INVERTIS
UNIVERSITY BAREILLY

SYLLABI AND EVALUATION SCHEME

for

Master of Science in Mathematics

TWO-YEARS FULL-TIME PROGRAMME
(Effective from session 2020-2021)

Second Year

INVERTIS
UNIVERSITY BAREILLY
Established by Govt. of U.P. u/s 2F of UGC Act, 1956 vide U.P. Act 22 of 2010.

Department of Applied Sciences & Humanities

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

Dean
Faculty of Science
Invertis University, Bareilly (U.P.)

15/01/2020

Head
Department of Applied Science

VICE CHANCELLOR

INVERTIS UNIVERSITY BAREILLY

Programme Outcome

PO-1: Critical Thinking: Inculcate critical thinking to carry out scientific investigation objectively. Formulate coherent arguments; critically evaluate practices, policies and theories by following scientific approach to knowledge development. Critically evaluate ideas, evidence and experiences from an open-minded and reasoned perspective.

PO-2: Knowledge Skill: Equip the student with skills to analyse problems, formulate an hypothesis, evaluate and validate results, and draw reasonable conclusions thereof. Capacity to extrapolate from what one has learned and apply their competencies to solve different kinds of non-familiar problems, rather than replicate curriculum contentknowledge.

PO-3: Scientific Communication Skills: Imbibe effective scientific and / or technical communication in both oral and writing. Ability to show the importance of the subject as precursor to various scientific developments since the beginning of the civilization.

PO-4: Ethics: Continue to acquire relevant knowledge and skills appropriate to professional activities and demonstrate highest standards of ethical issues in the subject concerned. Ability to identify unethical behaviour such as fabrication, falsification or misrepresentation of data and adoptive objective, unbiased and truthful actions in all aspects.

PO-5: Enlightened Citizenship: Create awareness to become an enlightened citizen with commitment to deliver one's responsibilities within the scope of bestowed rights and privileges

PO-6: Analytical Reasoning: Ability to evaluate the reliability and relevance of evidence; identify logical flaws and holes in the arguments of others; analyse and synthesise data from a variety of sources; draw valid conclusions and support them with evidence andexamples, and addressing opposing viewpoints.

PO-7: **Multicultural Competence**: Development of a set of competencies in order to enhance and promote the growth of multicultural sensitivity within universities. Integrating multicultural awareness such as race, gender, physical ability, age, income and other social variables, and by creating an environment that is "welcomingfor all students".

Dean
Faculty of Science
Invertis University, Barcilly (U.P.)
15/10/2020

Head
Department of Applied Science

VICE CHANCELLOR
INVERTIS UNIVERSITY

M.Sc. Mathematics

PO-8: Lifelong Learning: Ability to think, acquire knowledge and skills through logical reasoning and to inculcate the habit of self-learning throughout life, through self- paced and self- directed learning aimed at personal development, and adapting to changing academic demands of work place through knowledge/ skill development/ reskilling.

PO-9: Leadership Qualities: Capability for mapping out the tasks of a team or an organization, and setting direction, formulating an inspiring vision, building a team who can help achieve the vision, motivating and inspiring team members to engage with that vision and using management skills to guide people to the right destination in a smooth and efficient way.

PO-10: Research Skills: Prepare students for pursuing research or careers in industry in concerned subjects and allied fields. Capability to use appropriate software to solve various problems and to apply programming concepts of C++ and Mathematica/Matlab to various scientific investigations, problem solving and interpretation.

PO-11: Modern Tool. Usage: Create, select and apply appropriate techniques, resources and modern scientific tools including prediction and modeling to complex activities with an understanding of the limitations.

PO-12: Project Management & Finance: Demonstrate knowledge and understanding of scientific and management principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments.

Dean
Faculty of Science
Invertis University, Bareilly (U.P.)

Head
Department of Applied Science

VICE CHANCELLOR

11/10/2020

INVERTIS UNIVERSITY BAREILLY

Programme Specific Outcomes -PG Mathematics

PSO-1: **Strong Foundation in Knowledge:** Have strong foundation in core areas ofMathematics, and able to communicate Mathematics effectively.

PSO-2: **Abstract Skills:** Evaluate hypotheses, theories, methods and evidence within theirproper contexts.

PSO-3: **Problem Solving**: Solve complex problems by critical understanding, analysis andsynthesis.

PSO-4: **Proficiency in Interdisciplinary Skills:** Select, interpret and critically evaluate information from a range of sources that include books, scientific reports, journals, casestudies and internet.

