ఆంధ్రప్రదేశ్ కేంద్రీయ విశ్వవిద్యాలయం आंध्रप्रदेश केंद्रीय विश्वविद्यालय

CENTRAL UNIVERSITY OF ANDHRA PRADESH

Jnana Seema, Ananthapuramu, India - 515701

DEPARTMENT OF COMPUTER SCIENCE & ARTIFICIAL INTELLIGENCE

SCHOOL OF INTERDISCIPLINARY AND APPLIED SCIENCES

Masters Programme

(as per the National Credit Framework 2023)

Vidya Dadati Vinayam

(Education Gives Humility)

Master of Computer Applications (MCA)

Programme Structure

(Effect from Academic Year 2026 - 27)

Master of Computer Applications
Department of Computer Science & AI
School of Interdisciplinary and Applied Sciences

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Master of Computer Applications
Department of Computer Science & AI
School of Interdisciplinary and Applied Sciences

1. Introduction to the Programme

The Master of Computer Applications (MCA) at Central University of Andhra Pradesh is a forward-looking postgraduate Programme to be introduced from the academic year 2026–27, developed in alignment with the National Education Policy (NEP 2020) and as per the University Grants Commission (UGC) credit framework. The Programme is designed to provide advanced knowledge in computer science and applications, building a strong theoretical foundation while emphasizing practical and industry-oriented learning. It offers flexibility and multidisciplinary exposure in line with NEP guidelines, ensuring a comprehensive, outcome-based educational experience. The curriculum covers core areas such as Advanced Programming, Data Structures and algorithms, Mathematics for Computer Application, Operating Systems, Database Management Systems, Computer Networks, Software Engineering, and Web Technologies. It also integrates emerging and high-demand domains, including Artificial Intelligence, Machine Learning, Data Science, Cybersecurity, Cloud Computing, Blockchain, and Full-Stack Web Development. The programme further emphasizes research aptitude, innovation, entrepreneurship, professional ethics, communication skills, teamwork, and sustainable technological practice. With a focus on practical learning, industry exposure, research orientation, ethics, and innovation, the MCA Programme prepares graduates to become skilled, responsible, and industry-ready professionals who can meet the demands of an evolving digital world.

2. Vision

The vision is to be the source of bringing out globally competent, pioneering computing professionals, innovative, and skilled professionals who excel in the field of Computer Applications and deliver sustainable solutions to global challenges.

3. Programme Educational Objectives (PEOs)

PEO1: Strong Computing Foundations Graduates will acquire comprehensive knowledge in computer science, programming, software development, database management, networking, and emerging technologies to address real-world computing problems effectively.

PEO2: Technical and Analytical Competence Graduates will develop strong analytical, problem-solving, and programming skills using modern tools, platforms, and technologies such as Python, Java, Web Technologies, Cloud Computing, Artificial Intelligence, Data Analytics, and Cyber Security.

PEO3: Research, Innovation, and Development Graduates will be capable of designing innovative software solutions, conducting research, and developing applications that contribute to industry, academia, and societal needs through creativity and technological innovation.

PEO4: Professionalism and Ethical Responsibility Graduates will demonstrate professional ethics, teamwork, communication skills, and social responsibility while working in multidisciplinary and multicultural environments.

PEO5: Lifelong Learning and Leadership Graduates will engage in continuous learning, adapt to rapidly evolving technologies, pursue higher studies or professional certifications, and take leadership roles in industry, entrepreneurship, research, and public sectors.

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4. Programme Outcomes (POs)

The MCA programme is designed to provide students with strong theoretical foundations, practical computing skills, research aptitude, and professional competencies in computer applications, software development, cyber security, Cloud computing, data science, and emerging technologies. After successful completion of the programme, students will be able to:

PO1: Computing Knowledge: Apply knowledge of computer science, mathematics, data structures, algorithms, database systems, operating systems, networking, artificial intelligence, and software engineering to solve complex computing problems.

PO2: Problem Analysis: Identify, formulate, analyse, and solve real-world computing and business problems using logical reasoning, computational thinking, statistical techniques, and analytical methods.

PO3: Design and Development of Solutions: Design, develop, test, and implement efficient software systems, web applications, Cloud-based solutions, secure applications, and intelligent systems that meet societal and industrial requirements.

PO4: Research and Investigation: Conduct research, experimentation, and investigations using modern computational tools, machine learning techniques, data analytics, and emerging technologies to derive meaningful conclusions and innovative solutions.

PO5: Modern Tool Usage: Select and apply appropriate modern tools, technologies, and platforms such as Python, Java, R, SQL, MongoDB, Hadoop, Cloud Computing tools, Cyber Security tools, Full Stack frameworks, AI and ML libraries for software development and data-driven applications.

PO6: Computing and Society: Understand and evaluate the impact of computing solutions on society, economy, healthcare, business, governance, and the environment while addressing legal, ethical, and social responsibilities.

PO7: Environment and Sustainability: Recognize the importance of sustainable and energy-efficient computing practices and apply technology solutions responsibly for environmental and societal well-being.

PO8: Ethics and Cyber Responsibility: Apply ethical principles, professional standards, cyber laws, data privacy practices, and security measures in software development, cyber security, digital forensics, and information management.

PO9: Individual and Team Work: Function effectively as an individual, team member, or leader in multidisciplinary and multicultural environments, demonstrating collaboration, coordination, and project management skills.

PO10: Communication Skills: Communicate effectively with technical and non-technical audiences through presentations, software documentation, technical reports, research publications, and professional interactions.

PO11: Project Management and Entrepreneurship: Apply project management principles, software development life cycle practices, financial literacy, innovation, and entrepreneurial skills in executing computing projects and technology-based solutions.

PO12: Lifelong Learning: Recognize the need for continuous learning and adapt to rapidly evolving technologies, industry trends, research advancements, and professional practices through higher education, certifications, and self-learning.

5. Programme-Specific Outcomes (PSOs):

The learning outcomes are designed to equip students with the knowledge, skills, and abilities necessary to succeed in careers related to economics, data analysis, and decision-making:

PSO1: Software Development and Programming Skills: Students will gain strong programming and software development skills using modern languages, tools, and technologies. They will be able to design and build efficient, scalable, and user-friendly software applications for real-world needs.

PSO2: Problem Solving and Computational Intelligence: Students will develop analytical thinking and problem-solving abilities by applying algorithms, data structures, artificial intelligence, machine learning, and computational techniques to solve practical computing problems.

PSO3: Emerging Technologies and System Design: Students will learn to design and manage secure, reliable, and modern computing systems using emerging technologies such as cloud computing,

cybersecurity, blockchain, data analytics, and full-stack web development.

PSO4: Research, Innovation, and Professional Practice: Students will cultivate research aptitude, creativity, and innovation to develop technology-driven solutions while following ethical practices and professional standards in multidisciplinary environments.

PSO5: Career Readiness and Lifelong Learning: Students will enhance their communication, teamwork, leadership, and entrepreneurial skills while developing the habit of continuous learning to adapt to evolving technologies and succeed in industry, research, higher education, and public service.

5. Pedagogy of the Programme

The pedagogy of the Master of Computer Applications (MCA) programme is designed to provide a balanced combination of theoretical knowledge, practical skills, research orientation, and industry exposure through an outcome-based learning approach. The programme follows Bloom's Taxonomy to gradually develop students' understanding, analytical ability, problem-solving skills, and innovation in computer applications and emerging technologies. Students begin by learning fundamental concepts in programming, mathematics, data structures, databases, operating systems, networking, and software engineering through lectures, tutorials, and laboratory sessions.

Practical learning is emphasized through coding exercises, assignments, mini-projects, and hands-on training in Python, Java, R, SQL, Cloud computing, Machine Learning, Cyber Security, Full-Stack Development, and Data Analytics tools. As the programme progresses, students apply modern technologies and computational techniques to solve real-world problems through case studies, interdisciplinary projects, internships, seminars, and research activities. Collaborative learning, technical presentations, workshops, and hackathons help enhance teamwork, communication, leadership, and professional skills.

The programme culminates in a major project or dissertation where students design innovative software solutions, intelligent systems, or research-based applications addressing societal and industrial challenges. Industry interactions, mentorship programmes, and career development activities further prepare students for employment, entrepreneurship, higher studies, and lifelong learning in the rapidly evolving IT sector.

6. Programme Structure

- The Master of Computer Applications is a two-year postgraduate programme divided into four semesters, comprising a total of 84 credits.
- The curriculum integrates Core Courses, Discipline-Specific Electives, Multidisciplinary Courses, MOOCs, Skill/Internship Components, and Dissertation Work, ensuring a balanced and comprehensive learning journey.
- **Semester-wise Structure:**
  - **Semester I:** The first semester focuses on building strong foundations in computer science and programming through courses such as Mathematics for Computer Applications, Python Programming, and Data Structures & Algorithms. Students are also introduced to interdisciplinary learning, domain-specific electives, MOOCs, and practical exposure through System Building Laboratory courses.
  - **Semester II:** The second semester emphasizes core computing concepts including Database Management Systems, Object-Oriented Programming through Java, and Operating Systems. Students further enhance their practical and analytical skills through laboratory sessions, R Programming, electives, and interdisciplinary courses.
  - **Semester III:** The third semester focuses on advanced and emerging technologies such as Machine Learning, Full Stack Web Development, and Computer Networks. The semester also includes domain electives, internship components, MOOCs, and hands-on laboratory training to strengthen industry readiness and application development skills.
  - **Semester IV:** The final semester is dedicated to Project Work / Dissertation, where students apply the knowledge and technical skills acquired throughout the programme to solve real-world problems, develop innovative software solutions, or carry out research-oriented work under faculty supervision.

Master of Computer Applications
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Semester and Course wise Credits Distribution

Semester	Core Course Credits				DSE Credits		IDE Credits		CCC Credits				SIP Credits		Dissertation Credits		Total Credits
	Code	T	L	Total	Code	Total	Code	Total	Code	T	L	Total	Code	Total	Code	Total	
1	MCA101	4	0	4	MCA111	3	MCA112	3	-		-	-	-	-	-	-	20
	MCA102	3	0	3													
	MCA103	3	0	3	MCA105 MOOC	2											
	MCA125	-	2	2													
	Total	**10**	**2**	**12**	**-**	**5**	**-**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	
II	MCA201	3	0	3	MCA211	3	MCA212	3	MCA213	2	2	4	-	-	-	-	24
	MCA202	3	0	3													
	MCA203	3	1	4	MCA205 MOOC	2											
	MCA225	-	2	2													
	Total	**9**	**3**	**12**	**-**	**5**	**-**	**3**	**-**	**2**	**2**	**4**	**-**		**-**	**-**	
III	MCA301	3	0	3	MCA311	3	MCA312	3	MCA313	2	0	2	MCA314	2	-	-	24
	MCA302	3	1	4													
	MCA303	3	0	3	MCA305 MOOC	2											
	MCA325	-	2	2													
	Total	**9**	**3**	**12**	**-**	**5**	**-**	**3**	**-**	**2**	**0**	**2**	**-**	**2**	**-**	**-**	
IV	MCA401	4	-	4	-	-	-	-	-	-	-	-	-	-	MCA402	**12**	**16**
	Total	**3**	**1**	**4**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**12**	
Total Courses	**15**	**-**	**-**	**-**	**6**	**-**	**3**	**-**	**2**	**-**	**-**	**-**	**1**	**-**	**1**	**-**	**27**
Total Credits	**-**	31	9	**40**	**-**	**15**	**-**	**9**	**-**	4	2	**6**	**-**	**2**	**-**	**12**	**84**
Percentage	**-**	37.0	10.71	**47.61**	**-**	**17.85**	**-**	**10.71**	**-**	4.78	2.39	**7.14**	**-**	**2.39**	**-**	**14.30**	**100**

Note: T: Theory **L/P:** Lab/Practicals **DSE:** Discipline Specific Elective
IDE: Inter-disciplinary Electives **CCC:** Common Compulsory Course **SIP:** Summer Internship Project

Programme Structure

Semester I						
Sl. No.	Course Code	Title of the Course	Credit Points	Credit Distribution		
				L*	T*	P*
1	MCA101	Mathematics for Computer Applications	4	3	1	0
2	MCA102	Python Programming	3	3	0	0
3	MCA103	Data Structures and Algorithms	3	3	0	0
4	MCA105	MOOCs/Online/Elective – I	2	2	-	-
5	MCA111	Domain-Specific Elective – II (DSE)	3	2	1	0
6	MCA112	IDE1	3	3	0	0
7	MCA125	System Building Lab – 1 (MCA102 & MCA103)	2	-	-	2
Total			**20**	**16**	**2**	**2**

Semester II						
Sl. No.	Course Code	Title of the Course	Credit Points	Credit Distribution		
				L*	T*	P*
1	MCA201	Database Management Systems	3	3	0	0
2	MCA202	Object-Oriented Programming through Java	3	3	0	0
3	MCA203	Operating System	3	3	0	0
		Lab: Operating System	1	0	0	1
4	MCA205	MOOCs / Online / Elective III	2	2	-	-
5	MCA211	Domain-Specific Elective – IV (DSE)	3	2	1	0
6	MCA212	IDE2	3	3	0	0
7	MCA213	CCC: Introduction to R Programming	2	2	0	0
		Lab: Introduction to R Programming	2	0	0	2
8	MCA225	System Building Lab-II (MCA201 & MCA202)	2	-	-	2
Total			**24**	**18**	**1**	**5**

