis Pipeline: Data pre-processing- Attribute values, Attribute transformation, Sampling, Dimensionality reduction: PCA, Eigen faces, Multidimensional Scaling, Non-linear Methods, Graph based Semi-supervised Learning, Representation Learning Feature subset selection, Distance and Similarity calculation.
Unit-4: Data Mining Techniques for Analysis: Classification: Decision tree induction, Bayes classification, Rule-based classification, Support Vector Machines, Classification Using Frequent Patterns.
Unit-5: Visualization: Traditional Visualization, Multivariate Data Visualization, Principles of Perception, Color, Design, and Evaluation, Text Data Visualization, Network Data Visualization, Temporal Data Visualization and visualization Case Studies. learning

Text and Reference Books:

1. Han, J., M. Kamber, M. and J. Pei,J. Data Mining Concepts and Techniques, Morgan Kaufmann, 3rd edition, 2011.
2. Peng, R. D. R Programming for Data Science, Lulu.com, 2012.
3. Hastie, T., Tibshirani, R., and Friedman, J. The Elements of Statistical Learning, Springer, 2nd edition, 2009.

Simon, P.The Visual Organization: Data Visualization, Big Data, and the Quest for Better Decisions, John Wiley & Sons, 2014.

Course Outcomes:
The student will be able to
1. analyze and extract features of complex datasets.
2. evaluate and visualize inter-dependencies among variables in dataset.
3. apply techniques for classification and clustering in datasets.
4. develop and validate models for real life datasets.

FINITE ELEMENT METHOD

Introduction: Finite element methods, History and range of applications.
Finite Elements: Definition and properties, Assembly rules and general assembly procedure, Features of assembled matrix, Boundary conditions.
Continuum Problems: Classification of differential equations, Variational formulation approach, Ritz method, generalized definition of an element, Element equations from variations, Galperin's weighted residual approach, Energy balance methods.
Element Shapes and Interpolation Functions: Basic element shapes, Generalized co-ordinates, Polynomials, Natural co-ordinates in one- two- and three-dimensions, Lagrange and Hermite polynomials, Two-D and three-D elements for Co and C1 problems, Co-ordinate transformation, Iso-parametric elements and numerical integration, Application of finite element methods to heat transfer problems.

Recommended Books:

1. Bathe, K.J., Finite Element Procedures, Prentice Hall(2008).

2. Cook, R.D., Malkus, M.E.P. and Witt, R.J., Concepts and Applications of Finite Element Analysis, John Wiley and Sons(2001).

3. Reddy, J.N., An Introduction to the Finite Element Methods, McGraw-Hill(2006).

4. Thomson E. G., Introduction to the Finite Element: Theory, Programming and applications, Willey,(2004).

NUMERICAL LINEAR ALGEBRA

Special Matrices, Vector and Matrix Norms, SVD. Floating Point Numbers and Errors. Stability, Conditioning and Accuracy. Gauss Elimination and Linear Systems, LU Factorization using Gaussian Elimination, Stability of Gaussian Elimination, Basic Results on Existence and Uniqueness, Some Applications Giving Rise to Linear Systems of Problems, LU Factorization Methods, Conditioning and Pivoting, Inverses and Determinants.
Iterative Methods for Large and Sparse Problems: Gauss Seidal, SOR, Chebyshev Acceleration, Conjugate Gradient Method, Preconditioning. QR Factorization, SVD, and Least Squares Solutions. Numerical Eigenvalue Problems, Generalized Eigenvalue Problem.
Text Books:

1. G. H. Golub and C. F. van Loan: Matrix Computations, Johns Hopkins University Press,1984.

2. L. N. Trefethen and D. Bau, III: Numerical Linear Algebra, SIAM,1997.

3. G. Allaire and S. M. Kaber: Numerical Linear Algebra, Springer,2007.

4. B. N. Datta: Numerical Linear Algebra and Applications, Springer,2008.

BIO MATHEMATICS

Mathematical Biology and the modeling process: an overview. Continuous models: Malthus model, logistic growth, Allee effect,
Gompertz growth, Michaelis-Menten Kinetics, Holling type growth, Bacterial growth in a Chemostat, Harvesting a single natural population, Prey predator systems and LotkaVolterra equations, Populations in competitions, Epidemic Models (SI, SIR, SIRS, SIC), Activator-Inhibitor system, Insect Outbreak Model: Spruce Budworm, Numerical solution of the models and its graphical representation.

Qualitative analysis of continuous models: Steady state solutions, stability and linearization, multiple species communities and Routh- Hurwitz Criteria, Phase plane methods and qualitative solutions, bifurcations and limit cycles with examples in the context of biological scenario.
Spatial Models: One species model with diffusion, Two species model with diffusion, Conditions for diffusive instability, Spreading colonies of microorganisms, Blood flow in circulatory system, Traveling wave solutions, Spread of genes in a population.
Discrete Models: Overview of difference equations, steady state solution and linear stability analysis, Introduction to Discrete Models, Linear Models, Growth models, Decay models, Drug Delivery Problem, Discrete Prey-Predator models, Density dependent growth models with harvesting, Host-Parasitoid systems (Nicholson-Bailey model), Numerical solution of the models and its graphical representation.
Case Studies: Optimal Exploitation models, Models in Genetics, Stage Structure Models, Age Structure Models.

Books

1. Keshet, L. E., "Mathematical Models in Biology", SIAM**1988**
2. Murray, J. D., "Mathematical Biology", Springer**1993**
3. Fung, Y. C., "Biomechanics", Springer-Verlag**1990**
4. Brauer, F., Driessche, P. V. D. and Wu, J., "Mathematical Epidemiology",Springer2008
5 Kot, M., "Elements of Mathematical Ecology", Cambridge University Press2001

MULTIVARIABLE CALCULUS

Prerequisites: Real Analysis, Linear Algebra

Functions on Euclidean spaces, continuity, differentiability; partial and directional derivatives, Chain Rule, Inverse Function Theorem, Implicit Function Theorem.

Riemann Integral of real-valued functions on Euclidean spaces, measure zero sets, Fubini's

Theorem. Partition of unity, change of variables.

Integration on chains, tensors, differential forms, Poincare Lemma, singular chains, integration on chains, Stokes' Theorem for integrals of differential forms on chains. (general version). Fundamental theorem of calculus.

Differentiable manifolds (as subspaces of Euclidean spaces), differentiable functions on manifolds, tangent spaces, vector fields, differential forms on manifolds, orientations, integration on manifolds, Stokes' Theorem on manifolds.

References:

1. V. Guillemin and A. Pollack, Differential Topology, Prentice-Hall Inc., Englewood Cliffe, New Jersey,1974.

2. W. Fleming, Functions of Several Variables, 2nd Ed., Springer-Verlag, 1977.

3. J.R. Munkres, Analysis on Manifolds, Addison-Wesley,1991.

4. W. Rudin, Principles of Mathematical Analysis, 3rd ed., McGraw-Hill,1984.

5. M. Spivak, Calculus on Manifolds, A Modern Approach to Classical Theorems of Advanced Calculus, W. A. Benjamin, Inc.,1965.

INTRODUCTION TO ALGEBRAIC GEOMETRY

Varieties: Affine and projective varieties coordinate rings, morphism and rational maps, local ring of a point, function fields, dimension of a variety.

Curves: Singular points and tangent lines, multiplicities and local rings, intersection multiplicities, Bezout's theorem for plane curves, Max Noether's theorem and some of its applications, group law on a nonsingular cubic, rational parameterization, branches and valuations.

References:

1. S.S. Abhyankar, Algebraic Geometry for Scientists and Engineers, American Mathe-matical Society,1990.

2. W. Fulton, Algebraic Curves, Benjamin,1969.

3. J. Harris, Algebraic Geometry: A First Course, Springer-Verlag, 1992.

4. M. Reid, Undergraduate Algebraic Geometry, Cambridge University Press, Cambridge,1990.

5. I.R. Shafarevich, Basic Algebraic Geometry, Springer-Verlag, Berlin,1974.

6. R.J. Walker, Algebraic Curves, Springer- Verlag, Berlin,1950.

THEORY OF ANALYTIC FUNCTIONS

Prerequisites: Real Analysis, Complex Analysis.