PSO-5: **Application and Research Efficiency:** Provide a systematic understanding of the concepts and theories of mathematics and their application in the real world- to an advanced level, and enhance career prospects in a huge array of fields, viz. in industry,commerce, education, finance and research.

PSO-6: **Lifelong Practical Knowledge**: Recognize the need to engage in lifelong learning through continuous education, and research leading to higher degrees like PhD, DSc

Dean
Faculty of Science
Invertis University, Bareilly (U.P.)

Head
Department of Applied Science

VICE CHANCELLOR

INVERTIS UNIVERSITY BAREILLY

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 200 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, II, III, IV semester. Thus for the entire course it comes out to be a total of 2400 marks.

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

15/10/2020

Head
Department of Applied Science

 VICE CHANCELLOR

M.Sc. Mathematics

INVERTIS UNIVERSITY BAREILLY

II Year (Mathematics)

III Semester			Teaching Scheme			Marks Distribution			
PAPER	CODE	SUBJECT	L	T	P	ESM	MSM	Total	Credit
Paper 1	MMA301	Python	3	1	0	70	30	100	4
Paper 2	MMA302	Functional Analysis	3	1	0	70	30	100	4
Paper 3	MMA303	Mathematical Methods	3	1	0	70	30	100	4
Paper 4	MMA304	Probability and Stochastic Processes	3	1	0	70	30	100	4
Paper 5	MMA031	DSE-I	3	1	0	70	30	100	2
Lab	MMA351	PYTHON Lab	0	0	2	35	15	50	2
Lab	MMA352	MATLAB	0	0	2	35	15	50	2
Lab	MMA354*	Field Project / Internship	0	0	2	70	30	100	2
Total			15	5	6	490	210	700	24

*Students will carryout field project/Internship during first year session break of the program

10/10/20

Head
Department of Applied Science
Invertis University, Bareilly (U.P.)

15/10/20
(Mr. Ashutosh Pradhan)

15/10/20
(Dr. Suchita Gupta)

Dean
Faculty of Science
Invertis University, Bareilly (U.P.)

INVERTIS
UNIVERSITY BAREILLY

M.Sc. Mathematics

II Year (Data Science)

III Semester			Teaching Scheme			Marks Distribution			
PAPER	CODE	SUBJECT	L	T	P	ESM	MSM	Total	Credit
Paper 1	MMA301	PYTHON	3	1	0	70	30	100	4
Paper 2	MMA305	Database Management System	3	1	0	70	30	100	4
Paper 3	MMA306	Data Warehouse and Data Mining	3	1	0	70	30	100	4
Paper 4	MMA304	Probability and Stochastic Processes	3	1	0	70	30	100	4
Paper 5	MMA032	DSE-I	3	1	0	70	30	100	2
Lab	MMA351	Python Lab	0	0	2	35	15	50	2
Lab	MMA353	Database Management System Lab	0	0	2	35	15	50	2
Lab	MMA354*	Field Project / Internship	0	0	2	70	30	100	2
Total			15	5	6	490	210	700	24

*Students will carry out field project/Internship during first year session break of the program

15/10/20

Head
Department of Applied Science
Invertis University, Bareilly (U.P.)

15/10/20
(Mr. Ashutosh Pradhan)

15/10/20
(Dr. Sucheta Gupta)

Dean
Faculty of Science
Invertis University, Bareilly (U.P.)

M.Sc. Mathematics

IV Semester (Mathematics)									
PAPER	**CODE**	**SUBJECT**	**L**	**T**	**P**	**ESM**	**MSM**	**Total**	**Credit**
Paper 6	MMA401	Mathematical Modeling	3	1	0	70	30	100	4
Paper 7	MMA041	DSE-II	3	1	0	70	30	100	4
Paper 8	MMA042	DSE- III	3	1	0	70	30	100	4
Paper 9	MMA043	DSE-IV	3	1	0	70	30	100	4
Paper 10	MMA452	Project work* / Dissertation	0	0	4	70	30	100	2
Total			12	4	4	350	150	500	18

IV Semester (Data Science)									
PAPER	**CODE**	**SUBJECT**	**L**	**T**	**P**	**ESM**	**MSM**	**Total**	**Credit**
Paper 6	MMA401	Mathematical Modeling	3	1	0	70	30	100	4
Paper 7	MMA044	DSE-II	3	1	0	70	30	100	4
Paper 8	MMA045	DSE- III	3	1	0	70	30	100	4
Paper 9	MMA046	DSE-IV	3	1	0	70	30	100	4
Paper 10	MMA452	Project work* / Dissertation	0	0	4	70	30	100	2
Total			12	4	4	350	150	500	18

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

15/10/20

Head
Department of Applied Science
Invertis University, Bareilly (U.P.)