Semester III						
Sl. No.	Course Code	Title of the Course	Credit Points	Credit Distribution		
				L*	T*	P*
1	MCA301	Machine Learning	3	3	0	0
2	MCA302	Full Stack Web Development	3	3	0	0
		Lab: Full Stack Web Development	1	0	0	1
3	MCA303	Computer Networks	3	3	0	0
4	MCA305	MOOCs / Online / Elective – V	2	2	-	-
5	MCA311	Domain-Specific Elective – VI (DSE)	3	2	1	0
6	MCA312	IDE3	3	3	0	0
7	MCA313	CCC: Building Mathematical Ability and Financial Literacy	2	1	1	0
8	MCA314	**SIP:** Summer Internship Programme	2	0	0	2
9	MCA325	System Building Lab -III (MCA301& MCA303)	2	-	-	2
Total			**24**	**17**	**2**	**5**

Semester IV

Sl. No.	Course Code	Title of the Course	Credit Points	Credit Distribution		
				L*	T*	P*
1	MCA401	Software Engineering	4	3	0	1
2	MCA402	Project Work / Dissertation	12	0	0	12
Total			**16**	**3**	**0**	**13**
Grand Total			**84**	**66**	**0**	**26**

Note: **L:** Lectures**; T:** Tutorials **P:** Practical /Lab

Elective Courses						
Sl. No.	Course Code	Title of the Course	Credit Points	Credit Distribution		
				L*	T*	P*
STREAM 1 – INFORMATION SECURITY						
1.	MCA111	Fundamentals of Cryptography (Level 1)	3	2	1	0
2.	MCA111	Cyber Law & Cyber Forensics (Level 1)	3	2	1	0
3.	MCA211	Database and Application Security (Level 2)	3	2	1	0
4.	MCA211	Mobile and Digital Forensics (Level 2)	3	2	1	0
5.	MCA211	Cyber Security (Level 2)	3	2	1	0
6.	MCA311	Information System Audit (Level 3)	3	2	1	0
7.	MCA311	Information Security Management (Level 3)	3	2	1	0
8.	MCA311	Ethical Hacking (Level 3)	3	2	1	0
STREAM 2 – DATA SCIENCE						
9.	MCA111	Big Data Analytics (Level 1)	3	2	1	0
10.	MCA111	Artificial Intelligence (Level 1)	3	2	1	0
11.	MCA111	Service Design Thinking (Level 1)	3	2	1	0
12.	MCA111	Statistics for Business Analytics (Level 1)	3	2	1	0
13.	MCA211	Digital Marketing (Level 2)	3	2	1	0
14.	MCA211	Social Network Analytics (Level 2)	3	2	1	0
15.	MCA211	Natural Language Processing (Level 2)	3	2	1	0
16.	MCA311	NoSQL Databases (Level 3)	3	2	1	0
STREAM 3 – NETWORK COMPUTING						
17.	MCA111	Principles of Distributed Computing (Level 1)	3	2	1	0
18.	MCA211	Introduction to Parallel Computing (Level 2)	3	2	1	0
19.	MCA211	Web Services Computing (Level 2)	3	2	1	0
20.	MCA311	Pervasive and Ubiquitous Computing (Level 3)	3	2	1	0
21.	MCA311	Cloud Computing (Level 3)	3	2	1	0
22.	MCA311	Wireless Sensor Networks (Level 2)	3	2	1	0

Semester-wise Credit Distribution

Semester	Total Credits	Cumulative credit at the end of the semester
1	20	20
II	24	44
III	24	68
IV	16	84

I. Credit Requirement

- The minimum number of credits required to be earned by a student for the award of the degree is 84.
- Students may earn credits in excess of 84 by opting for additional courses; however, the upper limit shall not exceed **86 credits**.

II. Assessment Pattern

- **Theory Courses**:
  - **Internal (40%)** – Formative evaluation comprising two best out of three tests (each test carrying a maximum of 15 marks, totalling 30 marks), along with seminar/assignments/attendance (10 marks).
  - **External (60%)** – Summative evaluation through the semester-end examination.

End Semester Examination
Maximum Marks: 60 Time: 3 Hours

- **Theory with laboratory Courses:**
  - **Internal (60%) –** Formative evaluation comprising two best out of three test (for a maximum of 15 marks each = 30 marks), practical lab (20 marks) and seminar / assignments / class presentations / quizzes (10 marks).
  - **External (40%)** – Summative evaluation through the semester examination.

End Semester Examination
Maximum Marks: 40 Time: 2 Hours

Dissertation / Project Report
Dissertation Evaluation – 60 Marks Seminar and Viva -Voce - 40 Marks

III. Laboratory Components:

- **Internal (60%)** – Continuous assessment through lab work and internal examination.
- **External (40%)** – Summative evaluation through the semester-end practical examination.

IV. End-Semester Examination:

- Maximum Marks: **60**
- Duration: **3 Hours**

Important Information to Students

i. Eligibility: Bachelor's degree in Computer Applications/ Computer Science/ Information Technology OR Bachelor's degree in Commerce/ Corporate Secretaryship/ Economics / Business Administration with Mathematics/ Business Mathematics / Statistics with Computer Applications as one of the subjects OR Bachelor's degree in Science with Mathematics /statistics as one of the subjects with a minimum of 50% marks.

ii. The minimum duration for completion of the PG Programme is four semesters (two academic years), and the maximum duration is eight semesters (four academic years), or as prescribed by the regulatory bodies/university from time to time.

iii. A student should have minimum 75% attendance in classes, seminars, practical/ lab in each course of study without which he/she will not be allowed for the Semester -end examination.

iv. All theory courses in the programme shall have Continuous Internal Assessment (CIA) component of 40 marks and a Semester-end component for 60 marks. The minimum pass marks for a course are 50%.

v. In case of courses with lab component Continuous Internal Assessment (CIA) component shall be of 60 marks and Semester-End Component for 40 marks. The minimum pass marks for a course are 50%.

vi. The student is given three Continuous Internal Assessment (CIA) tests per semester in each course from which the best two performances are considered for the purpose of calculating the marks in CIA. A record of the continuous assessment is maintained by the academic unit. The three internal tests are conducted for 15 Marks each, out of the best two tests' scores are considered for 30 marks and for Academic Participation (10 marks).
The remaining 10 marks shall be awarded based on participation and performance in assignments, class presentations, seminars, and quizzes.

vii. A student should pass separately in both CIA and the Semester-end Examination (SEE), i.e., a student should secure 20 (50% of 40) out of 40 marks for theory in CIA and 30 (50% of 60) out of 60 marks for theory in the SEE.

viii. Semester-end examination shall consist of Objective type questions, descriptive type questions, short answer questions and case studies or any others.

ix. A student failing to secure the minimum pass marks in the CIA is not allowed to take the Semester-end examination of that course. She/he has to redo the course by attending special classes for that course and get the pass percentage in the internal tests to become eligible to take the semester-end examination.

x. Semester-end examination shall consist of objective type questions, descriptive type questions, short answer questions and case studies or any other recommended by the Board of Studies (BoS).

xi. Students failing a course due to lack of attendance should redo the course.

xii. Re-evaluation is applicable only for theory papers and shall not be entertained for other components such as practical/ thesis/ dissertation/ internship etc.

xiii. An on-campus elective course is offered only if 10 or 50% of the students registered, whichever is higher.

SEMESTER WISE
DETAILED SYLLABUS

SEMESTER-I

Course Code : MCA**101** Course Type : **Core** No. of Credits : **4.00** No. of Hours : **60**	**Course Title** **Mathematics for Computer Applications**

Course Objectives:

- To understand the basic foundation knowledge on linear algebra and calculus essential for solving engineering problems.
- To develop analytical skills through the application of differentiation, integration, and matrix operations.
- To apply the concepts of Engineering Mathematics in solving the real-world applications.

Course Outcomes (COs):

By the end of the course, students will be able to:

- **CO1:** Apply fundamental concepts of calculus, determine the Rank of a matrix using echelon and normal forms and understand its implications for solving linear systems.
- **CO2:** Understand and manipulate vector spaces by exploring subspaces, linear independence, basis, dimension, and linear transformations.
- **CO3:** Analyze multivariable functions, Jacobians, optimization techniques such as Lagrange multipliers, vector spaces and perform linear transformations using basis and dimension concepts.
- **CO4:** Solve systems of linear equations using matrix methods, and interpret matrix properties such as rank, eigenvalues, and diagonalizability.
- **CO5:** Evaluate definite and multiple integrals for solving problems related to area, volume, and special functions.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	–	2	2	–	–	–	–	–	–	-
CO2	3	3	–	2	2	–	–	–	–	–	–	–
CO3	3	3	2	3	2	–	–	–	–	–	–	–
CO4	3	3	-	3	3	-	-	-	–	–	–	–
CO5	3	2	2	3	–	–	–	–	-	-	-	–

Course Outline:

Unit-I: **[10 Hours]**

Sets, Relations, and Functions: Introduction to sets and set operations, Cartesian products, relations and their types, equivalence relations, functions and types of functions, composition and inverse of functions, and basic concepts of mathematical logic with applications in computer science.

Unit-II: **[12 Hours]**

Differential Calculus: Functions, limits, and continuity, partial differentiation, total derivatives and chain rule, Taylor and Maclaurin series with basic applications, Jacobian, and maxima and minima of functions of two variables.

Unit-III: **[13 Hours]**

Matrices and Linear Algebra: Matrices and matrix operations, rank of a matrix using echelon method, consistency of systems of linear equations, vector spaces and subspaces, linear independence, basis and dimension, eigenvalues and eigenvectors, Cayley–Hamilton theorem, and diagonalization of matrices.

Unit-IV: **[10 Hours]**

Probability, Statistics, and Regression: Basic concepts of probability, conditional probability and Bayes theorem, random variables and probability distributions, measures of central tendency and dispersion, correlation and regression, and curve fitting using least squares method.

Unit-V: **[15 Hours]**

Graph Theory and Applications: Introduction to graph theory and graph terminology, types and representation of graphs, paths, circuits and connectivity, trees and spanning trees, graph traversal techniques such as BFS and DFS, shortest path concepts, and applications of graph theory in computer science and computer networks.

Suggested Readings:

1. Kenneth H. Rosen, Discrete Mathematics and Its Applications, McGraw Hill, 8th ed., 2019.
2. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 10th ed., 2023.

Text/Reference Books:

1. G. Strang, “Linear Algebra and its Applications”, Brooks/Cole, 4th ed., 2006.
2. S.C. Gupta and V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons, 12th ed., 2020.
3. Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice Hall of India, 2017.

Course Code : MCA**102** Course Type : **Core** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Python Programming**

Course Objectives:

- To introduce Python programming fundamentals and problem-solving skills.
- To develop ability to use functions, modules and GUI programming.
- To apply Python libraries for scientific computing and data analysis.
- To perform data visualization and build small applications.

Course Outcomes (COs):

After completion of the course, students will be able to:

- **CO1:** Understand Python syntax, control structures and data types.
- **CO2:** Apply functions, modules and GUI programming concepts.
- **CO3:** Use NumPy for numerical computation.
- **CO4:** Apply Pandas for data cleaning and analysis.
- **CO5:** Develop visualization and GUI-based data applications.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	–	1	1	–	–	–	–	–	–	-
CO2	3	2	2	1	2	–	–	–	–	–	–	–
CO3	3	2	2	2	3	–	–	–	–	–	–	1
CO4	3	2	2	2	3	-	-	-	–	–	1	1
CO5	3	2	3	2	3	–	–	–	1	1	1	1

Course Outline:

Unit-I: [08 Hours]

Introduction to Python, interactive execution, identifiers, variables and data types. Operators, expressions, built-in functions, type conversions. Strings and string operations, slicing, formatting. Control flow: indentation, conditional statements, loops, break/continue/pass. Functions basics, recursion, exception handling. Data structures: lists, tuples, dictionaries, sets.

Unit-II: [10 Hours]

Defining functions, parameters, keyword and optional arguments, variable length arguments. Scope and namespaces, functions as first-class objects. Functional programming concepts: lambda expressions, mapping, filtering, reduction, list comprehensions.

Unit-III: [10 Hours]

NumPy arrays and vectorized computation, ndarray creation and data types. Array indexing, slicing and fancy indexing. Array operations, universal functions, reshaping, transpose and concatenation. Tensors and multidimensional data representation. Reading data from files (CSV, JSON, URL).

Unit-IV: **[08 Hours]**

Pandas Series and DataFrame, indexing and selection. Data cleaning and wrangling, reindexing, sorting and filtering. Descriptive statistics, correlation and covariance. Handling missing data, function mapping and alignment.

Unit-V: **[09 Hours]**

Matplotlib fundamentals, figures and subplots. Line plots, bar charts, histograms, scatter plots, box plots. Visualization with Pandas. Advanced visualization concepts and saving plots. Tkinter GUI integration with data applications.

Suggested Readings:

1. Wes McKinney – *Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython*, O'Reilly Media.
2. *Mark Lutz – Learning Python*, O'Reilly Media.