Maximum Modulus Theorem. Schwarz Lemma. Phragmen-Lindelof

Theorem. Riemann Mapping Theorem. Weierstrass Factor-ization

Theorem. Runge's Theorem. Simple connectedness. Mittag-Leffler

Theorem. Schwarz Reflection Principle. Basic properties of harmonic

functions. Picard Theorems.

References:

1. L. Ahlfors, Complex Analysis, McGraw-Hill, 3rd ed., New York, 1979.
2. J.B. Conway, Functions of One Complex Variable, 2nd ed., Narosa, New Delhi1978.
3. T.W. Gamelin, Complex Analysis, Springer International, 2001.
4. R. Narasimhan, Theory of Functions of One Complex Variable, Springer (India),2001.
5. W. Rudin, Real and Complex Analysis, 3rd ed., Tata McGraw-Hill,1987.

FOURIER ANALYSIS AND APPLICATIONS

Prerequisite: Real Analysis

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.

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.
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.
Optional Topics:

Applications to PDEs, Wavelets and X-ray
tomography. Applications to Number Theory.

References:

1. R. Strichartz, A Guide to Distributions and Fourier Transforms, CRCPress.
2. E.M. Stein and R. Shakarchi, Fourier Analysis: An Introduction, Princeton University Press, Princeton2003.
3. I.Richards and H. Youn, Theory of Distributions and Non-technical Approach, Cambridge University Press, Cambridge,1990.

INVERTIS UNIVERSITY BAREILLY

NETWORK MODELS

Recap of Linear Programming and duality. Transportation and Assignment. Maximum flow and minimum cut (duality, Ford and Fulkerson algorithm, polynomial time algorithms).
Minimum Cost Flows (cycle cancelling algorithms, successive path algorithms). Matching (bipartite matching, weighted bipartite matching, cardinality general matching).
Routing algorithms (Bellman Ford algorithm in computer networks, Dijkstra's algorithm in computer networks), Application of network models.

References:

1. R.K. Ahuja, T.L. Magnanti, J.B. Orlin, Network Flows, Prentice Hall,1993
2. D. Bertsekas, Network Optimization: Continuos and Discrete Models, Athena Scientific,1998
3. M.S. Bazaraa, J.J. Jarvis, H.D. Sherali, Linear Programming and Network Flows, SecondEdition,

STOCHASTIC PROGRAMMING AND APPLICATIONS

Quadratic and Nonlinear Programming solution methods applied to Chance Constrained Pro-ramming problems. Stochastic Linear and Non-linear Programming Problems. Applications in inventory control and other industrial systems, optimization of queuing models of computer networks, information processing under uncertainty. Two stage and multi-stage solution techniques. Dynamic programming with Recourse. Use of Monte Carlo, probabilistic and heuristics algorithms. Genetic algorithms and Neural networks for adaptive optimization in random environment.

References:

1. J.R. Birge, and F. Louveaux: Introduction to Stochastic Programming. Springer, New York,1997.
2. V.V. Kolbin, Stochastic programming, D. Reidel Publications, Dordrecht,1977
3. S.S. Rao Engineering Optimization: Theory and Practice. 3rd Ed., John Wiley & Sons Inc., NY 1996/ 2002.
4. J.K. Sengupta, Stochastic Optimizations and Economic Models. D. Reidel Publications, Dordrecht, 1986.
5. K. Marti: Stochastic Optimization Methods. Springer,2005
6. Y. Ermoliev and R.J-B. Wets, Numerical Techniques for Stochastic Optimization, .Springer Verlag, Berlin,1988.
7. Z. Michaeleawicz, General Algorithms + Data Structures - Evolution Program. Springer-Verlag, Berlin,1992.

8. R. J.-B. Wets and W. T. Ziemba (eds.): Stochastic Programming: State of the Art, 1998, Annals of Oper. Res. 85, Baltzer, Amsterdam, 1999.

DIFFERENTIAL GEOMETRY

Curves in space R^3, parameterized curves, regular curves, helices, arc length, reparameterization (by arc length), tangent, principal normal, binormal, osculating plane, normal plane, rectifying plane, curvature and torsion of smooth curves, Frenet-Serret formulae, Frenet approximation of a space curve. Osculating circle, osculating sphere, spherical indicatrices, involutes and evolutes, intrinsic equations of space curves, isometries of $R3$, fundamental theorem of space curves, surfaces in $R3$, regular surfaces, co-ordinate neighborhoods, parameterized surfaces, change of parameters, level sets of smooth functions on $R3$, surfaces of revolution, tangent vectors, tangent plane, differential of a map. Normal fields and orientability of surfaces, angle between two intersecting curves on a surface, Gauss map and its properties, Weingarten map, second and third fundamental forms, classification of points on a surface.Curvature of curves on surfaces, normal curvature, Meusnier theorem, principal curvatures, geometric interpretation of principal curvatures, Euler theorem, mean curvature, lines of curvature, umbilical points, minimal surfaces, definition and examples, Gaussian curvature, intrinsic formulae for the Gaussian curvature, isometries of surfaces, Gauss Theorem Egregium (statement only). Christoffel symbols, Gauss formulae, Weingarten formulae, Gauss
equations, Codazzi-Mainardi equations, curvature tensor, geodesics, geodesics on a surface of revolution, geodesic curvature of a curve, Gauss-Bonnet Theorem (statement only).

References:

1. M. P. Do Carmo, Differential Geometry of Curves and Surfaces, Prentice-Hall, Inc., Englewood Cliffs,
New Jersey, 1976.
2. B. O' Neill, Elementary Differential Geometry, Academic Press, 1997.
3. A. Gray, Differential Geometry of Curves and Surfaces, CRC Press, 1998.
4. A. Pressley, Elementary Differential Geometry, Springer (Undergraduate Mathematics Series), 2001.
5. J. A. Thorpe, Elementary Topics in Differential Geometry, Springer (Undergraduate Texts in Mathematics),
1979.

MODERN THEORY OF PARTIALDIFFERENTIAL EQUATIONS

Prerequisites: Functional Analysis, Partial Differential Equations.
Theory of distributions: supports, test functions, regular and singular distributions, generalized derivatives. Sobolev Spaces: definition and basic properties, approximation by smooth functions, dual spaces, trace and imbedding results (without proof).
Elliptic Boundary Value Problems: abstract variational problems, Lax-Milgram Lemma, weak solutions and well posed Ness with examples, regularity result, maximum principles, eigen value problems.

Semigroup Theory and Applications: exponential map, C_0-semigroups, Hille-Yosida and Lummer-Phillips theorems, applications to heat and wave equations.

References:

1. S. Kesavan, Topics in Functional Analysis Wiley Eastern Ltd., New Delhi,1989.
2. M. Renardy and R.C. Rogers, An Introduction to Partial Differential Equations,2nd ed., Springer Verlag International Edition, New York,2004.
3. L.C. Evans, Partial Differential Equations, AMS, Providence,1998

Fluid Mechanics

Elementary notions of fluid motion Equation of continuity,: Body forces and surface forces, streamlines, Nature of stresses, Transformation of stress components, Stress invariants, Principal stresses, Nature of strains, Rates of strain components, Relation between stress and rate of strain components, General displacement of a fluid element, Newton's law of viscosity, Navier-Stokes equation (sketch of proof).Equation of motion for inviscid fluid, Energy equation, Vortex motion-Helmholtz's vorticity theorem and vorticity equation, Kelvin's circulation Theorem, Mean Potential over a spherical surface, Kelvin's Minimum kinetic energy Theorem, Acyclic irrotational motion. Euler's Equation of motion, Bernoulli's theorem, Impulsive actions. Two dimensional irrotational motion – Complex potential, Concept offline vortices, Vortex rows and the Karman vortex street,

Milne-Thomson Circle Theorem, Complex potential for a uniform flow past a circular cylinder, Streaming and circulation about a fixed circular cylinder, Blasius Theorem, Conformal transformation Uniform line distributions (source, vortex and doublet) under conformal transformation. Three dimensional irrotational flow: Axisymmetric flow, Stokes stream function, Axisymmetric potential flow, Butler's sphere theorem, Liquid streaming past a stationary sphere, Uniform motion of a sphere in a liquid at rest at infinity, Concentric spheres (Problem of Initial motion). Gravity waves – Surface waves on the infinite free surface of liquids, Waves at the interface between finitely and infinitely deep liquids.