15/10/20

Dean
Faculty of Science
Invertis University, Bareilly (U.P.)

VICE CHANCELLOR
INVERTIS UNIVERSITY
BAREILLY

INVERTIS UNIVERSITY BAREILLY

Data Science

Discipline Specific Elective (DSE)

MMA032 / MMA044 / MMA045 / MMA046				
S. No.	**Course Name**	**L-T-P**	**Credit**	**Contact Hrs.**
1.	Big Data Analysis	4-0-0	4	40
2.	Digital Marketing	4-0-0	4	40
3.	Machine Learning	4-0-0	4	30
4.	Advance Machine Learning	4-0-0	4	30
5.	Portfolio Management	4-0-0	4	40
6.	Quality Management	4-0-0	4	40
7.	Discrete Mathematics	4-0-0	4	40
8.	Marketing Management	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 Mathematics	4-0-0	4	40
12.	Financial Management	4-0-0	4	40
13.	Reliability and Maintenance theory	4-0-0	4	40
14.	Software Reliability	4-0-0	4	40

Head
Department of Applied Science
Invertis University, Bareilly (U.P.)

VICE CHANCELLOR
INVERTIS UNIVE

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.	Finite Element Method	4-0-0	4	40
3.	Numerical Linear Algebra	4-0-0	4	40
4.	Bio Mathematics	4-0-0	4	40
5.	Multivariable Calculus	4-0-0	4	40
6.	Introduction to Algebraic Geometry	4-0-0	4	40
7.	Theory of Analytic functions	4-0-0	4	40
8.	Fourier Analysis and applications	4-0-0	4	40
9.	Network Models	4-0-0	4	40
10.	Stochastic Programming and applications	4-0-0	4	40
11.	Differential Geometry	4-0-0	4	40
12.	Modern theory of PDE	4-0-0	4	40
13.	Fluid Mechanics	4-0-0	4	40
14.	Numerical Methods of PDE	4-0-0	4	40
15.	Tensors & Riemannian Geometry	4-0-0	4	40
16.	Number theory and Cryptography	4-0-0	4	40
17.	Integral Equation and Calculus of variations	4-0-0	4	40
18	Financial Mathematics	4-0-0	4	40

Skill Enhancement Courses (SEC) for Pure Mathematics and Data Science

S. No.	Course Name	Code	L-T-P	Credit	Contact Hrs.
1.	PYTHON	MMA 301	**3-1-0**	4	40
2.	Lab Python and ML	MMA 351	**0-0-2**	2	20
3.	Statistical Analysis Lab with R-Programming	MMA 251	**0-0-2**	2	20
4.	Statistical Analysis	MMA 204	**3-1-0**	4	40

Head
Department of Applied Science
Invertis University, Bareilly (U.P.)

VICE CHANCELLOR
INVERTIS UNIV
BAREI

15/11/2020

INVERTIS UNIVERSITY BAREILLY

Ability Enhancement Compulsory (AECC)

S. No.	Course Name	Code	L-T-P	Credit	Contact Hrs.
1.	Dissertation	MMA 454	**0-0-4**	4	40

Head
Department of Applied Science
Invertis University, Bareilly (U.P.)

5/11/2020

VICE CHANCELLOR
INVERTIS UNIVERSITY

M.Sc. Mathematics

SEMESTER – III

MMA301: PYTHON

Course Objectives:

CO1	Describe the core syntax and semantics of Python programming language.
CO2	Discover the need for working with the strings and functions.
CO3	Illustrate the process of structuring the data using lists, dictionaries, tuples and sets.
CO4	Infer the Object-oriented Programming concepts in Python.
CO5	Discuss concept of Function

Detailed Syllabus

MODULE-I

Parts of Python Programming Language: Identifiers, Keywords, Statements and Expressions, Variables, Operators, Precedence and Associativity, Data Types, Indentation, Comments, Reading Input, Print Output, Type Conversions, The type() Function and Is Operator, Dynamic and Strongly Typed Language, **Control Flow Statements:** The if Decision Control Flow Statement, The if…else Decision Control Flow Statement, The if…elif…else Decision Control Statement, Nested if Statement, The while Loop, The for Loop, The continue and break Statements, Catching Exceptions Using try and except Statement, **Functions:** Built-In Functions, Commonly Used Modules, Function Definition and Calling the Function, The return Statement and void Function, Scope and Lifetime of Variables, Default Parameters, Keyword Arguments, *args and **kwargs, Command Line Arguments.