Text/Reference Books:

1. Allen B. Downey – *Think Python: How to Think Like a Computer Scientist*, O'Reilly Media.
2. Jake VanderPlas – *Python Data Science Handbook: Essential Tools for Working with Data*, O'Reilly Media.
3. John V. Guttag – *Introduction to Computation and Programming Using Python*, MIT Press.
4. Martin C. Brown – Python: The Complete Reference, McGraw Hill.

Course Code : MCA**103** Course Type : **Core** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Data Structures and Algorithms**

Course Objectives:

- To understand fundamental data structures.
- To analyze algorithm efficiently and complexity.
- To implement tree and graph structures.
- To apply algorithm design techniques.

Course Outcomes (COs):

After completion of the course, students will be able to;

- **CO1:** Understand linear data structures and their applications.
- **CO2:** Apply tree and graph representations.
- **CO3:** Analyze algorithm complexity using asymptotic notations.
- **CO4:** Apply divide-and-conquer and greedy techniques.
- **CO5:** Select suitable data structures for real-world problems.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	–	–	–	–	–	–	-
CO2	3	2	3	2	1	–	–	–	–	–	–	–
CO3	3	2	2	3	2	–	–	–	–	–	1	1
CO4	2	2	2	2	1	-	-	-	–	–	–	1
CO5	3	2	2	2	2	–	–	–	-	-	1	1

Course Outline:

Unit-I: **[09 Hours]**

Introduction and Linear Structures: Definition and importance of data structures, operations and applications. Arrays: representation, traversal, insertion, deletion, multidimensional arrays. Pointers and dynamic memory allocation, dynamic arrays, structures and unions. Stacks: array and linked representation, applications, postfix evaluation, infix to postfix conversion. Queues: array and linked representation, circular queue, priority queue and dequeue.

Unit-II: **[09 Hours]**

Linked lists: singly, doubly, circular and header linked lists, operations and applications. Algorithm Analysis and Brute Force Techniques: Algorithm concepts and properties, pseudo code specification. Performance analysis: time and space complexity, best, worst and average case. Asymptotic notations: Big-O, Ω and Θ. Mathematical analysis of recursive and non-recursive algorithms. Brute force techniques: bubble sort, selection sort, sequential search and string matching.

Unit-III: **[10 Hours]**

Algorithm Design Techniques: Divide and conquer: binary search, quick sort. Greedy techniques: Dijkstra's shortest path algorithm, Prim's and Kruskal's minimum spanning tree algorithms. Decrease and conquer: DFS and BFS as algorithmic strategies. Applications of sorting and searching in real problems.

Unit-IV: **[08 Hours]**

Trees and Graph Representation: Trees: terminology, binary trees, tree representation, tree traversals, binary search trees. Graphs: terminology, directed and undirected graphs, adjacency matrix and list representation. Graph traversal: Breadth First Search (BFS), Depth First Search (DFS), spanning trees.

Unit-V: **[09 Hours]**

Advanced Tree Structures and Applications: Binary search tree operations and applications. Expression trees and tree applications. Priority queues. Recap and comparative study of data structures for problem solving.

Suggested Readings:

1. V. Del Toro, Seymour Lipschutz — Data Structures (Schaum Series).
2. Ellis Horowitz, Sartaj Sahni & Susan Anderson-Freed — *Fundamentals of Data Structures in C*.

Text/Reference Books:

1. Anany Levitin — Introduction to the Design and Analysis of Algorithms
2. Thomas H. Cormen et al. — Introduction to Algorithms
3. Mark Allen Weiss — Data Structures and Algorithm Analysis
4. Robert Lafore — Data Structures and Algorithms in Java/C++
5. Reema Thareja — Data Structures Using C
6. Goodrich, Tamassia & Goldwasser — Data Structures and Algorithms in Python

SEMESTER-II

Course Code : MCA**201** Course Type : **Core** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Database Management Systems**

Course Objectives:

- To understand database architecture and modeling.
- To design relational databases using normalization.
- To develop SQL queries and database applications.
- To understand transaction and recovery mechanisms.

Course Outcomes (COs):

After completion of the course, students will be able to:

- **CO1:** Explain database concepts and ER modelling.
- **CO2:** Apply relational algebra and SQL queries.
- **CO3:** Design normalized database schemas.
- **CO4:** Analyze transaction management and concurrency.
- **CO5:** Evaluate distributed database concepts.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	–	1	1	–	–	–	–	–	–	-
CO2	3	2	2	2	2	–	–	–	–	–	–	–
CO3	3	2	3	2	2	–	–	–	–	1	1	–
CO4	3	2	2	3	2	-	-	-	–	1	1	–
CO5	3	2	1	2	2	–	–	1	-	1	1	1

Course Outline:

Unit-I: [11 Hours]

Introduction and Database Architecture: Purpose of DBMS, file system vs DBMS, database applications and users. Database characteristics, schemas and instances, three-schema architecture and data independence. Data models and database languages. Overview of data storage, indexing, data mining and specialty databases.
ER Modeling and Relational Model: Entity–Relationship model: entities, attributes, keys, relationships, weak entities and constraints. ER diagrams and design issues, extended ER features. Mapping ER model to relational schema.

Unit-II: [08 Hours]

Introduction to relational model: schema, keys, schema diagrams and query languages. Relational model concepts, relational algebra operations, join and division operations. Relational vs NoSQL overview.

Unit-III: [08 Hours]

SQL and Database Programming: SQL data definition and manipulation commands. Basic and advanced queries, joins, nested subqueries, set operations and null values. Aggregate functions, grouping and views.

Transactions, integrity constraints and authorization. Stored procedures, triggers and embedded SQL. Practical exposure using database tools and SQL laboratory exercises.

Unit-IV: **[10 Hours]**

Database Design and Normalization: Informal design guidelines, functional dependencies. Normalization: 1NF, 2NF, 3NF, BCNF and multivalued dependencies. Decomposition algorithms and dependency preservation. Formal relational query languages: relational algebra and relational calculus.

Unit-V: **[08 Hours]**

Transaction Management and Recovery: Transaction concepts and ACID properties. Concurrency control: lock-based protocols. Recovery techniques, backup and catastrophic recovery. Distributed database considerations and overview of OLAP. Recap and case study of real-time database applications.

Suggested Readings:

1. Ramez Elmasri & Shamkant Navathe — Fundamentals of Database Systems.
2. Abraham Silberschatz, Henry Korth & S. Sudarshan — Database System Concepts.

Text/Reference Books:

1. Raghu Ramakrishnan & Johannes Gehrke — Database Management Systems.
2. C. J. Date — An Introduction to Database Systems.
3. Garcia-Molina, Ullman & Widom — Database Systems: The Complete Book.
4. Thomas Connolly & Carolyn Begg — Database Systems: A Practical Approach.

Course Code : MCA**202** Course Type : **Core** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Object-Oriented Programming through Java**

Course Objectives:

- To understand object-oriented programming concepts.
- To develop Java-based applications.
- To implement multithreading and exception handling.
- To build web and database-driven Java applications.

Course Outcomes (COs):

After completion of the course, students will be able to;

- **CO1**: Apply OOP principles using Java.
- **CO2**: Implement packages, interfaces and exception handling.
- **CO3**: Develop multithreaded programs.
- **CO4**: Build servlet and JSP-based applications.
- **CO5**: Develop database connectivity using JDBC.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	1	2	–	–	–	–	–	–	-
CO2	3	2	2	2	2	–	–	–	–	–	–	–
CO3	2	2	3	2	2	–	–	1	–	–	–	–
CO4	2	2	3	2	3	-	-	1	1	1	–	–
CO5	3	2	3	2	3	–	–	–	1	1	1	–

Course Outline:

Unit-I: [10 Hours]

Java Fundamentals and OOP Concepts: Overview of Java, features and JVM architecture. Data types, operators, control statements and arrays. Classes and objects, methods, constructors, this keyword, garbage collection. Method overloading, recursion and encapsulation. Inheritance, use of super, method overriding, polymorphism, abstract classes and final keyword.

Unit-II: [11 Hours]

Packages, Interfaces and Exception Handling: Packages, access modifiers and importing packages. Interfaces, multiple inheritance using interfaces, nested interfaces and default methods. Exception hierarchy, try–catch–finally, throw and throws. User-defined exceptions and best practices.

Unit-III: [08 Hours]

Multithreading and Enumerations: Thread lifecycle and thread model. Thread class and Runnable interface. Synchronization, inter-thread communication using wait(), notify() and notifyAll(). Thread priorities and thread states. Enumerations and wrapper classes.

Unit-IV: **[08 Hours]**

Servlets and Java Server Pages: Servlet architecture and lifecycle. Handling HTTP request and response, cookies and session tracking. Introduction to JSP, scripting elements, directives and implicit objects. MVC concept in Java web applications.

Unit-V: **[08 Hours]**

JDBC and Java Application Development: JDBC architecture and driver types. Establishing database connectivity. Statement, PreparedStatement and ResultSet. Transaction handling and metadata. Mini application development using Java and database.

Suggested Readings:

1. Java: The Complete Reference — Herbert Schildt.
2. Core Servlets and JavaServer Pages — Marty Hall & Larry Brown.

Text/Reference Books:

1. Head First Java — Kathy Sierra & Bert Bates.
2. Thinking in Java — Bruce Eckel.
3. Effective Java — Joshua Bloch.
4. Java Concurrency in Practice — Brian Goetz.

Course Code : MCA**203** Course Type : **Core** No. of Credits : **4.00** No. of Hours : **75**	**Course Title** **Operating System**

Course Objectives:

- To understand OS architecture and services.
- To study process management and synchronization.
- To understand memory and file management techniques.
- To analyze deadlock and scheduling mechanisms.

Course Outcomes (COs):

After completion of the course, students will be able to;

- **CO1**: Explain OS components and services
- **CO2**: Apply process scheduling and synchronization
- **CO3**: Analyze deadlock handling techniques
- **CO4**: Apply memory and virtual memory management
- **CO5**: Explain file systems and disk scheduling.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	–	1	1	–	–	–	–	–	–	-
CO2	3	3	1	2	1	–	–	–	–	–	–	–
CO3	3	2	3	2	2	–	–	–	–	–	1	–
CO4	3	2	3	2	2	-	-	-	–	–	1	–
CO5	2	2	2	1	3	–	–	–	-	-	-	–

Course Outline:

Unit-I: [15 Hours]

Operating System Fundamentals: Role and importance of operating systems in modern computing. Types of operating systems: mainframe, desktop, multiprocessor, distributed, clustered, real-time, and handheld systems. Computing environments and system evolution. Operating system components and services. System calls, system programs, and OS structure.

Unit-II: [15 Hours]

Process Management & Synchronization: Process concept and process lifecycle. CPU scheduling criteria and scheduling algorithms. Thread fundamentals and benefits. Process Synchronization: Critical section problem, Semaphores and synchronization tools, Classical synchronization problems: Readers–Writers problem, Dining philosophers problem.

Unit-III: [15 Hours]

Deadlock Management: System model and necessary conditions for deadlock. Deadlock characterization.

Deadlock handling techniques: Prevention, Avoidance, Detection, Recovery.

Unit-IV: [15 Hours]

Memory & Virtual Memory Management: Memory management strategies and hardware support, Swapping and contiguous allocation, Paging and segmentation. Virtual Memory: Demand paging, Page replacement algorithms, Performance issues and common problems.

Unit-V: [15 Hours]

File Systems & Secondary Storage: File system structure and implementation, File concepts and access methods, Directory organization, File allocation methods and free-space management. Secondary Storage: Disk structure and management, Disk scheduling algorithms.

Suggested Readings:

1. Abraham Silberschatz, Peter Galvin, Greg Gagne — Operating System Principles
2. D. M. Dhamdhere — Operating Systems: A Concept-Based Approach.

Text/Reference Books:

1. Behrouz Forouzan & Richard Gilberg — Linux and Shell Programming.

Course Code : MCA**213** Course Typ : **Common Compulsory** No. of Credits : **4.00** No. of Hours : **30 (T) + 60 (Lab)**	**Course Title** **CCC: Introduction to R Programming**

Course Objectives:

- To introduce R programming for data analysis.
- To perform data cleaning and transformation.
- To apply statistical analysis techniques.
- To develop visualization and GUI-based analysis.

Course Outcomes (COs):

After completion of the course, students will be able to

- **CO1**: Understand R data structures and programming constructs.
- **CO2**: Perform data preprocessing and transformation.
- **CO3**: Apply statistical analysis and visualization.
- **CO4**: Develop interactive analytical applications.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	–	1	1	–	–	–	–	–	–	-
CO2	3	3	2	2	2	–	–	–	–	–	–	1
CO3	3	2	2	2	3	–	–	–	–	–	1	1
CO4	3	2	3	2	3	-	-	-	–	1	1	1

Course Outline:

Unit-I: [18 Hours]

Introduction: R interpreter, Introduction to major R data structures like vectors, Matrices, arrays, list and data frames, Control Structures, vectorized if and multiple Selections, functions.

Unit-II: [18 Hours]

Installing, loading and using packages: Read/write data from/in files, extracting data from web-sites, clean data, transform data by sorting, adding/removing new/existing Columns, converting types of Values, using string in-built functions.