References:

1. L. D. Landau and E. M. Lifshitz, Fluid Mechanics, Butterworth-Heinemann, 2ndEdition, 1987.
2. N. Curle and H. J. Davies, Modern Fluid Dynamics, Vol. I, D. van Nostrand Comp. Ltd., London, 1968.
3. S. W. Yuan, Foundations of Fluid Mechanics, Prentice-Hall, Englewood Cliffs, NJ, 1967.
4. A. S. Ramsey, A Treatise on Hydrodynamics, Part I, G. Bell and Sons Ltd. 1960.
5. W. H. Besant and A. S. Ramsey, *A Treatise on Hydrodynamics*, CBS Publishers and Distributors, Delhi,
1988.

NUMERICAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS

Prerequisite: Partial Differential Equations

Finite differences: grids, derivation of difference equations. Elliptic equations, discrete maximum principle and stability, residual correction methods (Jacobi, Gauss-Seidel and SOR methods), LOD and ADI methods. Finite difference schemes for initial and boundary value problems: Stability (matrix method, von- Neumann and energy methods), Lax-Richtmyer equivalence Theorem. Parabolic equations: explicit and implicit methods (Backward Euler and Crank-Nicolson schemes) with stability and convergence, ADI methods. Linear scalar conservation law: upwind, Lax-Wendroff and Lax-Friedrich schemes and CFL condition.

Lab Component: Exposure to MATLAB and computational experiments based on the algorithms discussed in the course.

References:

1. R. Mitchell and S. D. F. Griffiths, The Finite Difference Methods in Partial Differential Equations, Wiley and Sons, NY,1980.
2. G.D. Smith, Numerical Solutions of Partial Differential Equations, 3rd Edition, Clarendon Press, Oxford,1985.
3. J.C. Strikwerda, Finite difference Schemes and Partial Differential Equations, Wadsworth and Brooks/ Cole Advanced Books and Software, Pacific Grove, California,1989.
4. J.W. Thomas, Numerical Partial Differential Equations: Finite Difference Methods, Texts in Applied Mathematics, Vol. 22, Springer Verlag, NY,1999.
5. J.W. Thomas, Numerical Partial Differential Equations: Conservation Laws and Elliptic Equations, Texts in Applied Mathematics, Vol. 33, Springer Verlag, NY, 1999.

TENSORS AND RIEMANNIAN GEOMETRY

n-dimensional real vector space, contra variant vectors, dual vector space, covariant vectors, tensor product, second
order tensors, tensors of type (r, s), symmetry and skew symmetry of tensors, fundamental algebraic operations, inner product, quotient law of tensors. Differentiable manifolds of dimension n, tangent spaces, transformation of coordinates, transformation laws for contra variant (tangent), covariant (cotangent) vectors and tensors of higher order, connection, covariant differentiation and curvature tensor, parallelism. Riemannian metric, Christoffel symbols, curvature tensor with respect to Christoffel symbols, differential operators, geodesics, Riemann curvature tensor. Lie derivative, Lie derivatives of scalars, vectors, tensors and linear connections, commutation formulae for Lie differential operator and covariant differential operator. Motion, affine motion, projective motion in a Riemannian space, curvature collineation, conformal and homothetic transformations.

References:

1. R. S. Mishra, A Course in Tensors with Applications to Riemannian Geometry, Pothishala Pvt. Ltd., Allahabad, 1965.
2. K. Yano, The Theory of Lie Derivatives and its Applications, North-Holland Publishing Company, Amsterdam, 1957.
3. C. E. Weatherburn, An Introduction to Riemannian Geometry and the Tensor Calculus, Cambridge University Press, 2008.
4. Matthew S. Smith, Principles and Applications of Tensor Analysis, W. Sons Indianapolis, 1963.

NUMBER THEORY AND CRYPTOGRAPHY

Number Theory: Introduction, Time estimates for doing arithmetic. Divisibility and Euclidean algorithm. Congruencies. Some applications to factoring. Finite Fields and quadratic residues: Finite Fields, Quadratic Residues and Reciprocity.
Cryptography: Some simple crypto Systems. Enciphering matrices. Public Key: The Idea of Public key Cryptography. RSA. Discrete log. Knapsack. Zero-knowledge protocols and Oblivious Transfer. Pseudo Primes, Rho Method, Fermat factorization and Factor bases.

References:

1. Neal Koblitz, A Course in Number Theory and cryptography: A Graduate Text, Springer (SecondEd).

INTEGRAL EQUATION AND CALCULUS OF VARIATION

Detailed Syllabus

Method of separation of variables: Laplace, Diffusion and Wave equations in Cartesian, cylindrical and spherical polar coordinates, Boundary value problems for transverse vibrations in a string of finite length and heat diffusion in a finite rod, Classification of linear integral equations, Relation between differential and integral equations. Fredholm equations of second kind with separable kernels, Fredholm alternative theorem, Eigen values and eigen functions, Method of successive approximation for Fredholm and Volterra equations, Resolvent kernel.

Functionals and extremals, Variation and its properties, Euler equations, Cases of several dependent and independent variables, Functionals dependent on higher derivatives, Parametric forms, Simple applications.

References:

1. I. N. Sneddon, Elements of Partial Differential Equations, McGraw-Hill, 1957.
2. T. Amaranath, An Elementary Course in Partial Differential Equations, Narosa Publishing House, New Delhi, 2005.
3. R. P. Kanwal, Linear Integral Equations, Birkhäuser, Inc., Boston, MA, 1997.
4. L. Elsgolts, Differential Equations and Calculus of Variations, Mir Publishers, 1970.
5. A. S. Gupta, Calculus of Variations, Prentice Hall of India, New Delhi, 1999.

FINANCIAL MATHEMATICS

Detailed Syllabus

Basic principles: Comparison, arbitrage and risk a version, Interest (simple and compound, discrete and continuous), time value of money, Inflation, net present value, internal rate of return (calculation by bisection and Newton-Raphson methods), comparison of NPV and IRR. Bonds, bond prices and yields, Macaulay and modified duration, term structure of interest rates: spot and forward rates, explanations of term structure, running present value, floating-rate bonds, immunization, convexity, puttable and callable bonds.

Asset return, short selling, portfolio return, (brief introduction to expectation, variance, covariance and correlation), random returns, portfolio mean return and variance, diversification, portfolio diagram, feasible set, Markowitz model (review of Lagrange multipliers for 1 and 2 constraints), Two fund theorem, risk free assets, One fund theorem, capital market line, Sharpe index. Capital Asset Pricing Model (CAPM), betas of stocks and portfolios, security market line, use of CAPM in investment analysis and as a pricing formula, Jensen's index.

Forwards and futures, marking to market, value of a forward/futures contract, replicating portfolios, futures on assets with known income or dividend yield, currency futures, hedging (short, long, cross, rolling), optimal hedge ratio, hedging with stock index futures, interest rate futures, swaps. Lognormal distribution, Lognormal model/ Geometric Brownian Motion for stock prices, Binomial Tree model for stock prices, parameter estimation, comparison of the models. Options, Types of options: put / call, European / American, pay off of an option, factors affecting option prices, put call parity.

References:

1. **David G. Luenberger**, *Investment Science*, Oxford University Press, Delhi, 1998.
2. **John C. Hull**, *Options, Futures and Other Derivatives* (6th Edition), Prentice-Hall India, Indian reprint,2006.
3. **Sheldon Ross**, *An Elementary Introduction to Mathematical Finance* (2nd Edition), Cambridge University Press, USA, 2003.

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Data Science

MMA 305: Artificial Intelligence & Machine Learning	
Teaching Scheme Lectures:3hrs/Week Tutorials:1hr/Week Credits:4	**Examination Scheme** ClassTest-12Marks Teachers Assessment: 6Marks Attendance– 12Marks End Semester Exam–70marks

Course Objectives:

The course is designed to teach:

1. To understand about Artificial Intelligence.
2. To learn about search strategies and scope of AI.
3. To learn about machine learning.
4. To learn about types of machine learning and applications.
5. To learn about supervised, unsupervised, semi-supervised and reinforcement learning.