MODULE-II

Strings: Creating and Storing Strings, Basic String Operations, Accessing Characters in String by Index Number, String Slicing and Joining, String Methods, Formatting Strings, **Lists:** Creating Lists, Basic List Operations, Indexing and Slicing in Lists, Built-In Functions Used on Lists, List Methods, The del Statement.

Files: Types of Files, Creating and Reading Text Data, File Methods to Read and Write Data, Reading and Writing Binary Files, The Pickle Module, Reading and Writing CSV Files, Python os and os.path Modules,

MODULE-III

Regular Expression Operations: Using Special Characters, Regular Expression Methods, Named Groups in Python Regular Expressions, Regular Expression with glob Module.

Object-Oriented Programming: Classes and Objects, Creating Classes in Python, Creating Objects in Python, The Constructor Method, Classes with Multiple Objects, Class Attributes versus Data Attributes, Encapsulation, Inheritance, Polymorphism.

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

CO1	Interpret the fundamental Python syntax and semantics and be fluent in the use of Python control flow statements.
CO2	Express proficiency in the handling of strings and functions.
CO3	Identify the commonly used operations involving file systems and regular expressions.
CO4	To apply various types of Function

CO5	Articulate the Object-Oriented Programming concepts such as encapsulation, inheritance and polymorphism

Text Books:

1.Gowrishankar S, Veena A, "Introduction to Python Programming", 1st Edition, CRC Press/Taylor & Francis, 2018.

Reference Books:

1. Jake VanderPlas, "Python Data Science Handbook: Essential Tools for Working with Data", 1st Edition, O'Reilly Media, 2016.

2. Aurelien Geron, "Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems", 2nd Edition, O'Reilly Media, 2019.

MMA302: FUNCTIONAL ANALYSIS

Course Objectives: To make the students understand the concepts of bounded operators between normed linear spaces, Banach spaces, Hilbert spaces and their properties.

Detailed Syllabus

Normed linear spaces, Banach spaces, Hilbert Spaces and basic properties, Heine Borel theorem, Riesz lemma and best approximation property.
Inner product spaces, Projection Theorem; Orthonormal bases, Bassel inequality and parseval's Formula, Riesz Fischer theorem.
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, Closed graph theorem and open mapping theorem, Applications.

Course Outcomes:

After studying these topics, the students will be able to

- Understand Banach spaces and Hilbert spaces
- Learn bounded operators and their properties
- Find orthonormal basis
- Use projection theorem
- Know the applications of closed graph theorem and open mapping theorem

References:

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. E. Kreyzig,Introduation to Functional Analysis with Applications, Wiley,1989.

MMA303: MATHEMATICAL METHODS

Course Objectives: To make the students understand the concepts of Integral Transform, properties of Integral transform and their applications and extrema of functional.

Detailed Syllabus

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.

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, Definition, Existence and Linearity of Laplace Transform.

Laplace Transform: The Inversion formula, First Shifting Theorem, Laplace Transform of the derivatives and of the Integrals of a function, Derivatives and Integrals of Transforms, Convolution Products and application to the Initial Value Problems.

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.

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.

Course Outcomes:

After studying these topics, the students will be able to

- Understand various types of transforms.
- Learn their properties and uses.
- Find Extrema of functional.
- Know the applications of all the transforms.

References:

1. E. Kreyszig, Advanced Engineering Mathematics, Wiley India Pvt.Ltd.,8th Edition, 2001.
2. A. D. Polyanin and A. V. Manzhirov, Handbook of Integral Equations, CRC Press, 2nd Edition,2008.
3. L. Elsgolts, Differential Equations and Calculus of Variations, Mir Publishers, 1970.
4. A. S. Gupta, Calculus of Variations, Prentice Hall of India, New Delhi,1999.
5. J. H. Davis, Methods of Applied Mathematics with a MATLAB Overview, Birkhäuser, Inc., Boston, MA, 2004.

MMA304: PROBABILITY AND STOCHASTIC PROCESS

Course Objectives: To introduce the concepts of probability and stochastic processes and illustrate these concepts with real applications to support other courses and research in mathematics.