Unit-III: [18 Hours]

Centring, scaling and normalizing the data values, converting types of Values, using string in-built functions, Handling Missing Values, Data Manipulation Techniques , Advanced String Operations ,Data Preparation for Analysis.

Unit-IV: [18 Hours]

Statistical analysis of data for summarizing and understanding data, Visualizing data Using scatter plot, line plot, bar chart, histogram, and box plot.

Unit-V: [18 Hours]

Designing GUI: Building interactive application and connecting it with database. Building Packages.

Suggested Readings:

1. A. B. Downey, “Think Python: How to Think Like a Computer Scientist,” Shroff O'Reilly Publishers, 3rd ed., 2019.
2. Cotton, R., Learning R: a step-by-step function guide to data analysis. 1st edition. O’Reilly Media Inc.

Text/Reference Books:

1. Bharti Motwani, Data analytics with R, (1st Edition), Wiley,2019 Michael J Crawley, The R Book, (2nd Edition), Wiley, 2018
2. Gareth James et.al., An Introduction to Statistical Learning: with Applications in R (Springer Texts in Statistics), (7th Edition), Springer, 2017.

SEMESTER-III

Course Code : MCA**301** Course Type : **Core** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Machine Learning**

Course Objectives:

- To understand machine learning foundations.
- To apply preprocessing and feature selection techniques.
- To implement supervised and unsupervised learning models.
- To evaluate machine learning models.

Course Outcomes (COs):

After completion of the course, students will be able to:

- **CO1**: Explain machine learning concepts and workflow.
- **CO2**: Apply preprocessing and association mining techniques.
- **CO3**: Implement supervised learning algorithms.
- **CO4**: Apply clustering and unsupervised techniques.
- **CO5**: Evaluate models using performance metrics.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	–	1	2	–	–	–	–	–	–	-
CO2	3	3	2	3	3	–	–	–	–	–	–	1
CO3	3	3	3	3	3	–	–	–	–	–	1	1
CO4	3	3	2	3	3	-	-	-	–	–	1	1
CO5	3	2	3	3	3	–	–	1	-	-	1	1

Course Outline:

Unit-I: **[08 Hours]**

Foundations of Machine Learning: Introduction to Machine Learning and its applications Machine learning process and real-world use cases. Types of learning: supervised, unsupervised, and reinforcement learning. Data objects, attribute types, and statistical data description Data visualization and similarity/dissimilarity measures.

Unit-II: **[09 Hours]**

Data Preprocessing & Association Mining: Data preprocessing techniques: cleaning, integration, reduction, transformation, discretization. Feature selection and dataset partitioning (training, validation, testing). Cross-validation methods. Concept learning and hypothesis representation.

Unit-III: **[10 Hours]**

Supervised Learning Techniques: Decision tree learning and ID3 algorithm, Bayesian learning and Bayes theorem, Naïve Bayes classifier and Bayesian belief networks. Regression & Classification: Linear regression and logistic regression, K-Nearest Neighbor (KNN), Support Vector Machines (SVM), Model Evaluation Metrics: SSE, MME, R^2 Confusion matrix, precision, recall, F-measure, ROC curve.

Unit-IV: **[10 Hours]**

Unsupervised Learning & Clustering: Association analysis fundamentals, categorization of clustering methods. Clustering Techniques: K-Means clustering, Hierarchical clustering (agglomerative and divisive methods). Frequent Pattern Mining: Association rule mining, Apriori algorithm, FP-Growth algorithm.

Unit-V: **[08 Hours]**

Model Evaluation & Instance-Based Learning: Hypothesis evaluation and estimating accuracy, Sampling theory and confidence intervals, Comparing learning algorithms, Instance-based learning and KNN in depth.

Suggested Readings:

1. Machine Learning — Tom M. Mitchell.
2. Data Mining: Concepts and Techniques — Jiawei Han et al.

Text/Reference Books:

1. Introduction to Data Mining — Vipin Kumar et al.
2. The Elements of Statistical Learning — Trevor Hastie et al.
3. Introduction to Machine Learning — Ethem Alpaydin
4. Jeeva Jose — Introduction to Machine Learning
5. Mueller & Massaron — Machine Learning for Dummies

Course Code : MCA**302** Course Type : **Core** No. of Credits : **4.00** No. of Hours : **75**	**Course Title** **Full Stack Web Development**

Course Objectives:

- To understand full stack architecture and lifecycle.
- To develop server-side applications using Node.js.
- To integrate databases with web applications.
- To build modern MERN stack application.

Course Outcomes (COs):

After completion of the course, students will be able to

- **CO1**: Explain full stack architecture and technologies.
- **CO2**: Develop Node.js server applications.
- **CO3**: Integrate MongoDB with applications.
- **CO4**: Build Express and Angular/React applications.
- **CO5**: Develop complete MERN stack solutions.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	–	1	3	–	–	–	–	–	–	-
CO2	3	3	2	2	3	–	–	–	–	–	–	–
CO3	3	3	3	2	3	–	–	–	–	–	–	–
CO4	3	3	3	2	3	-	-	1	1	1	–	–
CO5	3	2	3	2	3	–	–	1	1	1	1	1

Course Outline:

Unit-I: [15 Hours]

Foundations: Overview of web development lifecycle, Interaction between user, browser, web server, and backend services, MVC architecture and layered application design, Introduction to full stack technologies and comparison of popular stacks, Roles of Express, Angular, Node.js, MongoDB, and React in modern applications and introduction to MERN stack architecture.

Unit-II: [15 Hours]

Node.js Server-Side Development: Node.js fundamentals and environment setup, package management using NPM, creating basic Node.js applications, event-driven programming: events, listeners, timers, and callbacks, file handling and asynchronous data I/O operations, building HTTP services and simple web servers using Node.js.

Unit-III: [15 Hours]

MongoDB and NoSQL Databases: NoSQL database concepts and MongoDB architecture, MongoDB installation and environment configuration, database administration: user accounts, roles, and access control, managing collections and documents, integrating MongoDB with Node.js applications, development of simple data-driven applications.

Unit-IV: **[15 Hours]**

Express Framework and React: Express framework fundamentals and middleware concepts, routing configuration and RESTful services using Express, working with request and response objects, introduction to React and JSX, React components, props, and state management, client-side routing and dynamic UI development.

Unit-V: **[15 Hours]**

MERN Stack Development: MERN stack architecture and workflow, creating REST APIs using Express, integrating frontend and backend applications, module bundling and optimization using Webpack, introduction to server-side rendering concepts, and development of simple MERN stack applications.

Suggested Readings:

1. Pro MERN Stack — Vasan Subramanian
2. The Full Stack Developer — Chris Northwood

Text/Reference Books:

7. Learning React — Kirupa Chinnathambi
8. Web Development with Node and Express — Ethan Brown
9. MongoDB: The Definitive Guide — Kristina Chodorow

Course Code : MCA**303** Course Type : **Core** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Computer Networks**

Course Objectives:

- To understand network models and architecture.
- To study data transmission and routing mechanisms.
- To analyze transport and application layer protocols.
- To implement socket-based networking applications.

Course Outcomes (COs):

After completion of the course, students will be able to

- **CO1**: Explain network models and communication concepts.
- **CO2**: Analyze physical and data link layer protocols.
- **CO3**: Apply routing and IP addressing concepts.
- **CO4**: Evaluate transport and application protocols.
- **CO5**: Develop socket-based network applications.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	–	–	–	–	–	–	-
CO2	2	3	1	1	1	–	–	–	–	–	–	–
CO3	2	3	2	2	2	–	–	–	–	–	–	–
CO4	2	3	2	2	2	-	-	-	–	–	–	–
CO5	3	2	3	2	3	–	–	–	1	1	1	1

Course Outline:

Unit-I: [08 Hours]

Introduction & Network Models: Data communication components, data representation, and data flow, Network types: LAN, WAN, and switching techniques, Network criteria and physical structures, Protocol layering principles and logical connections, OSI reference model and TCP/IP protocol suite, Addressing and multiplexing concepts, Comparison of OSI and TCP/IP models.

Unit-II: [10 Hours]

Physical Layer & Data Link Layer: Physical Layer-Analog and digital signals, Transmission impairments and data rate limits, Network performance metrics, Transmission media, Circuit switching and packet switching. Data Link Layer: Framing and link-layer addressing (ARP overview), Error detection and correction techniques, Cyclic Redundancy Check (CRC), Data link control and multiple access protocols.

Unit-III: [09 Hours]

Network Layer: Logical addressing and Internet Protocol, Address mapping and ARP concepts Error reporting

and multicasting, Packet delivery, forwarding, and routing, Datagram and virtual circuit approaches, Network performance: delay, throughput, packet loss.

Unit-IV: **[10 Hours]**

Transport & Application Layer: Transport Layer-Process-to-process delivery, UDP, TCP, and SCTP protocols, Flow control, congestion control, and Quality of Service, Application Layer: Application layer services and paradigms, World Wide Web and HTTP, FTP and e-mail architecture, Domain Name System (DNS) and name resolution.

Unit-V: **[08 Hours]**

Linux Networking & Socket Programming: Overview of networking in Linux/UNIX environments TCP and UDP communication basics, Socket programming fundamentals, TCP client-server model Elementary socket-based applications, Recap: Integrated review of networking concepts.

Suggested Readings:

1. Data Communications and Networking — Behrouz A. Forouzan.
2. UNIX Network Programming Volume 1 — W. Richard Stevens.

Text/Reference Books:

1. Computer Networks — Andrew S. Tanenbaum.
2. Computer Networks: A Systems Approach — Larry Peterson & Bruce Davie.
3. Data and Computer Communications — William Stallings.

Course Code : MCA313 Course Type : **Common Compulsory** No. of Credits : **2.00** No. of Hours : **30**	**Course Title** **Building Mathematical Ability and Financial Literacy**

Course Objectives:

The main objectives of this course are:

- Solving skills through mathematical reasoning, quantitative aptitude, and data interpretation, enabling them to apply these concepts in academic, professional, and real-life scenarios.
- Familiarize students with investment options, banking structures, financial institutions, taxation, insurance, and the roles of RBI and SEBI in the financial system.
- Enable students to make informed financial decisions through understanding of investment planning, risk management, digital payments, and awareness of financial frauds.

Course Outcomes (COs):

By the end of the course, students can be able to;

- **CO1:** Enhance logical thinking and decision-making through structured problem-solving.
- **CO2:** Demonstrate competence in fractions, simple and compound interest ratio and proportion, and percentage-based problems.
- **CO3:** Calculate mean, median, and mode to summarize data effectively. Present data using bar charts, pie charts, and line charts for clear communication.
- **CO4:** Prepare budgets, track expenses, manage savings, and set financial goals using basic money management principles.
- **CO5:** Evaluate financial risks, use digital payment systems securely, and adopt appropriate strategies for financial planning and risk reduction.

COs /POs Mapping:

Cos/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	–	–	–	–	–	–	–	–	–	–
CO2	3	3	–	–	–	–	–	2	–	–	–	–
CO3	3	3	2	–	2	–	–	–	–	2	–	–
CO4	–	3	–	2	–	3	2	–	–	–	2	2
CO5	–	2	2	2	3	2	2	3	–	–	2	–

Course Outline:

Unit-I **[7 Hours]**

Logical Reasoning: Number series, letter series, coding-decoding, problems on ages. **Basic Set Theory**: Operations on sets, Venn diagrams, and cardinality of sets.

Unit-II **[5 Hours]**

Mathematical aptitude: Fractions, time and work, time and distance, ratio and proportion, percentage, profit and loss, discount, simple interest, compound interest, mensuration.

Unit-III **[6 Hours]**

Basic Statistics: Sources and classification of data, data interpretation, quantitative and qualitative data, graphical representation (bar chart, pie chart, line chart), mean, median, and mode for ungrouped data.

Unit-IV **[5 Hours]**

Foundations of Financial Literacy: Introduction to financial literacy and its process and structure, personal finance, income, expenditure, savings, and budgeting, financial goals, financial discipline, money management skills, awareness of financial frauds, basic budgeting and expense tracking activities.

Unit-V **[7 Hours]**

Financial Institutions: Banking system and credit process, recent innovations in the banking system, Reserve Bank of India role and functions, monetary policy tools. **Capital Market;** Primary market, secondary market, financial decision-making,SEBI. **Digital Finance:** Digital payments system and digital currency.

Suggested Readings:

Arihant, (2019). *Teaching and Research Aptitude (General Paper 1)*. Arihant Publication (India) Limited.
Jain, L. & Vashistha, K. C. (2024). *Teaching and Research Aptitude (General Paper 1)*. Upkar Prakashan Agra.
Lewis, M. K. (2000). *Monetary economics*. Oxford University Press, New York.

References:

Aggarwal, R.S. (n.d). *Quantitative Aptitude*. S. Chand.
C Rangarajan. (1991). *Indian economy: Essays in money and finance*. UBS Publishers' Distributors Ltd.
Lewis, M. K. (2000). *Monetary economics*. Oxford University Press.

SEMESTER-IV

Course Code : MCA**401** Course Type : **Core** No. of Credits : **4.00** No. of Hours : **75**	**Course Title** **Software Engineering**

Course Objectives:

- To understand software development processes and lifecycle models.
- To gain skills in requirement analysis, system modeling, and documentation.
- To learn modern software design, testing, and quality assurance practices.
- To acquire basic project management, risk management, and configuration skills.