Detailed Syllabus

UNIT 1	Introduction of AI, foundation of AI and history of AI intelligent agents, the concept of rationality, the nature of environments, structure of agents, problem solving agents, problem formulation, scope and applications of AI
UNIT 2	Searching for solutions, uniformed search strategies - Breadth first search, depth limited Search. Search with partial information (Heuristic search) Greedy best first search, Memory -bounded heuristic search Local search algorithms- Hill climbing, Simulated annealing search, Local beam search.
UNIT 3	Introduction to Machine learning, definition of Machine Learning, Basic components of learning process, Application of Machine Learning
UNIT 4	Types of machine learning, Supervised learning, Unsupervised Learning, applications of supervised and unsupervised learning
UNIT 5	Self-supervised learning, Semi-supervised Learning, Reinforced Learning, Batch learning, Online learning, Instance-based learning, Model based learning, advantages and disadvantages of instance-based learning

Text and Reference Books:

1. Yagna Narayana, B. Artificial Neural Networks, Pearson Education, Delhi.
2. Kolman, Bernard, & Hill, David R. (2001). Introductory Linear Algebra with Applications (7th ed.). Pearson Education, Delhi.
3. Hoffman, Kenneth, & Kunze, Ray Alden (1978). Linear Algebra (2nd ed.). Prentice Hall of India

Pvt. Limited. Delhi. Pearson Education India Reprint, 2015.

4. Bishop,C.(2006).PatternRecognitionandMachineLearning.Berlin:Springer-Verlag.
5. Russel,S. andNorving,P.(2003).ArtificialIntelligence: A ModernApproach.2ndEdition, New York:Prentice-Hall.

Course Outcomes:

At the end of the course, the student should be able to:

1. Explain Artificial Intelligence
2. Utilize Artificial Intelligence
3. Understanding about machine learning
4. Understanding of the strengths and weaknesses of many popular machine learning approaches.
5. Understanding of mathematical relationships within and across Machine Learning algorithms and the paradigms of supervised and un-supervised learning.

MMA306: Data Warehouse and Data Mining	
Teaching Scheme	**Examination Scheme**
Lectures:3hrs/Week	ClassTest-12Marks
Tutorials:1hr/Week	TeachersAssessment-6 Marks Attendance– 12Marks
Credits:4	End Semester Exam–70marks

Course Objectives:

CO1	To learn a basic concept of Data warehousing.
CO2	To learn various models of data warehousing
CO3	To understand the concept of data mining
CO4	To understand the concept of Data Compression. Statistical measures in large Databases
CO5	To understand basic OLAP functions

Detailed Syllabus

MODULE-I

Data Warehousing: Overview, Definition, Delivery Process, Difference between Database System and Data Warehouse, Multi-Dimensional Data Model, Data Cubes, Stars, Snow Flakes, Fact Constellations, Concept hierarchy, 3 Tier Architecture, Historical information, Query Facility, OLAP function and Tools. OLAP Servers, ROLAP, MOLAP, HOLAP, Data Mining interface, Security, Backup and Recovery, Testing Data Warehouse

MODULE-II

Data Mining: Overview, Definition & Functionalities, Data Processing, Form of Data Preprocessing, Data Cleaning: Missing Values, Noisy Data, (Binning, Clustering, Regression, Computer and Human inspection),Inconsistent Data, Data Integration and Transformation. Data Reduction: Data Cube Aggregation, Dimensionality reduction, Data Compression. Statistical measures in large Databases. Measuring Central Tendency, Measuring Dispersion of Data, Graph Displays of Basic Statistical class

Description, Mining Association Rules in Large Databases, Association rule mining, Mining Single-Dimensional Boolean Association rules from Transactional Databases, Apriori-Algorithm, Mining Multilevel Association rules from Transaction Databases and Mining Multi-Dimensional Association rules from Relational Databases

MODULE-III

Classification and Predictions: What is Classification & Prediction, Issues regarding Classification and prediction, Decision tree, Bayesian Classification, Classification by Back propagation, Multilayer feed-forward Neural Network, Back propagation Algorithm, Classification methods K-nearest neighbor classifiers, Genetic Algorithm. Cluster Analysis: Data types in cluster analysis, Categories of clustering methods, Partitioning methods. Hierarchical Clustering- CURE and Chameleon, Grid Based Methods-STING, CLIQUE, Model Based Method –Statistical Approach, Neural Network approach, Outlier Analysis

Course Outcomes: After the completion of the course the student will be able to:

CO1	Analyze the basic functions of data warehouse and data mining.
CO2	Design data warehouse with dimensional modelling and apply different operations.
CO3	Analyze OLAP functions
CO4	Analyze appropriate data mining algorithms to solve real world problems
CO5	Evaluate different data mining techniques like classification, prediction.

Text Books:

1. Alex Berson, Stephen Smith,"Data Warehousing, Data Mining & OLAP" TMH Publication.
2. Jiawei Han, Micheline Kamber, "Data Mining Concepts & Techniques" Elsevier

Reference Books:

1. Sam Anahory, Dennis Murray, "Data Warehousing in the Real World: A Practical Guide for Building Decision Support Systems, Pearson Education
2. Mallach,"Data Warehousing System", McGraw –Hill3. M.H. Dunham," Data Mining: Introductory and Advanced Topics" Pearson Education

MMA353: Machine Learning with Python Lab	
Teaching Scheme Lab: 2Hrs/Week Tutorials: 0 Hrs./Week Credits: 2	**Examination Scheme** Internal-15Marks External- 35 Marks

Course Objectives:

The main objectives of this course are to:

To understand the creation, compilation and debug a python program

To understand decision making programs using control statements
To understand Label Encoding and One-Hot Encoding
To understand Simple Linear Regression, Multiple Linear Regression and ,Logistic Regression
To understand K-Nearest Neighbors (KNN) ,K-Means Clustering and Confusion Matrix

List of Programs
Program 1: Write a Python program to load a dataset (CSV file) using Pandas, display the first few rows, and check for missing values.
Program 2: Write a Python program to calculate basic statistical measures (mean, median, mode, standard deviation) for a dataset using NumPy and Pandas.
Program 3: Write a Python program to create data visualizations like histograms, scatter plots, and box plots using Matplotlib and Seaborn.
Program 4: Write a Python program to handle missing data by dropping or filling missing values with mean or median.
Program 5: Write a Python program to convert categorical text data into numerical values using Label Encoding and One-Hot Encoding.
Program 6: Write a Python program to scale numerical features using StandardScaler and MinMaxScaler from Scikit-Learn.
Program 7: Write a Python program to split a dataset into training and testing sets using train_test_split.
Program 8: Write a Python program to implement Simple Linear Regression to predict a target variable based on a single feature.
Program 9: Write a Python program to implement Multiple Linear Regression and evaluate the model using Mean Squared Error (MSE) and R^2 score.
Program 10: Write a Python program to implement Logistic Regression for a binary classification problem.
Program 11: Write a Python program to build a K-Nearest Neighbors (KNN) classifier and find the best value for K.
Program 12: Write a Python program to implement a Decision Tree Classifier and plot the decision tree structure.
Program 13: Write a Python program to generate a Confusion Matrix, accuracy score, precision, and recall for a classification model.
Program 14: Write a Python program to implement K-Means Clustering and find the optimal number of clusters using the Elbow Method.
Program 15: Write a Python program to perform Principal Component Analysis (PCA) for dimensionality reduction.

Course Outcomes:
After successful completion of the course, students will be able to:
1. Explain the fundamental concepts of python and Machine Learning
2. Demonstrate an understanding of the fundamentals of python programming
3. Develop Python program to create data visualizations
4. Develop python program to generate a Confusion Matrix
5. Develop Python program to perform Principal Component Analysis (PCA) for dimensionality reduction.