Detailed Syllabus

Basic Probability: Introduction, definitions, axioms, Laws, Conditional & Total probability, Bayes theorem.

Random Variables& Distribution functions: Definition, continuous, discrete and mixed Random Variables, Probability Mass Function (PMF), Probability Density Function (PDF), Cumulative Distribution Function (CDF).

Properties of Random Variables: Mean and variance of random variable, Coefficients of variation, Skewness and kurtosis, Moments, Covariance and correlation coefficient. Properties of Distribution Functions.

Probability distributions: Uniform, Exponential, Gamma, Gaussian and Rayleigh

Reliability : Reliability of a series and parallel system, hazard rate

Random Processes:

Discrete and Continuous-time Markov Chains (MCs): Transition probability matrix, Chapman-Kolmogorov equations; n-step transition and limiting probabilities, ergodicity, stationary distribution,

Poisson Process: Poisson process & related distributions, birth and death process

Renewal Process: Renewal process in continuous time, renewal equation, renewal theorem.

Learning Outcomes:

- At the end of this course the students will be able to apply concept of Probability.
- random variables and random process.
- In the various areas of study and research.

Text Book:

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

Reference Books:

- Papoulis, S. U. Pillai, "Probability, Random Variables and Stochastic Processes", Tata McGraw Hill
- S L Miller, D G.Childers, "Probability and Random Processes", Academic press.

MMA305: DATABASE MANAGEMENT SYSTEM

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 RelationalAlgebra.
CO3	To introduce the concepts of basic SQL as a universal Database language.
CO4	To demonstrate the principles behind systematic database design approaches by coveringconceptual design, logical design through normalization.
CO5	To provide an overview of physical design of a database system, by discussing Databaseindexing 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, Timstamping 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 andOperation of the relational data model.
CO3	. Construct simple and moderately advanced database queries usingStructured 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

MMA306: DATA WAREHOUSE AND DATA MINING

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

MMA351 PYTHON Lab

Pre-requisites: None

Course Objectives:

CO1	Describe the core syntax and semantics of Python programming language.
CO2	Discover the need for working with the strings and functions.
CO3	Illustrate the process of structuring the data using lists, dictionaries, tuples and sets.
CO4	Infer the Object-oriented Programming concepts in Python.
CO5	Discuss concept of Function

Detailed Syllabus

MODULE-I

Parts of Python Programming Language: Identifiers, Keywords, Statements and Expressions, Variables, Operators, Precedence and Associativity, Data Types, Indentation, Comments, Reading Input, Print Output, Type Conversions, The type() Function and Is Operator, Dynamic and Strongly Typed Language, **Control Flow Statements:** The if Decision Control Flow Statement, The if…else Decision Control Flow Statement, The if…elif…else Decision Control Statement, Nested if Statement, The while Loop, The for Loop, The continue and break Statements, Catching Exceptions Using try and except Statement, **Functions:** Built-In Functions, Commonly Used Modules, Function Definition and Calling the Function, The return Statement and void Function, Scope and Lifetime of Variables, Default Parameters, Keyword Arguments, *args and **kwargs, Command Line Arguments.

MODULE-II

Strings: Creating and Storing Strings, Basic String Operations, Accessing Characters in String by Index Number, String Slicing and Joining, String Methods, Formatting Strings, **Lists:** Creating Lists, Basic List Operations, Indexing and Slicing in Lists, Built-In Functions Used on Lists, List Methods, The del Statement.

Files: Types of Files, Creating and Reading Text Data, File Methods to Read and Write Data, Reading and Writing Binary Files, The Pickle Module, Reading and Writing CSV Files, Python os and os.path Modules,

MODULE-III

Regular Expression Operations: Using Special Characters, Regular Expression Methods, Named Groups in Python Regular Expressions, Regular Expression with glob Module.

Object-Oriented Programming: Classes and Objects, Creating Classes in Python, Creating Objects in Python, The Constructor Method, Classes with Multiple Objects, Class Attributes versus Data Attributes, Encapsulation, Inheritance, Polymorphism.

MMA354 DBMS Lab (For Data Science)

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

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, Time stamping protocols for concurrency control, validation based protocol, multiple granularity, Multi version schemes, Recovery with concurrent transaction, case study of Oracle.

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 andOperation of the relational data model.
CO3	. Construct simple and moderately advanced database queries usingStructured 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.