Course Outcomes (COs):

After completion of the course, students will be able to:

- **CO1**: Explain software engineering principles, SDLC, and process models.
- **CO2**: Analyze requirements and prepare SRS using modeling techniques.
- **CO3**: Apply software design principles and architectural concepts.
- **CO4**: Demonstrate software testing and quality assurance techniques.
- **CO5**: Apply project management, estimation, risk, and maintenance concepts.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	2	–	–	–	–	–	1	1
CO2	3	3	2	2	2	–	–	–	1	1	1	1
CO3	3	3	3	2	3	–	–	–	1	1	1	1
CO4	3	3	3	3	3	-	-	1	1	1	1	1
CO5	2	3	2	2	2	1	1	1	1	1	3	2

Course Outline:

Unit-I: **[15 Hours]**

Software Process and Lifecycle Models: Introduction - Role and Characteristics of Software, Software Components, Software Crisis and Need for Software Engineering. Software Engineering as a Layered Technology. Software Development Life Cycle (SDLC). Process Models - Waterfall Model, Prototyping Model, and Incremental Model, Spiral Model, Agile Development and Scrum basics. Comparison of Traditional and Agile Approaches.

Unit-II: **[15 Hours]**

Requirements Engineering and System Modeling: *Requirements Engineering*: Requirement Gathering and Elicitation, Requirement Analysis and Validation, Feasibility Study, Requirement Management. *SRS Document*: Characteristics of a Good SRS, Structure of an SRS, and IEEE Standards Overview. *System Modeling*: Data Flow Diagrams, Entity Relationship Diagrams, Data Dictionary, Decision Tables and Decision Trees, User Stories in Agile Development.

Unit-III: **[15 Hours]**

Software Design and Architecture: *Design Concepts* - Design Process and Principles (Abstraction, Modularity, Encapsulation, Information Hiding), Coupling and Cohesion Measures. Design Strategies - Function-Oriented vs. Object-Oriented Design, Top-Down vs. Bottom-Up Design. Architectural & Detailed Design - Software

Architecture Basics, Common Architectural Styles, Structure Charts. Flowcharts and Pseudocode. User Interface Design and Principles.

Unit-IV: **[15 Hours]**

Software Testing and Quality Assurance: Testing Fundamentals - Objectives, Verification vs. Validation, Test Case Design, and Test Data Suite Preparation. Testing Techniques - White Box and Black Box Testing, Basis Path Testing, Test Coverage Concepts. Testing Levels & Strategies - Unit Testing, Integration Testing, Regression Testing, System Testing, and Acceptance Testing. Static Testing and Reviews - Walkthroughs, Peer Reviews, Code Inspections.

Unit-V: **[15 Hours]**

Project Management, Quality, and Maintenance: Project Planning and Management Spectrum, W5HH Principle, Software Estimation Basics, Function Point and COCOMO Models. Risk and Quality Management - Risk Identification and Mitigation, Software Quality Assurance, ISO and CMM Overview. Software Configuration Management, Version Control and Change Management, Types of Software Maintenance.

Suggested Readings:

1. Roger S. Pressman, Software Engineering: A Practitioner's Approach, McGraw-Hill Education, 8th/9th Edition.
2. Pankaj Jalote, An Integrated Approach to Software Engineering, Springer/Narosa.

Text/Reference Books:

1. Ian Sommerville, Software Engineering, Pearson Publishers, 10th Edition.
2. Rajib Mall, Fundamentals of Software Engineering, PHI Publication.
3. K. K. Aggarwal and Yogesh Singh, Software Engineering, New Age International Publishers

Course Code : MCA**402** Course Type : **Core (Compulsory)** No. of Credits : **12.00**	**Course Title** **Project Work / Dissertation**

Objectives:

Implement some of the existing techniques and develop some new algorithm/ tool and produce meaningful research outputs.

Each student will work on a dissertation to apply the knowledge of Computer Applications for solving a wide variety of real-world problem. Problems may be decided based on literature survey by standard research articles. Significance of proposed problem and the state-of the art to be explored. Relevant tools may be used for demonstrating the results with physical meaning and create necessary research components.

Student is required to submit a detailed project report on the selected topic for their project as per the guidelines decided by the department. The project work is to be evaluated through presentations and viva-voce during the semester and final evaluation will be done at the end of the semester as per the guidelines decided by the department from time to time. The candidate shall present/ publish one paper in national/international conference/seminar/journal of repute.

However, candidate may visit research labs/institutions with the due permission of chairperson on recommendation of supervisor concerned.

Electives

STREAM 1 – INFORMATION SECURITY

Course Code : MCA**111** Course Type : **Specific Elective** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Fundamentals of Cryptography**

Course Objectives:

- To understand the fundamental concepts and mathematical foundations of cryptography.
- To study modern cryptographic algorithms and their implementation.
- To explore cryptographic applications in financial systems and blockchain.
- To analyze secure communication protocols and their security mechanisms.
- To implement cryptographic techniques using standard APIs like JCE/.NET.

Course Outcomes (COs):

After completion of the course, students will be able to:

- **CO1**: Explain basic concepts, evolution, and importance of cryptography.
- **CO2**: Apply number-theoretic concepts like modular arithmetic and GCD in cryptographic problems.
- **CO3**: Analyze and implement symmetric and asymmetric cryptographic algorithms.
- **CO4**: Evaluate cryptographic applications in blockchain, cryptocurrency, and financial systems.
- **CO5**: Examine and implement secure communication protocols such as SSL/TLS, SSH, and IPsec.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	–	–	–	–	–	–	-
CO2	3	3	2	2	2	–	–	–	–	–	–	–
CO3	3	3	3	2	3	–	–	–	–	–	–	–
CO4	2	3	2	2	2	1	-	-	–	1	1	1
CO5	3	3	3	3	3	–	–	–	1	1	1	1

Course Outline:

Unit-I: **[09 Hours]**

Foundations of Cryptography: Evolution and significance of cryptography; principles of secure software development; use of security-focused APIs; overview of Java Cryptography Extension (JCE) and .NET Cryptography Extension (.NCE).

Unit-II: **[09 Hours]**

Number Theoretic Foundations: Concepts of prime numbers and integer factorization; modular arithmetic operations; Fermat's and Euler's theorems; computation of GCD using Euclid's algorithm; discrete logarithm problem; practical implementation of number-theoretic algorithms through JCE/.NCE.

Unit-III: **[09 Hours]**

Contemporary Cryptographic Techniques: Symmetric encryption models; mechanisms ensuring message integrity; public key cryptography and digital signatures; implementation and analysis of DES, RSA, TDES, ECC, IDEA, MD, and SHA using JCE/.NCE.

Unit-IV: **[09 Hours]**

Cryptography in Financial Systems: Fundamentals of cryptocurrency; blockchain-based applications; contactless payment and ticketing technologies; digital cash frameworks and electronic payment infrastructures; security aspects in banking and financial services; microfinance and micropayment models; implementation of cryptocurrency and blockchain concepts using JCE/.NCE.

Unit-V: **[09 Hours]**

Secure Communication Protocols: Design and functioning of secure communication protocols including SSL/TLS, SSH, HTTP/HTTPS, IPsec, P2P, and PGP; analysis of protocol security; implementation practices using JCE/.NCE.

Suggested Readings:

1. Beginning Cryptography with Java — David Hook.
2. Cryptography and Network Security — William Stallings.
3. Handbook of Applied Cryptography — Alfred J. Menezes, Paul C. van Oorschot, and Scott A. Vanstone.

Text/Reference Books:

1. The Mathematics of Encryption — Margaret Cozzens and Steven J. Miller.
2. Applied Cryptography — Bruce Schneier.
3. Information Security: Principles and Practice — Mark Stamp.
4. Computer Security: Art and Science — Matt Bishop.
5. Bitcoin and Cryptocurrency Technologies — Arvind Narayanan et al.

Course Code : MCA**111** Course Type : **Specific Elective** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Cyber Law and Cyber Forensic**

Course Objectives:

- To understand the fundamentals of cyber law, cybercrime, and cyber forensics.
- To learn cyber laws, IT Act provisions, and legal issues in cyberspace.
- To study digital evidence collection, preservation, and forensic investigation techniques.
- To understand computer, mobile, network, and cloud forensic methods.
- To develop awareness of cyber security challenges, ethical practices, and cybercrime investigation procedures.

Course Outcomes (COs):

After completion of the course, students will be able to;

- **CO1**: Explain cyber law, cybercrime, and cyber forensic concepts.
- **CO2**: Describe cyber laws, IT Act provisions, and legal issues in cyberspace.
- **CO3**: Analyze digital evidence collection and forensic investigation methods.
- **CO4**: Apply computer, mobile, and network forensic techniques for cybercrime analysis.
- **CO5**: Examine legal, ethical, and emerging challenges in cyber security and digital forensics.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	–	–	2	–	–	–	1
CO2	3	3	2	2	2	1	–	3	–	1	–	1
CO3	3	3	2	3	3	-	–	2	1	1	–	1
CO4	3	3	3	3	3	-	-	3	1	1	1	1
CO5	2	3	2	2	2	2	1	3	1	1	1	2

Course Outline:

Unit-I: **[09 Hours]**

Introduction to Cyber Law and Cybercrime: Introduction to Cyberspace and Cybercrime – Types of Cyber Crimes: Hacking, Phishing, Identity Theft, Financial Frauds, DoS and DDoS Attacks – Need for Cyber Laws – Overview of Information Technology Act, 2000 and Amendments – Cyber Offences and Penalties – Jurisdiction in Cyberspace – Cyber Ethics and Legal Challenges.

Unit-II: **[09 Hours]**

Digital Evidence and Forensic Fundamentals: Introduction to Cyber Forensics – Digital Evidence and Its Characteristics – Admissibility of Digital Evidence – Chain of Custody – Evidence Collection and Preservation – Data Acquisition and Disk Imaging – Storage Devices and File Systems – Data Deletion and Recovery Techniques – Role of First Responders in Cyber Investigation.

Unit-III: **[09 Hours]**

Computer and Network Forensics: Windows and Linux Forensics – Registry and Log File Analysis – Email and Browser Forensics – Network Forensics and Packet Analysis – IP Tracking and Log Monitoring – Steganography and Hidden Data Detection – Password Cracking Techniques: Brute Force, Dictionary, and Rainbow Attacks.

Unit-IV: **[09 Hours]**

Mobile, Cloud, and Cyber Investigation Techniques: Mobile Forensics and Data Acquisition – Cloud Forensics and Challenges – Malware, Spyware, and Keyloggers – Surveillance and Investigation Tools – Ethical Hacking and Cyber Investigation – Evidence Analysis and Reporting – Emerging Trends in Cyber Forensics.

Unit-V: **[09 Hours]**

Cyber Law, Ethics, and Emerging Technologies: Internet Intermediaries and Legal Responsibilities – Intellectual Property Rights in Cyberspace – Privacy and Data Protection – Legal Aspects of Digital Evidence – Role of CERT and Cyber Security Agencies – Cyber Laws Related to AI, IoT, Blockchain, and Social Media – International Approaches to Cyber Law – Case Studies on Cybercrime and Digital Forensics.

Suggested Readings:

1. Nina Godbole & Sunit Belapure, Cyber Security: Understanding Cyber Crimes, Computer Forensics and Legal Perspectives, Wiley.
2. Bill Nelson, Amelia Phillips & Christopher Steuart, Guide to Computer Forensics and Investigations, Cengage Learning.
3. William Stallings, Cryptography and Network Security: Principles and Practice, PHI.

Text/Reference Books:

1. Marjie T. Britz, Computer Forensics and Cyber Crime, Pearson Education.
2. Eoghan Casey, Digital Evidence and Computer Crime, Academic Press.
3. Vakul Sharma, Information Technology Law and Practice, Universal Law Publishing.
4. Michael E. Whitman & Herbert J. Mattord, Principles of Information Security, Cengage Learning.
5. Chris Reed & John Angel, Computer Law, Oxford University Press.

Course Code : MCA**211** Course Type : **Specific Elective** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Database and Application Security**

Course Objectives:

- To understand database security concepts and layered security mechanisms.
- To study authentication, authorization, and access control models.
- To analyze secure database communication and threat mitigation.
- To implement encryption and auditing techniques in databases.
- To identify and prevent application vulnerabilities (OWASP Top 10).

Course Outcomes (COs):

After completion of the course, students will be able to;

- **CO1**: Describe database security concepts and layered protection mechanisms.
- **CO2**: Implement authentication and authorization techniques in databases.
- **CO3**: Analyze database communication threats and secure data flow.
- **CO4**: Apply encryption and auditing techniques for data protection.
- **CO5**: Identify and mitigate application vulnerabilities based on OWASP standards.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	–	–	–	–	–	–	-
CO2	3	3	2	1	2	–	–	–	–	–	–	–
CO3	2	3	2	2	2	–	–	–	–	–	–	–
CO4	3	2	3	2	3	-	-	-	–	–	–	–
CO5	3	3	3	3	3	–	–	–	1	1	1	1

Course Outline:

Unit-I: **[09 Hours]**

Fundamentals of Database Security: Overview of database security concepts; role of security in information technology; significance and evaluation of data; identity theft concerns; layered security approaches including human factors (malicious or careless users), network/user interface security, database application layer, database management system security, operating system protection, and physical safeguards.