MMA402: Database Management System	
Teaching Scheme	**Examination Scheme**
Lectures:3hrs/Week	ClassTest-12Marks

Tutorials:1hr/Week	TeachersAssessment-6 Marks Attendance– 12Marks
Credits:4	End Semester Exam–70marks

Course Objectives:

CO1	To describe a sound introduction to the discipline of database management systems.
CO2	To give a good formal foundation on the relational model of data and usage of Relational Algebra.
CO3	To introduce the concepts of basic SQL as a universal Database language.
CO4	To demonstrate the principles behind systematic database design approaches by covering conceptual design, logical design through normalization.
CO5	To provide an overview of physical design of a database system, by discussing Data base indexing techniques and storage techniques.

Detailed Syllabus

MODULE-I

Introduction: An overview of database management system, database system Vs file system, Database system concept and architecture, data model schema and instances, data independence and database language and interfaces, data definitions language, DML, Overall Database Structure.

Data Modeling:

ER Data model, notation for ER diagram, mapping constraints, keys, Concepts of Super Key, candidate key, primary key, Generalization, aggregation, reduction of an ER diagrams to tables, extended ER model, relationship of higher degree.

Relational data model concepts, integrity constraints, entity integrity, referential integrity, Keys constraints, Domain constraints, relational algebra, relational calculus, tuple and domain calculus.

MODULE-II

Introduction on SQL: Characteristics of SQL, advantage of SQL. SQl data type and literals, Types of SQL commands, SQL operators, Tables, views and indexes, Insert, update and delete operations, Queries and sub queries Aggregate functions, Joins, Unions, Intersection, Minus, Cursors, Triggers.

Data Base Design & Normalization: Functional dependencies, normal forms, first, second, third normal forms, BCNF, inclusion dependence, loss less join decompositions, normalization using FD, MVD, and JDs, alternative approaches to database design.

MODULE-III

Transaction Processing Concept: Transaction system, testing of serializability, serializability of schedules, Types of serializability, recoverability, Recovery from transaction failures, log-based recovery, checkpoints, deadlock handling.

Concurrency Control Techniques: Concurrency control, Locking Techniques for concurrency control, Timestamping protocols for concurrency control, validation-based protocol, multiple granularity, Multi version schemes, Recovery with concurrent transaction, case study of Oracle.

Course Outcomes: After the completion of the course the student will be able to:

CO1	Understand the role of a database management system in an Organization.
CO2	Understand basic database concepts, including the structure and Operation of the relational data model.
CO3	. Construct simple and moderately advanced database queries using Structured Query Language (SQL).
CO4	Understand and successfully apply logical database design Principles, including E-R diagrams and database normalization.
CO5	Understand the concept of a database transaction and related database facilities, including concurrency control, journaling, backup and recovery, and data object locking and protocols.

Text Books:-

1. Date C J, " An Introduction to Database Systems", Addision Wesley
2. Korth, Silbertz, Sudarshan," Database Concepts", McGraw Hill

Reference Books:-

1. Elmasri, Navathe, " Fudamentals of Database Systems", Addision Wesley
2. O'Neil, Databases, Elsevier Pub.
3. Leon &Leon,"Database Management Systems", Vikas Publishing House
4. Bipin C. Desai, " An Introduction to Database Systems", Gagotia Publications
5. Majumdar& Bhattacharya, "Database Management System", TMH

MMA453: Database Management System Lab	
Teaching Scheme	**Examination Scheme**
Lab: 2 hrs/Week	Internal:15Marks
Tutorials:0 hr/Week	External: 35 Marks
Credits:2	

Pre-requisites: None

Course Objectives:

CO1	To describe a sound introduction to the discipline of database management systems.
CO2	To give a good formal foundation on the relational model of data and usage of Relational Algebra.
CO3	To introduce the concepts of basic SQL as a universal Database language.
CO4	To demonstrate the principles behind systematic database design approaches by covering conceptual design, logical design through normalization.

CO5	To provide an overview of physical design of a database system, by discussing Database indexing techniques and storage techniques.

Detailed Syllabus

List of Practicals
1. ER Model and Database Design: Design an ER diagram for a real-world application and convert it into relational tables.
2. DDL and Integrity Constraints: Create tables using DDL commands and implement Primary Key, Foreign Key, NOT NULL, UNIQUE and CHECK constraints.
3. DML Operations: Perform INSERT, UPDATE and DELETE operations on relational tables.
4. SQL Queries: Execute SQL queries using operators, aggregate functions, GROUP BY, HAVING and ORDER BY clauses.
5. Joins and Subqueries: Implement different types of joins and nested/subqueries for retrieving data from multiple tables.
6. Views and Indexes: Create, modify and use views and indexes for efficient data retrieval.
7. Set Operations: Perform UNION, INTERSECT and MINUS/EXCEPT operations on relational tables.
8. Cursors and Triggers: Implement cursors and triggers for automated database operations and data validation.
9. Normalization: Identify functional dependencies and normalize a given relation up to 3NF/BCNF.
10. Transaction Processing: Demonstrate transactions using COMMIT, ROLLBACK and SAVEPOINT and study ACID properties.
11. Serializability and Concurrency Control: Analyze transaction schedules for conflict serializability and implement basic Two-Phase Locking (2PL).
12. Database Recovery and Deadlock: Demonstrate log-based recovery, checkpoints and analyze a simple deadlock situation.

Text Books:-

1. Date C J, “ An Introduction to Database Systems”, Addision Wesley
2. Korth, Silbertz, Sudarshan,” Database Concepts”, McGraw Hill

Reference Books:-

1. Elmasri, Navathe, “ Fudamentals of Database Systems”, Addision Wesley
2. O’Neil, Databases, Elsevier Pub.
3. Leon &Leon,”Database Management Systems”, Vikas Publishing House
4. Bipin C. Desai, “ An Introduction to Database Systems”, Gagotia Publications
5.Majumdar& Bhattacharya, “Database Management System”, TMH

Course Outcomes: After the completion of the course the student will be able to:

CO1	Understand the role of a database management system in an Organization.
CO2	Understand basic database concepts, including the structure and Operation of the relational data model.

CO3	. Construct simple and moderately advanced database queries using Structured Query Language (SQL).
CO4	Understand and successfully apply logical database design Principles, including E-R diagrams and database normalization.
CO5	Understand the concept of a database transaction and related database facilities, including concurrency control, journaling, backup and recovery, and data object locking and protocols.

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Discipline Specific Elective (Data Science) **MMA032 / MMA044 / MMA045**	
Teaching Scheme Lectures:3hrs/Week Tutorials:1hr/Week Credits:4	**Examination Scheme** ClassTest-12Marks TeachersAssessment-6 Marks Attendance– 12Marks End Semester Exam–70marks

DISCRETE MATHEMATICS

Course Objectives:

6. To build formal logical reasoning and proof skills using mathematical induction and first-order logic.
7. To apply combinatorics, generating functions, and binary relations to model structural connections in data.
8. To analyze the time and space complexity of recursive and sorting algorithms using recurrence relations.
9. To utilize lattices, algebraic systems, and Boolean algebra to optimize digital logic circuits and expressions.
10. To implement classic graph and tree algorithms to solve network routing, searching, and optimization problems.

Detailed Syllabus

UNIT 1	**Mathematical Logic, Set Theory, and Induction:** Combinations of sets, Finite and infinite sets, Uncountably infinite sets, Propositions, Fundamentals of logic, first order logic, Principle of inclusion and exclusion, Mathematical induction, Ordered sets.

UNIT 2	**Combinatorics, Relations, and Functions:** Permutations, Combinations, Numeric functions, Generating functions, Properties of binary relations, Equivalence relations and partitions, Partial and total ordering relations, Transitive closure, Wars hall's algorithm.
UNIT 3	**Recurrence Relations and Recursive Algorithms:** Recurrence relations, Linear recurrence relations with constant coefficients, Solution by the method of generating functions, Recursive algorithms, Sorting algorithms
UNIT 4	**Lattices and Boolean Algebra:** Chains, Lattices and algebraic systems, Principle of duality, Basic properties of algebraic systems, Distributive and complemented lattices, Boolean lattices and algebras, Uniqueness of finite Boolean algebras, Boolean expressions and functions.
UNIT 5	**Graph Theory and Tree Algorithms:** Basic terminology of graphs, Multigraphs and weighted graphs, Paths and circuits, Shortest paths in weighted graphs, Eulerian paths and circuits, Hamiltonian paths and circuits, Colourable graphs, Chromatic numbers, Five-colour theorem, Four-colour problem, Trees, Rooted trees, Path lengths in rooted trees, Spanning trees, BFS and DFS algorithms, Minimum spanning trees, Prim's and Kruskal's algorithms.