--

MMA352 MATLAB (For Mathematics)

Modeling of any two programs from each sections using *Matlab*

Section-A

(i) Plotting of graphs of function e^{ax+b}, $\log(ax+b)$, $1/(ax+b)$, $\sin(ax+b)$, $\cos(ax+b)$, $|ax+b|$ and be able to find the effect of a and b on the graph.

(ii) Plotting the graphs of polynomial of degree 4 and 5, the derivative graph, the second derivative graph and comparing them.

(iii) Any one of the following

(a) Sketching parametric curves (Eg. Trochoid, cycloid, epicycloids, hypocycloid)
(b) Obtaining surface of revolution of curves
(c) Tracing of conics in Cartesian coordinates/ polar coordinates
(d) Sketching ellipsoid, hyperboloid of one and two sheets, elliptic cone, elliptic paraboloid, hyperbolic paraboloid using Cartesian co-ordinates.

(iv) Any one of the following

(a) To find numbers between two real numbers.
(b) Plotting subsets of R to study boundedness/unboundedness and bounds (if they exist).
(c) Plotting of sets on R to discuss the idea of cluster points, lim sup, liminf.

(v) Any one of the following

(a) Plotting of recursive sequences.
(b) Study the convergence of sequences through plotting.
(c)Verify Bolzano Weirstrass theorem through plotting of sequences and hence identify convergent subsequences from the plot.
(d) Studying the convergence /divergence of infinite series by plotting their sequences of partial sum.

Section-B

(i) Plotting second and third order solution families

(ii) Acceleration-velocity model

(iii) Growth and decay model (both exponential and logistic)

(iv) Lake pollution model (with constant/ seasonal flow and pollution concentration)

(v) Any two of the following

(a) Predator prey model (basic Lotkavolterra model, with density dependence, effect of DDT, two prey one predator)
(b) Epidemic model of influenza (basic epidemic model, contagious for life, disease with carriers, disease with re-infection, density dependent contact rate)
(c) Battle model (basic battle model, jungle warfare, with desertion, long range weapons)

(vi) Taylor and Maclaurin series of sin x, cos$x$, log $(1+x)$, e^x, $(1+x)^n$, maxima and minima, inverse of graphs.

Section-C

(i) Calculate the sum 1/1 + 1/2 + 1/3 + 1/4 + ----------+ 1/ N.

(ii) To find the absolute value of an integer.

(iii) Enter 100 integers into an array and sort them in an ascending order.

(iv) Any two of the following
- (a) Bisection Method
- (b) Newton Raphson Method
- (c) Secant Method
- (d) RegulaFalsi Method

(v) LU decomposition Method

(vi) Gauss-Jacobi Method

(vii) SOR Methodor Gauss-Siedel Method

(viii) Lagrange Interpolation or Newton Interpolation

(ix) Simpson's rule.

Section-D

(i) Plotting of Legendre polynomial for $n = 1$ to 5 in the interval [0,1]. Verifying graphically that all the roots of $P_n(x)$ lie in the interval [0,1].

(ii) Automatic computation of coefficients in the series solution near ordinary points

(iii) Plotting of the Bessel's function of first kind of order 0 to 3.

(iv) Automating the Frobenius Series Method

(v) Random number generation and then use it for one of the following
- (a) Simulate area under a curve
- (b) Simulate volume under a surface

(vi) Programming of either one of the queuing model
- (a) Single server queue (e.g. Harbor system)
- (b) Multiple server queue (e.g. Rush hour)

(vii) Programming of the Simplex method for 2/3 variables

Semester - IV

MMA 401 MATHEMATICAL MODELING

Detailed Syllabus

Simple situations requiring mathematical modeling, techniques of mathematical modeling, Classifications, Characteristics and limitations of mathematical models, some simple illustrations.

Mathematical modeling through differential equations, linear growth and decay models, Nonlinear growth and decay models, Compartment models, Mathematical modeling in dynamics through ordinary differential equations of first order.

Mathematical models through difference equations, some simple models, Basic theory of linear difference equations with constant coefficients, Mathematical modeling through difference equations in economic and finance, Mathematical modeling through difference equations in population dynamic and genetics.

Situations that can be modeled through graphs. Mathematical models in terms of Directed graphs, Mathematical models in terms of signed graphs, Mathematical models in terms of weighted digraphs.

Mathematical modeling through linear programming, Linear programming models in forest management. Transportation and assignment models.