Unit-II: **[09 Hours]**

Authentication and Authorization Mechanisms: Password management, user profiles, privileges, and role-based access control; authentication techniques including operating system–based, database-level, and network/third-party authentication; password policies; user account authorization; security considerations in database and application environments; limitations of SQL authorization; application-layer access control; Oracle Virtual Private Database concepts; privacy protection mechanisms.

Unit-III: **[09 Hours]**

Securing Database Communications: Controlling and monitoring outbound database communications; securing database links and protecting associated credentials; monitoring link utilization; safeguarding database replication processes; identification and protection of data sources and sinks; database Trojans and their classifications.

Unit-IV: **[09 Hours]**

Data Encryption and Auditing: Techniques for encrypting data during transmission and storage; auditing frameworks and architectures; audit trails and external auditing systems; archival and protection of audit data; ensuring integrity and security of auditing mechanisms.

Unit-V: **[09 Hours]**

Application Security and Vulnerability Analysis: Principles of application security; identification of application vulnerabilities; overview of **OWASP Top 10 web security risks including unvalidated input, broken access control, session management issues, cross-site scripting (XSS), buffer overflow attacks, SQL injection, improper error handling, insecure data storage, denial-of-service attacks, insecure configuration, and unsafe file handling practices.

Suggested Readings:

1. Implementing Database Security and Auditing — Ron Ben-Natan, Elsevier, 2005.
2. Database Security — Silvana Castano, Addison-Wesley, 1994.
3. Database Security — Alfred Basta et al., 2011.
4. Database System Concepts — Abraham Silberschatz, Henry F. Korth, and S. Sudarshan, 6th Edition, 2010.

Resources:

1. OWASP official website for application security guidelines.
2. Online resources on web application security scanning tools.
3. Documentation and tutorials on SQL injection vulnerabilities.
4. Articles and learning materials on common web application attack techniques.
5. Oracle documentation on database security features and implementation practices.

Course Code : MCA**211** Course Type : **Specific Elective** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Mobile and Digital Forensics**

Course Objectives:

- To understand wireless technologies and associated security threats.
- To study mobile security frameworks and GSM vulnerabilities.
- To learn forensic investigation techniques for mobile devices.
- To understand digital forensics principles and evidence handling.
- To analyze and interpret digital forensic data for investigations.

Course Outcomes (COs):

After completion of the course, students will be able to;

- **CO1**: Explain wireless technologies and associated security threats.
- **CO2**: Analyze mobile security mechanisms and GSM vulnerabilities.
- **CO3**: Apply mobile forensic techniques for evidence collection and analysis.
- **CO4**: Demonstrate digital forensic procedures and evidence handling.
- **CO5**: Analyze digital evidence using forensic tools and techniques.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	–	–	–	–	–	–	-
CO2	2	3	2	2	2	–	–	–	–	–	–	–
CO3	3	3	3	2	3	–	–	–	–	–	–	–
CO4	3	3	2	3	2	-	-	-	–	1	1	1
CO5	3	3	3	3	3	–	–	–	1	1	1	1

Course Outline:

Unit-I: **[09 Hours]**

Wireless Technologies and Security: Overview of wireless communication technologies including Personal Area Networks, Wireless Local Area Networks, Metropolitan Area Networks, and Wide Area Networks; wireless security threats and vulnerabilities; attacks such as wardriving, war chalking, and war flying; recommended Wi-Fi security practices; security issues in PDAs and mobile devices; wireless denial-of-service attacks; GPS jamming and identity theft risks.

Unit-II: **[09 Hours]**

Mobile Security Framework: Application of the CIA triad to mobile environments; interception risks in GSM voice and SMS communications; identification data exposure; practical setup and tools for analysing GSM security; implementation aspects involving hardware and software; mobile device diagnostic and service features including Netmonitor, GSM service codes, mobile command codes, AT command usage, and SMS-related security concerns.

Unit-III: **[09 Hours]**

Mobile Phone Forensics: Role of mobile devices in cybercrime investigations; identification and collection of mobile evidence; forensic investigation procedures; analysis of SIM card data, internal device storage, and external memory; examination of operator-specific systems; Android forensic procedures including safe handling, acquisition techniques, USB mass storage imaging, and logical and physical extraction methods.

Unit-IV: **[09 Hours]**

Fundamentals of Digital Forensics: Introduction to digital forensics and its importance in investigations; evidentiary value of digital devices; comparison of closed and open systems; evaluation of evidence potential; device seizure procedures; identification and handling of digital devices; challenges posed by networked devices and prevention of evidence contamination.

Unit-V: **[09 Hours]**

Digital Forensic Analysis Techniques: Principles of forensic examination including previewing, imaging, evidence continuity, hashing techniques, and identification of evidence sources; seven-element security model; developmental model of digital systems; analysis of audit trails and system logs; interpretation of digital evidence with emphasis on data content and contextual relevance.

Suggested Readings:

1. Mobile Phone Security and Forensics: A Practical Approach — Iosif I. Androulidakis, Springer, 2012.

Text/Reference Books:

1. Android Forensics — Andrew Hoog, Elsevier, 2011.
2. Digital Forensics: Digital Evidence in Criminal Investigation — Angus M. Marshall, John Wiley & Sons, 2009.
3. Wireless Crime and Forensic Investigation — Gregory Kipper, Auerbach Publications.

Course Code : MCA**211** Course Type : **Core** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Cyber Security**

Course Objectives:

- To understand the basics of information security, threats, vulnerabilities, and security standards.
- To learn classical and modern cryptographic techniques for securing information and communication systems.
- To study network, host, and application security along with intrusion detection and prevention methods.
- To understand cyber threats, malware, digital forensics, wireless security, and attack prevention techniques.
- To develop knowledge of security practices, risk analysis, and protection methods in modern computing environments.

Course Outcomes (COs):

After completion of the course, students will be able to:

- **CO1**: Explain the fundamentals of information security, threats, vulnerabilities, and security standards.
- **CO2**: Apply cryptographic techniques, access control, biometrics, and DRM concepts for securing information systems.
- **CO3**: Analyze network security mechanisms such as firewalls, intrusion detection/prevention systems, VPNs, and e-commerce security.
- **CO4**: Identify and mitigate host and application security vulnerabilities including malware, buffer overflow, and software exploits.
- **CO5**: Evaluate wireless, mobile, and GSM security issues using security measures, forensic techniques, and risk analysis methods.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	–	–	2	–	–	–	-
CO2	3	3	2	2	2	–	–	3	–	–	–	–
CO3	3	3	3	2	3	1	–	3	1	–	–	–
CO4	3	3	3	3	3	-	-	3	–	1	1	–
CO5	2	3	2	2	2	2	1	3	1	1	1	1

Course Outline:

Unit-I: **[09 Hours]**

Critical characteristics of Information - NSTISSC Security Model -Components of information System –SDLC – Information assurance - Security Threats and vulnerabilities - Overview of Security threats-– Security Standards.

Unit-II: **[09 Hours]**

Classical Cryptography - Symmetric Cryptography- Asymmetric Cryptography - Modern Cryptography – Access Control - DRM – Steganography – Biometrics.

Unit-III: **[09 Hours]**

Network Security - Intrusion Prevention, detection and Management - Firewall – Ecommerce Security - Computer Forensics - Security for VPN and Next Generation Networks.

Unit-IV: **[09 Hours]**

Host and Application security -Control hijacking, Software architecture and a simple buffer overflow - Common exploitable application bugs, shellcode - Buffer Overflow - Side-channel attacks - Timing attacks, power analysis, cold-boot attacks, defenses – Malware - Viruses and worms, spyware, key loggers, and botnets; defenses auditing, policy - Defending weak applications - Isolation, sandboxing, virtual machines.

Unit-V: **[09 Hours]**

Mobile, GSM and Wireless LAN security - Protection measures - Business risk analysis – Information Warfare and Surveillance – Case study on Attack prevention, detection and response.

Suggested Readings:

1. William Stallings, “Cryptography and Network Security: Principles and Practice”, 6th Edition, PHI,2014.

Text/Reference Books:

1. Michael E. Whitman and Herbert J Mattord, “Principles of Information Security”, 6th Edition, Vikas Publishing House, 2017.
2. Bill Nelson, Amelia Phillips, F. Enfinger and Christopher Stuart, “Guide to Computer Forensics and Investigations”, 4th Edition, Thomson Course Technology, 2010.
3. Matt Bishop, “Computer Security: Art and Science”, 1st Edition, Addison-Wesley Professional, 2015.

Course Code : MCA**211** Course Type : **Specific Elective** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Information System Audit**

Course Objectives:

- To examine multi-layered information system security frameworks within organizational environments.
- To analyse risk management strategies for safeguarding information assets aligned with business and operational objectives.
- To evaluate physical, logical, and automated control mechanisms employed in information system security and auditing.

Course Outcomes (COs):

After completion of the course, students will be able to:

- **CO1**: Explain IS auditing standards, governance frameworks, and regulatory compliance requirements.
- **CO2**: Analyze IS management practices, policies, and organizational structures for effective governance.
- **CO3**: Evaluate IS infrastructure, operations, and service management for reliability and performance.
- **CO4**: Assess security controls ensuring confidentiality, integrity, availability, and business continuity.
- **CO5**: Apply auditing techniques to system development, acquisition, and maintenance processes for compliance and risk management.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	1	–	–	–	–	–	-
CO2	3	3	2	2	2	1	–	–	–	–	–	–
CO3	3	3	2	3	2	–	–	–	–	–	–	–
CO4	3	3	2	3	3	1	-	-	–	1	1	1
CO5	3	3	3	3	3	1	–	-	1	1	1	1

Course Outline:

Unit-I: **[09 Hours]**

IS Audit Standards and Governance*:* Overview of information systems auditing standards, frameworks, and professional practices; information system security and control mechanisms; regulatory requirements and compliance considerations; control objectives and governance structures influencing IS audit activities.

Unit-II: **[09 Hours]**

Auditing IS Management and Organizational Structure Alignment of information systems strategies with business objectives; development and enforcement of security policies and procedures; evaluation of IS management practices; organizational structures supporting IS governance; auditing methodologies and evaluation techniques for management processes.

Unit-III: **[09 Hours]**

Auditing IS Infrastructure and Operations

Assessment of hardware platforms, software environments, and supporting technologies; auditing network and telecommunication infrastructures; evaluation of operational procedures, service management practices, and system reliability within enterprise environments.

Unit-IV: **[09 Hours]**

Ensuring Integrity, Confidentiality, and Availability

Logical and physical access control mechanisms; environmental and facility security controls; data validation, processing accuracy, and reconciliation controls; business continuity planning, disaster recovery strategies, and resilience testing.

Unit-V: **[09 Hours]**

Auditing System Development and Maintenance

System integration concepts and challenges; System Development and Acquisition Methodology (SDAM) frameworks; auditing development practices, change management, and maintenance procedures; evaluation of lifecycle security and compliance in system acquisition and enhancement.

Suggested Readings:

1. Principles of Information Security — Michael E. Whitman and Herbert J. Mattord, Thomson Course Technology, 2003.
2. Handbook of Information Security Management — Micki Krause and Harold F. Tipton, ISACA Publication.

Text/Reference Books:

1. Handbook of IT Auditing — D. Warren et al., Warren Gorham & Lamont.
2. Scholarly article on information auditing as a strategic management tool by Katherine Bertolucci.
3. The Value and Impact of Information — M. Feeney and M. Grieves, Bowker Saur.
4. The Value of Information to the Intelligent Organisation, University of Hertfordshire Press.
5. Competitive Advantage: Creating and Sustaining Superior Performance — Michael E. Porter.

Web Resources:

- ISACA resources on IS auditing standards and governance frameworks.
- British Standards Institution guidelines for security and compliance standards.
- Online repositories and digital libraries focusing on information assurance and auditing frameworks.
- COBIT and governance-related resources available through ISACA.

Course Code : MCA311 Course Type : **Core** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Information Security Management**

Course Objectives:

- To reinforce and expand foundational knowledge of information security principles and industry best practices.
- To develop an understanding of governance, risk management, and compliance aspects of information security.
- To explore secure communication, network protection strategies, and identity and access management frameworks.

Course Outcomes (COs):

After completion of the course, students will be able to:

- **CO1**: Explain principles of security governance, risk management, compliance, and policy frameworks.
- **CO2**: Analyze asset security, data classification, and data protection mechanisms.
- **CO3**: Evaluate security architecture, engineering principles, and vulnerability assessment techniques.
- **CO4**: Analyze communication and network security strategies to mitigate threats.
- **CO5**: Apply identity and access management techniques for secure system operations.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	–	–	–	–	–	–	-
CO2	3	3	2	2	2	–	–	–	–	–	–	–
CO3	3	3	3	2	3	–	–	–	–	–	–	–
CO4	2	3	2	2	2	1	-	-	–	1	1	1
CO5	3	3	3	3	3	–	–	–	1	1	1	1

Course Outline:

Unit-I: **[09 Hours]**

Security Governance and Risk Management: Fundamental concepts of confidentiality, integrity, and availability; security governance frameworks; risk management and compliance requirements; legal and regulatory considerations; professional ethics; development and implementation of security policies, standards, procedures, and guidelines; business continuity and resilience planning.