Text Books:

3. C.L. Liu: Elements of Discrete Mathematics, McGraw Hill,1985.
4. J.P. Tremblay and R Manohar: Discrete Mathematical Structures with applications to Computer Science, McGraw Hill Book Co., New Delhi1975.

Reference Books:

3. J. L. Mott, A. Kandel and T. P. Baker: Discrete Mathematics for Computer Scientists, Reston Pub. Co,1983.
4. K.D. Joshi: Foundations in Discrete Mathematics, New Age International,1989.

Course Outcomes:

At the end of the course, the student should be able to:

6. Students will be able to construct formal mathematical proofs using first-order logic, set theory, and the principle of mathematical induction.
7. Students will be able to compute complex counting combinations and analyze properties of equivalence and partial ordering relations.
8. Students will be able to solve linear recurrence relations using generating functions to determine the efficiency of recursive and sorting algorithms.
9. Students will be able to apply properties of lattices and minimize boolean expressions for digital circuit design optimization.
10. Students will be able to execute graph coloring methods and tree traversal algorithms like BFS, DFS, Prim's, and Kruskal's for network optimization.

BIG DATA ANALYSIS

Course Objectives:

CO1	Provide an overview of Apache Hadoop

CO2	Provide HDFS Concepts and Interfacing with HDFS
CO3	Understand Map Reduce Jobs
CO4	Apply analytics on Structured, Unstructured Data.
CO5	Understand the analysis of Big data

Detailed Syllabus

MODULE-I

Introduction – distributed file system – Big Data and its importance, Four Vs, Drivers for Big data, Bigdata analytics, Big data applications. Algorithms using map reduce, Matrix- Vector Multiplication by Map Reduce INTRODUCTION HADOOP Big Data – Apache Hadoop & Hadoop EcoSystem – Moving Data in and out of Hadoop.

MODULE 2

HADOOP ARCHITECTURE Hadoop Architecture, Hadoop Storage: HDFS, Common Hadoop Shell commands, Anatomy of File Write and Read., NameNode, Secondary NameNode, and DataNode, Hadoop MapReduce paradigm, Map and Reduce tasks, Job, Task trackers - Cluster Setup – SSH & Hadoop Configuration – HDFS Administering –Monitoring & Maintenance

MODULE 3

HADOOP ECOSYSTEM AND YARN Hadoop ecosystem components - Schedulers – Fair and Capacity, Hadoop 2.0 New Features Name Node High Availability, HDFS Federation, MRv2, YARN, Running MRv1 in YARN, Hive Architecture and Installation, Comparison with Traditional Database, HiveQL - Querying Data - Sorting And Aggregating.

Course Outcomes: After the completion of the course the student will be able to:

CO1	Analyze Infosphere BigInsights Big Data Recommendations.
CO2	Manage Job Execution in Hadoop Environment
CO3	Develop Big Data Solutions using Hadoop Eco System
CO4	Apply Machine Learning Techniques using R.
CO5	Analyze Big Data by using various techniques

Text Books:

1. The Big Data-Driven Business: How to Use Big Data to Win Customers, Beat Competitors, and Boost Profits Russell Glass,Sean Callahan.
2. Data Fluency: Empowering Your Organization with Effective Data Communication, Zach Gemignani,ChrisGemignani,Richard Galentino.
3. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data,GebundeneAusgabe,von EMC Education Services (Herausgeber)
4. Hadoop: The Definitive GuideAuthor: Tom White Publisher: Hadoop: The Definitive Guide
5. Hadoop in Action Author: Chuck Lam Publisher: Manning

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SOFTWARE RELIABILITY

Detailed syllabus

Introduction to Software Development. Software life cycle models, software verification, validation, and testing, Error, Failure and faults in software, Concept o f Perfect and Imperfect Debugging. Introduction to Software Reliability, Difference between hardware and software reliability, Software Reliability and Availability Models, Markovian models. Non Homogenous Poisson* Process ‘based models. Imperfect Debugging models, Discrete Software reliability growth models. Introduction to commercial-off-the-shelf (COTS) software. Optimization models for COTS software. Release time problems and testing effort allocation problem.

Suggested Readings:

1. R.S. Pressman, Software Engineering: A Practitioner’s Approach, 6th Edition,McGraw Hill, 2005.
2. J. D. Musa, A. Iannino. K. Okumoto: Softawre Reliability (Professional Edition) McGraw Hill Publishing Company, 1990.
3. P.K. Kapur, R.B. Garg, Santosh Kumar: Contributions to Hardware and Software Reliability. World Scientific, 1999.
4. M. R. Lyu: Handbook o f Software Reliability. McGraw-Hill Publishing Company. 1996.
5. N. Fenton. B. Littlewood (Editors): Software Reliability and Metrics. Springer- VerlagNew York Ltd. 2007.
6. Hoang Pham: System Software Reliability, Springer Series in Reliability Engineering, Springer-Verlag, London, 2006.

STATISTICAL INFERENCE

Detailed syllabus

UNIT – I (Properties of Random Sample): Location and scale family, Exponential family (regular and curved), Basic Concepts of Random Samples, Sampling distributions, Sampling from the Normal Distribution: Order Statistics: Joint and marginal distributions, Distributions of range, midrange of order statics, Convergence in Probability, Weak law of large numbers, Consistency of sample mean, sample variance and sample standard deviation, Convergence in distribution, Central Limit Theorem with continuity correction, Delat Method, Slutsky’s Theorem

UNIT II: Sufficient Statistics, complete statistics, minimal sufficient statistics, Ancillary statistics

UNIT – III (Point Estimation): Methods of Finding Point Estimators: Method of Moments, Maximum Likelihood Estimators(MLEs), Asymptotic normality of MLE, Baeye’s Estimators, Methods of Evaluating Estimators: Mean Squared Error, Best Unbiased Estimators, Cramer-Rao inequality, Sufficiency and Unbiasedness, Rao-Blackwell Theorem, Completeness and UMVUE

UNIT – IV (Hypothesis Testing): Methods of Finding Tests: Likelihood Ratio Tests, Methods of Evaluating Tests: CO4 Error Probabilities and the Power Function, Most Powerful Tests, Neyman-Pearson Lemma, p- Values

UNIT-V (Interval Estimation): 10 Methods of Finding Interval Estimators: Inverting a Test Statistic, Pivotal Quantities, Pivoting the CDF, Bayesian Intervals, Methods of Evaluating Interval Estimators: Size and Coverage Probability, Test-Related Optimality

Textbooks:

1. George Casella & Roger L. Berger, Statistical Inference, Second Edition, Wadsworth, a part of Cengage Learning (2002).
2. Måns Thulin, Modern Statistics with R, 2025-02-04 - Second edition - Version 2.0.1(Online)
3. Norman Matloff, The Art of R Programming, No Starch Press, 2011.

References Books:

Vijay K. Rohatgi & A.K. Md. Ehsanes Saleh, An Introduction to Probability and Statistics, Third Edition, John Wiley & Sons (2015).

Hogg, R., McKean. J. and Craig, A., Introduction to Mathematical Statistics, 8th Edition, Pearson, Boston, 2019.

DeGroot, M. and Schervish, M., Probability and Statistics, 4th Edition, Addison Wesley, Boston, 2002.

Course outcomes (COs):

On completion of this course, the students will have the ability to:

Discuss random sampling, order statistics, various mode of convergence, consistency of estimators

Understand the concept of complete sufficient statistics

compute the point estimators and evaluate the estimators

Illustrate hypothesis testing. 3 CO-5 Compute interval estimators and analyze them

ADVANCE MACHINE LEARNING

Course Objectives:

CO1	understanding of issues and challenges of Machine Learning
CO2	Should be able to select data, model selection, model complexity etc.
CO3	Understanding of the strengths and weaknesses of many popular machine learning approaches.
CO4	To learn about Artificial Neural Networks
CO5	To understand Logistic Regression

Detailed Syllabus

MODULE-I

Artificial Neural Networks (Early models, Back Propagation, Initialization, Training & Validation) Parameter Estimation (Maximum Likelihood Estimation, Bayesian Parameter Estimation) Decision Trees Evaluation Measures, Hypothesis Testing Ensemble Methods, Graphical Models.