References:

1. J. N. Kapur, *Mathematical Modeling*, WileyEastern.
2. D. N. Burghes, *Mathematical Modeling in the Social Management and Life Science*, Ellie Herwood and JohnWiley.
3. F. Charlton, *Ordinary Differential and Difference Equations*, VanNostrand.

DISCIPLINE SPECIFIC ELECTIVE (Mathematics)
MMA031 / MMA041 / MMA042 / MMA043

DISCRETE MATHEMATICS

Sets and propositions: Combinations of sets, Finite and Infinite sets, Uncountably infinite sets, Principle of inclusion and exclusion, Mathematical induction. Propositions, Fundamentals of logic, First order logic, Ordered sets.
Permutations, Combinations, Numeric functions, Generating functions.
Recurrence relations and recursive algorithms:Recurrence relations, Linear recurrence relations with constant coefficients, Solution by the method of generating functions, Sorting algorithm.
Relations and functions: Properties of binary relations, Equivalence relations and partitions, Partial and total ordering relations, Transitive closure and Warshal's algorithm.
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.
Graphs and planar graphs : Basic terminology, Multigraphs and weighted graphs, Paths and circuits, Shortest paths in weighted graphs, Eulerian paths and circuits, Hamiltonian paths and circuits. Colourable graphs, Chromatic numbers, Fivecolour theorem and Four colour problem.
Trees and cut-sets : trees, rooted trees, Path lengths in rooted trees, Spanning trees and BFS & DFS algorithms, Minimum spanning trees and Prims &Kruskal's algorithms.

Text Books:

1. C.L.Liu: Elements of Discrete Mathematics, McGraw Hill,1985.

2. J.P. Tremblay and RManohar : 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.

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, Galerkin'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 C_0 and C_1 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",Springer 2008
5 Kot, M., "Elements of Mathematical Ecology", Cambridge University Press 2001

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.

PicardTheorems.

References:

1. L. Ahlfors, Complex Analysis, McGraw-Hill, 3rd ed., New York, 1979.
2. J.B. Conway, Functions of One Complex Varliable, 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 Summ-ation 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.

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-gramming 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 randomenvironment.

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, reparametrization (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.
6. D. Somasundaram, Differential Geometry, A First Course, Narosa Publishing House, New Delhi, 2005.
7. L. P. Eisenhart, A Treatise on the Differential Geometry of Curves and Surfaces, Ginn and Company, Boston, 1909.

MODERN THEORY OF PARTIAL DIFFERENTIAL EQUATIONS

Prerequisites: Functional Analysis, Partial Differential Equations.
Theory of distributions: supports, test functions, regular and singular distributions, generalised 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 andwellposedness with examples, regularity result, maximum principles, eigenvalueproblems.
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 of line 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, 2nd Edition, 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.
6. S. W. Yuan, *Foundations of Fluid Dynamics*, Prentice-Hall of India, 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, Calrendorn 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. Divisibilty 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, putable 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.

DISCIPLINE SPECIFIC ELECTIVE (Data Science)
MMA032 / MMA044 / MMA045 / MMA046

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, Big data 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,Chris Gemignani,Richard Galentino.
3. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data,Gebundene Ausgabe,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

DIGITAL MARKETING

On successful completion of this Course, the learner will be able to:
• *Explain the role and importance of digital marketing in a rapidly changing business landscape*
• Discuss the key elements of a digital marketing strategy
• Illustrate how the effectiveness of a digital marketing campaign can be measured
• *Demonstrate advanced practical skills in common digital marketing tools such as SEO, SEM, Social media and Blogs*

Hours: 40 Hrs
UNIT I (10 Hrs): Digital Marketing Fundamentals, Website Planning and Structure, Website Design using WordPress CMS
UNIT II (10 Hrs): Facebook Marketing for Business, Google AdWords' and PPC Advertising, YouTube and Video Marketing, E-mail Marketing for Business
UNIT III (10 Hrs): Content Creation and Promotion, Product Marketing (Google Ads, Instagram, Facebook, YouTube etc), Blogging and Bing Advertising, Freemium and Premium Digital Marketing Tools.
UNIT IV (10 Hrs): Lead Generation & marketing automation, GEO Marketing, Social Media Marketing, Optimization & Advertising, Search Engine Optimization (SEO).
Suggested Reading:
• Blanchard O. (2014) *Social Media ROI: Managing and Measuring Social Media Efforts in Your Organization*
• Pulizzi, J. (2013) *Epic Content Marketing*
• *Marketing on Facebook – Best practice guide* (2015) Facebook Marketing Press
• Chaffey, D., & Ellis-Chadwick, F. (2012) *Digital Marketing: Strategy, Implementation and Practice,* 5/E, Pearson
• Tapp, A., & Whitten, I., & Housden, M. (2014) *Principles of Direct, Database and Digital Marketing*, 5/E, Pearson
• Tasner, M. (2015) *Marketing in the Moment: The Digital Marketing Guide to Generating More Sales and Reaching Your Customers First,* 2/E, Pearson