Unit-II: **[09 Hours]**

Asset Security and Data Protection: Information asset identification and classification; roles and responsibilities of asset ownership including data and system owners; privacy protection mechanisms; data retention and lifecycle considerations; implementation of data security controls; secure handling practices including labeling, storage, and transmission requirements.

Unit-III: **[09 Hours]**

Security Engineering and Architecture: Secure design principles and engineering processes; fundamental security and evaluation models; assessment of security capabilities within information systems; security architecture and solution design; vulnerability assessment in web applications, mobile environments, embedded devices, and cyber-physical systems; application of cryptographic techniques; secure site and facility design; physical security controls.

Unit-IV: **[09 Hours]**

Communication and Network Security: Design of secure network architectures incorporating IP and non-IP protocols; network segmentation strategies; security of network devices and infrastructure; establishment of secure communication channels; identification and mitigation of network-based attacks.

Unit-V: **[09 Hours]**

Identity and Access Management: Control mechanisms for physical and logical assets; identification and authentication of users and devices; identity as a service and cloud-based identity management; third-party and on-premise identity services; access control threats and mitigation; lifecycle management of identity and access provisioning including review and monitoring processes.

Suggested Readings:

1. CISSP Certified Information Systems Security Professional Study Guide — James M. Stewart, Ed Tittel, and Mike Chapple, Wiley, 2009.

Course Code : MCA**311** Course Type : **Specific Elective** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Ethical Hacking**

Course Objectives:

- To understand the structured methodology and lifecycle of ethical hacking and penetration testing.
- To gain practical familiarity with tools, techniques, and frameworks used for vulnerability assessment and exploitation.
- To analyse malware threats and defensive countermeasures within enterprise security environments.

Course Outcomes (COs):

After completion of the course, students will be able to:

- **CO1**: Explain ethical hacking methodologies, security concepts, and legal considerations.
- **CO2**: Analyze reconnaissance, footprinting, scanning, and enumeration techniques.
- **CO3**: Evaluate system exploitation, privilege escalation, and steganography techniques.
- **CO4**: Apply malware analysis and penetration testing methodologies.
- **CO5**: Analyze network attacks, social engineering, and session exploitation techniques with countermeasures.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	–	–	–	–	–	–	-
CO2	3	3	2	2	2	–	–	–	–	–	–	–
CO3	3	3	3	2	3	–	–	–	–	–	–	–
CO4	2	3	2	2	2	1	-	-	–	1	1	1
CO5	3	3	3	3	3	–	–	–	1	1	1	1

Course Outline:

Unit-I: **[09 Hours]**

Foundations of Ethical Hacking and Security Architecture: Overview of information security principles and ethical hacking practices; essential skills and responsibilities of ethical hackers; hacking lifecycle and attack methodologies; classification of threats, attack vectors, and security controls; information assurance concepts; legal and regulatory considerations; development of security policies and their organizational implications; physical security fundamentals; threat modelling techniques; enterprise information security architecture and network zoning strategies.

Unit-II: **[09 Hours]**

Reconnaissance, Footprinting, and Network Scanning: Advanced footprinting methodologies including search engine intelligence, social media reconnaissance, website analysis, competitive intelligence, and WHOIS-based investigations; scanning methodologies and countermeasures; intrusion detection evasion techniques; HTTP tunnelling and IP spoofing; network discovery, mapping, and diagramming using modern tools; proxy chaining techniques; mobile-based reconnaissance tools; enumeration protocols such as NetBIOS, SNMP, LDAP, NTP, SMTP, and DNS along with defensive controls.

Unit-III: **[09 Hours]**

System Exploitation and Steganography: System hacking techniques including password cracking, privilege escalation, application execution, data hiding, and anti-forensic practices; fundamentals of steganography, classification methods, and attack techniques; detection and analysis tools for steganographic threats; hands-on exploration of reconnaissance, scanning, enumeration, and system exploitation techniques.

Unit-IV: **[09 Hours]**

Malware Threats and Penetration Testing: Comprehensive overview of malware categories including Trojans, viruses, and worms; infection strategies, crypters, and payload deployment methods; behavioral analysis and detection techniques; countermeasure development; malware analysis methodologies; antivirus technologies; structured penetration testing approaches and reporting practices.

Unit-V: **[09 Hours]**

Network Attacks, Social Engineering, and Session Exploitation: Packet sniffing techniques and attacks involving MAC spoofing, DHCP manipulation, ARP and DNS poisoning; social engineering methodologies including impersonation and identity theft with preventive controls; denial-of-service and botnet-based attacks with detection strategies; session hijacking at application and network levels including TCP/IP hijacking; lifecycle of web-based malware attacks; practical exposure to backdoors, sniffers, DoS tools, and session exploitation techniques.

Suggested Readings:

1. CEH Certified Ethical Hacker Study Guide — Kimberly Graves, Wiley, 2010.

STREAM 2 – DATA SCIENCE

Course Code : MCA**111** Course Type : **Specific Elective** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Big Data Analytics**

Course Objectives:

- To understand big data concepts, characteristics, and applications.
- To explore big data ecosystem tools and cloud integration.
- To learn distributed data processing and storage techniques.
- To develop skills in Hadoop, MapReduce, and real-time analytics.

Course Outcomes (COs):

After completion of the course, students will be able to:

- **CO1**: Explain big data concepts, characteristics, and application domains.
- **CO2**: Analyze big data ecosystem tools, Hadoop architecture, and cloud integration.
- **CO3**: Apply data integration and processing techniques for large-scale datasets.
- **CO4**: Evaluate Hadoop MapReduce and distributed storage mechanisms.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	–	–	–	–	–	–	-
CO2	3	3	2	2	2	–	–	–	–	–	–	–
CO3	3	3	3	2	3	–	–	–	–	–	–	–
CO4	2	3	2	2	2	1	-	-	–	1	1	1
CO5	3	3	3	3	3	–	–	1	1	1	1	1

Course Outline:

Unit-I: **[09 Hours]**

Foundations of Big Data Analytics: Conceptual overview of big data, characteristics (Volume, Velocity, Variety, Veracity, and Value), technological drivers, data lifecycle, and application domains including business intelligence, healthcare analytics, and smart systems.

Unit-II: **[09 Hours]**

Big Data Ecosystem and Technologies: Hadoop ecosystem architecture, data discovery and ingestion frameworks, open-source analytics tools, integration of cloud computing with big data platforms, predictive analytics, mobile analytics, crowdsourced intelligence, and enterprise information management.

Unit-III: **[09 Hours]**

Big Data Processing and Integration: Data integration from heterogeneous sources, data ingestion and

transformation pipelines, distributed storage connectivity, ETL optimization, and data partitioning strategies for parallel processing using Hadoop frameworks.

Unit-IV: **[09 Hours]**

Hadoop MapReduce and Distributed Storage: Map Reduce programming model, job lifecycle and execution workflow, Hadoop daemons and cluster architecture, Hadoop Distributed File System (HDFS) internals, monitoring job execution, and comparison of execution modes (local, pseudo-distributed, and fully distributed clusters).

Unit-V: **[09 Hours]**

Advanced Analytics Platforms and Real-Time Processing: Real-time big data architectures, orchestration of analytics engines, batch vs stream processing, discovery from data at rest and in motion, enterprise analytics deployment strategies, big data convergence trends, and analytics maturity models.

Suggested Readings:

1. Michael Minelli, Michele Chambers & Ambiga Dhiraj — Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends, Wiley CIO Series.
2. Arvind Sathi — Big Data Analytics: Disruptive Technologies for Changing the Game, IBM Press.
3. Bill Franks — Taming the Big Data Tidal Wave, Wiley

Text/Reference Books:

1. Tom White — Hadoop: The Definitive Guide, O'Reilly.
2. Nathan Marz & James Warren — Big Data: Principles and Best Practices of Scalable Realtime Data Systems.
3. Holden Karau et al. — Learning Spark: Lightning-Fast Big Data Analytics.
4. Tyler Akidau et al. — Streaming Systems: The What, Where, When, and How of Large-Scale Data Processing.

Course Code : MCA**111** Course Type : **Specific Elective** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Artificial Intelligence**

Course Objectives:

- To understand the concepts and importance of real-time stream computing.
- To study architectures and tools used for streaming data processing.
- To develop skills for building data pipelines and analysing streaming data.

Course Outcomes (COs):

After completion of the course, students will be able to:

- **CO1**: Explain concepts of stream computing and real-time data processing.
- **CO2**: Analyze streaming analytics architectures and requirements.
- **CO3**: Apply data pipeline and messaging systems.
- **CO4**: Evaluate stream processing and storage mechanisms.
- **CO5**: Develop solutions for real-time analytics and visualization.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	–	–	–	–	–	–	-
CO2	3	3	2	2	2	-	–	–	–	–	–	–
CO3	3	3	3	2	3	–	–	–	–	–	–	–
CO4	2	3	2	2	2	1	-	-	–	1	1	1
CO5	3	3	3	3	3	-	–	–	1	1	1	1

Course Outline:

Unit-I: **[09 Hours]**

Introduction to AI, Agents and Uninformed Search

History of AI, intelligent agents, agents and environments, rationality, nature of the environment, and structure of agents. Problem-solving agents, example problems, and searching for solutions. Uninformed search strategies including breadth-first search, uniform cost search, depth-first search, depth-limited search, iterative deepening depth-first search, bidirectional search, and comparison of uninformed search strategies.

Unit-II: **[09 Hours]**

Informed Search and Constraint Satisfaction Problems

Informed search strategies: greedy best-first search, A* search, AO* search, and heuristic functions. Constraint Satisfaction Problems: definition of CSPs, constraint propagation and inference in CSPs, backtracking search, local search for CSPs, and structure of CSP problems.

Unit-III: **[09 Hours]**

Knowledge Representation and Propositional Logic

Knowledge and reasoning: knowledge-based agents, Wumpus World, logic, propositional logic, propositional theorem proving, effective propositional model checking, and agents based on propositional logic.

Unit-IV: **[09 Hours]**

First Order Logic and Inference

First Order Logic: representation, syntax and semantics of FOL, using first order logic, and knowledge engineering in first-order logic. Inference in First Order Logic: propositional vs first-order inference, lifting, forward chaining, backward chaining, and resolution.

Unit-V: **[09 Hours]**

Expert Systems: introduction, basic concepts, and structure of expert systems. Application-oriented understanding of knowledge-based AI systems derived from logical reasoning frameworks.

Suggested Readings:

1. Artificial Intelligence: A Modern Approach– Standard and most widely used textbook covering search, logic, agents, and reasoning.
2. Computational Intelligence: A Logical Approach– Strong coverage of logic-based AI, reasoning, and intelligent agents.

Text/Reference Books:

1. Artificial Intelligence: Structures and Strategies for Complex Problem Solving – Covers search strategies, problem solving, and knowledge representation.
2. Artificial Intelligence: A New Synthesis– Classical AI concepts including search, logic, and knowledge-based systems.

Course Code : MCA**111** Course Type : **Specific Elective** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Service Design Thinking**

Course Objectives:

- To introduce the principles and methodologies of Service Design Thinking.
- To develop skills in user-centered research and service experience analysis.
- To enable students to design innovative and technology-enabled services.
- To apply design thinking tools for problem-solving and service innovation.
- To familiarize students with prototyping, testing, and evaluation of service systems.

Course Outcomes (COs):

After completion of the course, students will be able to;

- **CO1**: Explain the concepts, principles, and process models of Service Design Thinking.
- **CO2**: Apply user research methods and empathy-driven approaches to identify customer needs.
- **CO3**: Develop customer journey maps and service blueprints for service systems.
- **CO4**: Design and prototype innovative service solutions using design thinking tools.
- **CO5**: Analyze the role of Service Design Thinking in digital transformation and IT-enabled services.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	1	–	–	–	1	1	–	1
CO2	2	3	2	2	2	1	–	–	2	2	–	1
CO3	2	3	3	2	2	1	–	–	2	2	1	1
CO4	2	3	3	3	3	-	1	-	2	2	2	1
CO5	2	2	3	2	2	2	2	1	2	2	2	2

Course Outline:

Unit-I: **[09 Hours]**

Foundations of Service Design Thinking: Introduction to Services and Service Systems – Product Design vs Service Design – Evolution of Design Thinking – Principles of Service Design – Human-Centered Design – Design Thinking Process – Double Diamond Model – Stakeholders in Service Systems – Service Innovation and Digital Transformation.

Unit-II: **[09 Hours]**

User Research and Problem Identification: User Research Methods – Observation and Interviews – Surveys and Contextual Inquiry – Personas and Empathy Mapping – Customer Needs and Pain Point Analysis – Problem Framing – Value Proposition Design – Stakeholder Mapping and Affinity Diagrams.

Unit-III: **[09 Hours]**

Service Journey and Blueprinting: Customer Journey Mapping – Service Touchpoints and Channels –

Experience Mapping – Service Blueprinting Concepts and Components – Frontstage and Backstage Activities – Co-creation Techniques – Workflow and Process Visualization – Tools for Service Modeling.