Neural Networks, threshold logic units, linear machines, networks of threshold learning units, Training of feed forward networks by back propagations, neural networks vs. knowledge-based systems.

MODULE-II

Clustering, Gaussian Mixture Models, Spectral Clustering Ensemble Methods Learning Theory, Inductive Logic Programming, notation and definitions, introducingrecursive programs, inductive logic programming vs decision tree induction.

Course Outcomes: After the completion of the course the student will be able to:

CO1	Identify the characteristics of datasets and compare the trivial data and big data for various applications.
CO2	Understand machine learning techniques and computing environment that are suitable for the applications under consideration.
CO3	Develop scaling up machine learning techniques and associated computing techniques and technologies for various applications
CO4	Implement various ways of selecting suitable model parameters for different machine learning techniques.
CO5	Discriminate inductive logic programming and decision treeinduction.

Text Books:

1. T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2008.
2. Christopher Bishop. Pattern Recognition and Machine Learning.
3. Andreas, C. Muller & Sarah Guido, O'Reilly Introduction to Machine Learning with Python A guide for data scientists,
4. Nils J.Nilsson, Introduction to Machine learning.

PORTFOLIO MANAGEMENT

Detailed syllabus

Portfolio optimization and asset allocation. Risk/return concepts and measurements. Diversification and portfolio risk. Mean-variance efficient frontiers. Efficient portfolios with short sales and without short sales. Markowitz portfolio selection model. Mean absolute deviation model. Capital market theory. Capital assets pricing model. Arbitrage pricing theory. Index models. Performance evaluation measures. Value at risk (VaR).Conditional Value at risk (CVaR).

Suggested Readings:

1. C. Marrison: The Fundamentals o f Risk Measurement, McGraw Hill, 2002.
2. F. K. Reilly, Keith C. Brown: Investment Analysis and Portfolio Management, South-Western Publishers, 2002.
3. M. Bartholomew-Biggs: Nonlinear Optimization with Financial Applications, Kluwer Academic Publishers, 2005.
4. H. M. Markowitz: Mean-Variance Analysis in Portfolio Choice and Capital Markets, New York, Blackwell, 1987.
5. W. F. Sharpe: Portfolio Theory and Capital Markets, McGraw Hill. 1970.
6. Richard C. Grinold, Ronald N. Kahn: Active Portfolio Management-A Quantitative Approach for Producing Superior Returns and Controlling Risk, McGraw Hill, 2000.
7. ZviBodie, Alex Kane. Alan ***).*** Marcus: Investments. Eight Edition, McGraw Hill,2009.
8. J. C. Hull: Options. Futures and Other Derivative Securities. 5th Edition, Prentice Hall, 2002.

MMA046: QUALITY MANAGEMENT

Detailed syllabus

Overview of quality, histoiyof quality, competitive advantage, industrial perspective, total quality system, Taguchi "Loss Function'' concept. Meaning and significance o f statistical process control (SPC)-construction o f control charts for variables and attributes. Acceptance sampling plans. Process capability meaning significance and measurement Six-sigma concepts o f process capability.DMAIC and DMADV.Pareto Analysis, Ishikawa (Cause/Effect) Diagrams, Failure Modes and Effects Analysis, Program for Quality Improving. Introduction to ISO 9000- quality management systems-guidelines for Performance improvements. Quality Audits. Introduction to Total Quality Management (TQM).

Suggested Readings:

1. J.R. Evans. W.M. Lindsay: The Management and Control o f Quality, West Publishing Company, 1996.
2. Kaoru Ishikawa: Introduction to Quality Control. Chapman and Hall, 1992.
3. Dale H. Besterfield et al, Total Quality Management, 3rd Edition, Pearson Education, 2004.
4. Shridhara Bhat K: Total Quality Management- Text and Cases, First Edition, Himalaya Publishing House, 2002.
5. AmitavaMitra: Fundamentals o f Quality Control and Improvement. 2nd Edition, Prentice-Hall Inc., 1998
6. William J. Kolarii: Creating quality. McGraw Hill, 1995.
7. PoornimaM.Charantimath: Total quality management, Pearson Education, 2003.
8. Indian standard quality management systems - Guidelines for performance improvement.Bureau of IndVan standards. New Delhi.

DATA STRUCTURES AND ALGORITHMS

Detailed syllabus

UNIT – I (Introduction and Analysis of Algorithms)

Definition, Structure and Properties of Algorithms; Development of an Algorithm; Data types, abstract data types and data structures, Efficiency of Algorithms; Apriori Analysis; Time Complexity of an Algorithm Using O Notation; Polynomial Vs Exponential Algorithms; Average, Best and Worst Case Complexities; Analyzing Recursive Programs

UNIT – II (Arrays, Stacks and Queues)

Introduction to Arrays, Array Operations, Number of Elements in an Array, Representation of Arrays in Memory, Applications, Introduction to Stacks, Stack Operations, Applications, Introduction to Queues, Operations on Queues, Circular Queues, Other Types of Queues, Applications

UNIT – III (Linked Lists, Linked Stacks and Linked Queues)

Singly Linked Lists, Circularly Linked Lists, Doubly Linked Lists, Multiply Linked Lists, Applications , Operations on Linked Stacks and Linked Queues, Dynamic Memory Management and Linked Stacks, Implementation of Linked Representations, Applications

UNIT-IV (Trees and Binary Trees, Graphs)

Trees: Definition and Basic Terminologies, Representation of Trees, Binary Trees: Basic Terminologies and Types, Binary Tree Traversals, Threaded Binary Trees, Applications

Graphs: Definition and Basic Terminologies, Representations of Graphs, Graph Traversals, Applications, heap and array implementation of heap

UNIT-V (Binary Search Trees and AVL Trees, Hash Tables)

Binary Search Trees: Definition and Operations; AVL Trees: Definition and Operations, Applications, Hash Table Structure, Hash Functions, Linear Open Addressing, Chaining

Text Books:

1. Mark Allen Weiss, Data Structures and Algorithm Analysis in C, Pearson, 2002.
2. Aho A.V., J.E. Hopcroft, J.D. Ullman, Data Structures and algorithms, Pearson, 1983.

Reference books:

1. Robert L. Kruse, Bruce P. Leung, Clovis L. Tondo, Data Structures and Program Design In C (2nd Edition), Prentice Hall, 1996.
2. Ellis Horowitz, Sartaj Sahni, Fundamentals of Data Structures, (9th edition), Computer Science Press, 1988. 3.
Aaron M. Tenenbaum, Y. Langsam, Moshe J. Augenstein, Data Structures Using C., PHI Learning, 2009.

Course outcomes:

On completion of this course, the students will have the ability to:

1. Understand the basic idea of Data structures and Algorithms and the concept of time complexity.
2. Explain the structures properties and operations of Arrays, Stacks and Queues.
3. Define and explain the Linked Lists, Linked Stacks and Linked Queues.
4. Define terms related to Trees and Binary Trees, Graphs. Apply them on solving related problems.
5. Define terms related to Binary Search Trees and AVL Trees, Hash Tables. Analyze them for solving related problems.

MARKETING RESEARCH

Detailed syllabus

Marketing Research and its objectives; Applications of Marketing Research: Advertising Research, Product Research, Sales Research, Planning the research design, Exploratory descriptive research, experimental research. Methods of collecting data, Sampling procedures in Marketing Research, Data Processing and Analysis, Advanced procedures of data analysis: Factor Analysis, Cluster Analysis and Discriminant Analysis. Research on Consumer behaviour, Group versus individual behaviour, Innovation Diffusion Model: Categorization of adopters, Estimation and Validation of Models. Introduction of a new product. Utility measures for product search. Break even analysis for product evaluation. PERT and CPM in product development.