COURSE OUTCOMES DESCRIPTION	
CO1	*Develop a digital marketing plan that will address common marketing challenges*
CO2	*Articulate the value of integrated marketing campaigns across SEO, Paid Search, Social, Mobile, Email, Display Media, Marketing Analytics*
CO3	*Recognize Key Performance Indicators tied to any digital marketing program*
CO4	*Improve Return on Investment for any digital marketing program*
CO5	*Launch a new, or evolve an existing, career path in Digital Marketing*
CO6	*Ability to identify and apply the knowledge of subject practically in real life situations*

ARTIFICIAL INTELLIGENCE & 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

Introduction to Machine Learning Supervised Learning, Unsupervised Learning, Reinforcement Learning. Probability Basics Linear Algebra Statistical Decision Theory – Regression & Classification Bias – Variance Linear Regression Multivariate Regression.
Dimensionality Reduction Subset Selection, Shrinkage Methods, Principle Components Regression Linear Classification, Logistic Regression, Linear Discriminant Analysis Optimization, Classification-Separating Hyperplanes Classification.

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.

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.

QUALITY MANAGEMENT

Detailed syllabus

Overview of quality, histoiyo f 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.

MARKETING MANAGEMENT

Detailed syllabus

Concept o f Marketing and its role in Business and Public Organization, Marketing Decisions, Need for Scientific Marketing Analysis. Uses and Limitations of Mathematical Models –in Marketing. Joint optimization o f price, quality and promotional effort. Purchasing under fluctuating prices. Factors affecting Pricing decision, Pricing methods.Promotional decisions in the presence of competition. Game theory models for Promotional Effort. Spatial Allocation of Promotional Effort, Media Allocation of Advertisement, Brand Switching Analysis. Sales Response to Advertising in Presence of Competition.Channels of distribution, Transportation decision, Locating company's wholesale dealers and warehouses.

Suggested Readings:

1. Tony Curtis: Marketing for Engineers. Scientists and Technologists, John Wiley & Sons Inc. 2008.
2. B. Bass (ed): Mathematical Models and Methods in Marketing. Irwin Series, 1971
3. S. Murty. G. L. Li lien. P. Kotier: Marketing Models, Prentice Hall o f India, 1998.
4. William R. King: Quantitative Analysis for Marketing Management, McGraw Hill Co., 1967.
5. J. M. Howard: Consumer behaviour in Marketing Strategies, Prentice Hall, 1989.
6. D.B. Montgomery, G.L.Urban: Management Science in Marketing, Prentice Hall, 1979.
7. Graham J. Hooley and Michael K. Hassey: Quantitative Methods in Marketing, 2nd Edition, International Thomson Business PressTT999.
8. Grahame R. Dowling: The Art and Science o f Marketing- Marketing for Marketing Managers, Oxford University Press, 2005.
9. Gary L. Lilien. Philip Kotier. K. Sridhar Moorthy: Marketing Models, Prentice Hall o f India. 2003.

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: Principle o 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.

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.

RECORDING AND ANALYSIS OF BUSINESS OPERATIONS

Course Objectives:

- *To provide a comprehensive treatment of accounting principles, technique and practices.*
- *To get the students acquainted with fundamental concepts and processes of accounting.*
- *To have a basic understanding of significant tools and techniques of financial analysis, which are useful in the interpretation of financial statements.*
- *To have a brief knowledge about international accounting standards.*
- *To understand basics of fundamental analysis*

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).

COURSE OUTCOMES DESCRIPTION

CO1	Understanding *the concepts and principles for their routine monetary transaction.*
CO2	*Analyse the needs of accounting data and demonstrate the ability to communicate*
CO3	*Recognize circumstances providing for increased exposure to fraud and define preventative internal control measures.*
CO4	*Prepare financial statements in accordance with Generally Accepted Accounting Principles and its excel application.*
CO5	*Employ critical thinking skills to analyze financial data as well as the effects of differing financial accounting methods on the financial statements.*
CO6	Ability to apply the knowledge of subject practically in real life situations