Suggested Readings:

1. P. E. Green, D. S. Tull, G. Album: Research for Marketing Decisions, Prentice hall of India, 1999.
2. D. J. Luck and R. S. Rubin: Marketing Research, Prentice Hall o f India, 1998.
3. H. W. Boyd. R. Westfall, S. F. Starch: Marketing Research-Text and Cases, 7th Edition, Richard

D. Irwin Inc., 1989.
4. Vijay M^hzyan, Robart A. Peterson: Models for Innovation Diffusion and Related Research Papers. SAGE Publication. 1990.
5. David A. Aaker, V. Kumara, George S. Day: Marketing Research, 9lh Edition, John Wiley & Sons Inc. 2007.
6. Scott M. Smith, Gerald S. Albaum: Fundamentals of Marketing Research, SAGE Publications Inc., 2005.
7. Carl McDaniel, Roger Gates: Marketing Research Essentials, John Wiley & Sons Inc. 2007.

LOGISTICS AND SUPPLY CHAIN MANAGEMENT

Detailed syllabus

Introduction to the Supply Chain. Customer driven strategies in production and distribution systems. Integrated production and distribution networks. Supply chain management in the context of JIT and MRP-II. Distributon Resource planning. Management of dealer networks. Total quality control and product innovation across the supply chain. Incoming logistics and supplier relationships.Value addition analysis. Metrics for measurement of supply- chain performance. Mathematical models and computer assisted decision support for supply chain management. Mathematical programming models for supply chain decisions: Vendor buyer coordination, production distribution coordination, inventory-distribution coordination.

Suggested Readings:

1. Martin Christopher: Logistics and Supply Chain Management, Richard Erwin, 1994.
2. F. W. Thomas: Customer Driven Strategies, Oliver White, 1992.
3. S. P. Bradley, A. Hax. T. L. Magnanti: Applied Mathematical Programming, Addison Wesley, 1977.
4. William A. Sandras (Jr): JIT: Making it happen, Oliver White. 1989.
5. M. G. Korgaonkar: Just-in-time manufacturing, Macmillan, 1992.
6. Sunil Chopra, Peter Meindl: Supply Chain Management-Strategy, Planning and Operation, 3rd Edition, Prentice-Hall Inc.. 2007.
7. S. Tayur, Ram Ganeshan, Michael Magazine, Quantitative Models for Supply Chain Management. Kluwer Academic Publishers, Boston. 1998.
8. G. Raghuram. N. Rangaraj [Editors]: Logistics and Supply Chain Management-Cases and Concepts, Macmillan. New Delhi. 2000.

FINANCIAL MANAGEMENT

Detailed syllabus

Role of Financial Management. Financial Analysis and Planning. Working Capital Management. Cost of Capital. Capital Structure and Dividend Policies. Short term and Long term Financial Planning. Analytical Appraoch to Finance. Application of Integer Programming & Goal Programming to Working Capital and Capital Budgeting Problems. Financing Decision: Problems of determining optimal capital structure, Leasing, Debt Management, Analysis of commitment of funds and risk of cash insolvency; Receivables and Inventory Management Approaches.

Suggested Readings

1.J. C. Van Horne, J. M. Wachowicz: Fundamentals o f Financial management, l lIh Edition." Prentice Hall of'lndiaf, 2000.
2. E. F. Brigham. L. C. Gapenski. C.E. Michael: Financial Management-Theory and Practice, The Dryden Press. 1 l lh Edition. 2004.
3. M. Y. Khan. P. K. Jain: Financial Management, Tata McGraw Hill Pub. Co.. New Delhi, 5lh Edition, 2008.
4. G. Comuejols, R. Tutuncu: Optimization Methods in Finance, Cambridge University Press, 2007.
5. R. Brealey, S. Mgres, A. Franklin: Principleo f Corporate Finance, 9,h Edition, McGraw Hill, 2008.
6. J. Spronk: Interactive Multiple Goal Programming: An Application to Financial Planning, Martinus N ijhoff Publishing, 1981.

RELIABILITY AND MAINTENANCE THEORY

Detailed syllabus

Basics of Reliability. Classes of life distributions based on Notions of Ageing. System Reliability: Reliability of Series, Parallel, Standby, k-out-of-n, Series-Parallel, Parallel –Series configurations and Bridge Structure. Reliability models of non-maintained & maintained systems, Availability theory and its modelling for various configurations. Introduction, tq Renewal theory. Types of Renewal Processes and their Asymptotic Properties, Application of Renewal theory to One-Unit Repairable Systems with Different Maintenance Policies (Age, Block. Preventive & Corrective). Reward Renewal Processes, Minimal Repair Replacement Policies.

Suggested Readings:

1. R. E. Barlow, F. Proschan: Statistical Theory o f Reliability and Life Testing, Holt, Rinehert& Winston Inc., 1975.
2. John G. Rau: Optimization and Probability in Systems Engineering, V.N. Reinhold Co., 1970.

3. P. K. Kapur, R. B. Garg, S. Kumar: Contributions to Hardware and Software Reliability, World Scientific. Singapore. 1999.
4. D. R. Cox: Renewal Theory, Mathew, London, 1962.
5. H. Pham: Handbook o f Reliability Engineering, Springer-Verlag London Ltd., 2003.
6. A. Hoyland. M. Rausand: System Reliability Theory-Models and Statistical Methods, John Wiley & Sons Inc. 1994.
7. D. L. Grosh: A Primer o f Reliability Theory. John Wiley & Sons Inc., 1989.
8. Way Kuo, Ming J. Zuo: Optimal Reliability Modeling- Principles and Applications, John Wiley & Sons Inc., 2003.

RECORDING AND ANALYSIS OF BUSINESS OPERATIONS

Detailed syllabus

Unit I (8 Hrs): Meaning and Scope of Accounting : Overview of Accounting, Users of Accounting, Accounting Concepts Conventions, Book keeping and Accounting, Principles of Accounting, Basic Accounting terminologies, Accounting Equation, Overview to Deprecation (straight line and diminishing method). Accounting Standards and IFRS : International Accounting Principles and Standards; Matching of Indian Accounting Standards with International Accounting Standards, Human Resource Accounting, Forensic Accounting.
Unit II (10 Hrs): Mechanics of Accounting : Double entry system of Accounting, Journalizing of transactions; Ledger posting and Trial Balance, Preparation of final accounts, Profit & Loss Account, Profit & Loss Appropriation account and Balance Sheet, Excel Application to make Balance sheet, Case studies and Workshops.
Unit III(10 Hrs): Analysis of financial statement: Ratio Analysis- solvency ratios, Profitability ratios, activity ratios, liquidity ratios, Market capitalization ratios; Common Size Statement; Comparative Balance Sheet and Trend Analysis of manufacturing, Service & Banking organizations, Case Study and Workshops in analysing Balance sheet.
Unit IV (12 Hrs): Funds Flow Statement: Meaning, Concept of Gross and Net Working Capital, Preparation of Schedule of Changes in Working Capital, Preparation of Funds Flow Statement and its analysis; Cash Flow Statement: Various cash and non-cash transactions, flow of cash, difference between cash flow and fund flow, preparation of Cash Flow Statement and its analysis.

SUGGESTED READINGS:
Text Books:
1. Maheshwari S.N & Maheshwari S K – A text book of Accounting for Management (Vikas, 10th Edition)
2. Essentials of Financial Accountng (based on IFRS), Bhattacharya (PHI,3rd Ed)
3. Ramachandran Kakani- Financial Accounting for Management (TMH ,3rd Edition).
4. PC Tulsian- Financial Accounting (Pearson, 2016)
5. Dhamija - Financial Accounting for managers: (Prentice Hall, 2nd Edition).

Reference Books:
1. Narayanswami - Financial Accounting: A Managerial Perspective (PHI,5th Ed)
2. Dhaneshk Khatri- Financial Accouting (TMH,2015)
3. Ambrish Gupta - Financial Accounting: A Managerial Perspective (Prentice Hall, 4th Edition)
4. Ramchandran & Kakani - Financial Accounting for Management (TMH, 2nd Edition).

5. Mukherjee - Financial Accounting for Management (TMH, 2nd Edition).