Unit-IV: [09 Hours]

Service Innovation and Prototyping: Ideation Techniques – Brainstorming Methods – SCAMPER Technique – Storyboarding – Rapid Prototyping – Wireframes and Mockups – Agile and Lean Service Design – Design Sprints – User Feedback and Iterative Improvement.

Unit-V: [09 Hours]

Applications of Service Design Thinking: Service Design in Software and IT Services – UX and Customer Experience Design – Smart and Digital Services – AI-enabled Service Systems – Ethical and Sustainable Service Design – Case Studies in Healthcare, Banking, E-Commerce, Education, and Public Services.

Suggested Readings:

1. Marc Stickdorn and Jakob Schneider, This is Service Design Thinking, Wiley Publications.
2. Marc Stickdorn et al., This is Service Design Doing, O'Reilly Media.

Text/Reference Books:

1. Tim Brown, Change by Design, Harper Business.
2. Tenny Pinheiro, The Service Startup: Design Thinking Gets Lean, Elsevier.
3. Jake Knapp, Sprint: How to Solve Big Problems and Test New Ideas in Just Five Days, Simon & Schuster.
4. IDEO.org, The Field Guide to Human-Centered Design.

Course Code : MCA**111** Course Type : **Specific Elective** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Statistics for Business Analytics**

Course Objectives:

- To understand statistical methods for business decision-making.
- To analyze relationships between variables.
- To apply probability and inference techniques.
- To develop predictive models using regression.

Course Outcomes (COs):

After completion of the course, students will be able to:

- **CO1**: Explain descriptive statistics and exploratory data analysis techniques.
- **CO2**: Analyze relationships using correlation and dependency measures.
- **CO3**: Apply probability models for risk and uncertainty analysis.
- **CO4**: Perform statistical inference and hypothesis testing.
- **CO5**: Develop regression models for prediction and decision-making.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	–	–	–	–	–	–	-
CO2	3	3	2	2	2	–	–	–	–	–	–	–
CO3	3	3	3	2	3	–	–	–	–	–	–	–
CO4	2	3	2	2	2	1	-	-	–	1	1	1
CO5	3	3	3	3	3	–	–	–	1	1	1	1

Course Outline:

Unit-I: **[09 Hours]**

Exploratory Data Analysis and Descriptive Statistics: Business data types and structures, data preprocessing, aggregation and recoding techniques, categorical data summarization, visualization principles, descriptive statistics for numerical variables, distribution analysis, histogram and boxplot interpretation, skewness and kurtosis, and introduction to time-series data exploration.

Unit-II: **[09 Hours]**

Association and Dependency Analysis: Contingency table analysis, measures of association for categorical variables, identification of lurking variables and Simpson's paradox, scatterplot-based exploratory analysis, correlation measures, regression line interpretation, detection of spurious relationships, and business interpretation of variable dependency.

Unit-III: **[09 Hours]**

Probability Models and Risk Quantification: Probability foundations for analytics, conditional probability and independence, discrete and continuous random variables, joint distributions, probability models for count data,

normal distribution and business applications, sampling variability, and statistical approaches to financial risk modeling.

Unit-IV: **[09 Hours]**

Statistical Inference and Decision Making: Sampling methodologies and survey design, sampling error and bias assessment, confidence interval estimation, hypothesis testing frameworks, parametric and non-parametric inference approaches, two-sample comparison tests, rare event modeling, and association testing in business contexts.

Unit-V: **[09 Hours]**

Regression Modeling and Predictive Analytics: Simple and multiple linear regression, detection of linear and nonlinear patterns, regression diagnostics and model validation, multicollinearity assessment, residual analysis, model interpretation for business forecasting, and introduction to predictive modeling strategies.

Suggested Readings:

1. Robert Stine & Dean Foster — Statistics for Business: Decision Making and Analysis.
2. Paul Newbold, William Carlson & Betty Thorne — Statistics for Business and Economics.
3. David Diez, Christopher Barr & Mine Çetinkaya-Rundel — OpenIntro Statistics.

Text/Reference Books:

1. Keller Gerald — Statistics for Management and Economics.
2. James Evans — Business Analytics: Methods, Models, and Decisions.
3. Douglas Montgomery & George Runger — Applied Statistics and Probability for Engineers.
4. Gareth James et al. — An Introduction to Statistical Learning.

Course Code : MCA**211** Course Type : **Specific Elective** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Digital Marketing**

Course Objectives:

- To introduce the use of MS Excel–based analytical techniques for solving marketing and business problems.
- To develop skills for sales forecasting, campaign response analysis, and pricing optimization.
- To understand analytical approaches for market segmentation, customer insights, and retail decision-making.

Course Outcomes (COs):

After completion of the course, students will be able to:

- **CO1**: Apply data summarization techniques for marketing data analysis.
- **CO2**: Analyze forecasting models for sales and demand prediction.
- **CO3**: Evaluate customer behavior using analytical models.
- **CO4**: Apply segmentation techniques for market analysis.
- **CO5**: Analyze retail and marketing data using advanced analytical tools.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	–	–	–	–	–	–	-
CO2	3	3	2	2	2	–	–	–	–	–	–	–
CO3	3	3	3	2	3	–	–	–	–	–	–	–
CO4	2	3	2	2	2	1	-	-	–	1	1	1
CO5	3	3	3	3	3	–	–	–	1	1	1	1

Course Outline:

Unit-I: **[09 Hours]**

Marketing Data Summarization: Data summarization using PivotTables, Excel charts, and built-in functions for effective marketing data analysis.

Unit-II: **[09 Hours]**

Forecasting Techniques: Correlation and simple regression, multiple regression for sales forecasting, handling special events, trend and seasonality modelling, moving average and Winter's methods, and introduction to neural network-based forecasting.

Unit-III: **[09 Hours]**

Customer Needs Analysis: Conjoint analysis, logistic regression, discrete choice models, and fundamentals of customer value and benefits assessment.

Unit-IV: **[09 Hours]**

Customer Needs Analysis: Conjoint analysis, logistic regression, discrete choice models, and fundamentals of customer value and benefits assessment.

Unit-V: **[12 Hours]**

Retailing and Marketing Research Tools: Retail analytics overview, market basket analysis and lift, marketing research techniques, and principal component analysis.

Suggested Readings:

1. Wayne L. Winston, Marketing Analytics: Data-Driven Techniques with Microsoft Excel, Wiley, 2014.

Text/Reference Books:

1. Stephan Sorger, Marketing Analytics: Strategic Models and Metrics, CreateSpace, 2013.

Course Code : MCA**211** Course Type : **Specific Elective** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Social Network Analytics**

Course Objectives:

- To understand the structure, properties, and evolution of social networks.
- To introduce interdisciplinary foundations from sociology, mathematics, and computer science for network analysis.
- To develop skills for analysing real-world social network data and interpreting network behaviour.

Course Outcomes (COs):

After completion of the course, students will be able to:

- **CO1**: Explain concepts of social networks and graph structures.
- **CO2**: Analyze social influence and link formation mechanisms.
- **CO3**: Evaluate web-based information networks and ranking algorithms.
- **CO4**: Apply network mining and community detection techniques.
- **CO5**: Analyze network dynamics and information diffusion processes.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	-	–	–	–	–	–	-
CO2	3	3	2	2	2	-	–	–	–	–	–	–
CO3	3	3	3	2	3	–	–	–	–	–	–	–
CO4	2	3	2	2	2	1	-	-	–	1	1	1
CO5	3	3	3	3	3	–	–	–	1	1	1	1

Course Outline:

Unit-I: [09 Hours]

Introduction to Social Networks: Social network data and datasets, graph representation of social relations, paths and connectivity, strong and weak ties, closure, and handling network data.

Unit-II: [09 Hours]

Social Influence and Link Formation: Homophily and its mechanisms, selection and social influence, affiliation networks, link formation in online systems, structural balance, and applications of positive and negative relationships.

Unit-III: [09 Hours]

Information Networks and the Web: Structure of the World Wide Web, web as a directed graph, bow-tie structure, link analysis and ranking, hubs and authorities, PageRank, spectral analysis, and random walk models.

Unit-IV: [09 Hours]

Social Network Mining: Community detection and clustering, Girvan–Newman algorithm, cliques and bipartite graphs, graph partitioning, matrix representation, eigenvalue analysis, and SimRank.

Unit-V: [09 Hours]

Network Dynamics: Diffusion and cascading behaviour in networks, cascade models and thresholds, six degrees of separation, decentralized search, randomness in networks, and empirical analysis of search processes.

Suggested Readings:

1. Networks, Crowds, and Markets: Reasoning About a Highly Connected World – David Easley and Jon Kleinberg.
2. Introduction to Social Network Methods – Robert A. Hanneman and Mark Riddle.
3. Mining of Massive Datasets – Jure Leskovec, Anand Rajaraman, and Jeffrey D. Ullman.

Text/Reference Books:

1. Social Network Analysis: Methods and Applications – Stanley Wasserman and Katherine Faust.
2. Analyzing Social Networks – Borgatti, Everett, and Johnson.
3. Social Network Analysis: A Handbook – John Scott.

Course Code : MCA**211** Course Type : **Specific Elective** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Natural Language Processing**

Course Objectives:

- To introduce fundamental concepts of risk, risk assessment, and risk management.
- To apply analytical techniques for risk mitigation in banking, insurance, and healthcare sectors.
- To understand the role of analytics in fraud detection, profitability improvement, and COst optimization.
- To explore workforce analytics for effective talent and organizational risk management.

Course Outcomes (COs):

After completion of the course, students will be able to:

- **CO1**: Explain concepts of risk, risk assessment, and management.
- **CO2**: Analyze banking risk and financial analytics models.
- **CO3**: Evaluate insurance risk and fraud detection techniques.
- **CO4**: Apply analytics in healthcare risk management.
- **CO5**: Analyze workforce data for organizational risk management.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	–	–	–	–	–	–	-
CO2	3	3	2	2	2	–	–	–	–	–	–	–
CO3	3	3	3	2	3	–	–	–	–	–	–	–
CO4	2	3	2	2	2	1	-	-	–	1	1	1
CO5	3	3	3	3	3	–	–	–	1	1	1	1

Course Outline:

Unit-I: **[09 Hours]**

Foundations of NLP and Language Processing: Introduction to Natural Language Processing, ambiguity in language, Turing test, regular expressions, Chomsky hierarchy, regular languages and limitations. Finite state automata and applications of regular expressions in text processing. Basic introduction to Python for NLP. String edit distance and dynamic programming with applications in spelling correction.

Unit-II: **[09 Hours]**

Syntax and Context Free Grammars: Context Free Grammars: definition, constituency, and limitations. Chomsky Normal Form. Top-down and bottom-up parsing. CYK parsing algorithm. Basic grammar design and parsing applications.

Unit-III: **[09 Hours]**

Language Modeling and POS Taggings: Language modeling: n-grams, probability estimation, and smoothing. Naive Bayes classifier for text classification. Part-of-speech tagging using Hidden Markov Models. Viterbi

algorithm for sequence prediction.

Unit-IV: **[09 Hours]**

Statistical NLP Basics: Basic concepts of information theory: entropy and cross entropy. Introduction to statistical language modeling. Overview of Maximum Entropy classifier and its use in text classification.

Unit-V: **[09 Hours]**

NLP Applications: Overview of PCFG (basic idea only), treebanks, and parsing evaluation. Introduction to information retrieval systems. NLP applications: sentence segmentation, information extraction, and basic NLP pipelines.

Suggested Readings:

1. Daniel Jurafsky and James H. Martin, "Speech and Language Processing", 2nd Edition, Prentice Hall, 2008.
2. Christopher D. Manning and Hinrich Schütze, "Statistical Natural Language Processing", MIT Press, 2001.
3. James Allen, "Natural Language Understanding", The Benjamin/Cummings Publishing Company, 1998.

Text/Reference Books:

1. Thomas M. Cover and Joy A. Thomas, "Elements of Information Theory", 2nd Edition, Wiley, 2006.
2. Eugene Charniak, "Statistical Language Learning", MIT Press, 1994.
3. Frederick Jelinek, "Statistical Methods for Speech Recognition", 4th Edition, MIT Press, 1998.

Course Code : MCA**311** Course Type : **Specific Elective** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **NoSQL Databases**

Course Objectives:

- To understand the fundamentals and concepts of NoSQL databases.
- To learn different NoSQL data models and their applications.
- To study data distribution techniques such as replication and sharding.
- To understand document, column-family, key-value, and graph databases.
- To develop knowledge of scalable database solutions for modern applications.

Course Outcomes (COs):

After completion of the course, students will be able to:

- **CO1**: Explain the concepts and features of NoSQL databases.
- **CO2**: Compare NoSQL databases with relational database systems.
- **CO3**: Analyze data distribution techniques such as replication and sharding.
- **CO4**: Evaluate document-oriented and column-family databases.
- **CO5**: Apply key-value and graph databases for real-world applications.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	2	–	–	–	–	–	–	-
CO2	3	3	2	2	2	–	–	–	–	–	–	1
CO3	3	3	3	2	3	–	–	–	–	–	1	1
CO4	3	3	3	3	3	3	-	-	1	–	1	1
CO5	3	2	3	2	3	1	–	–	1	1	1	1

Course Outline:

Unit-I: **[09 Hours]**

Introduction: Overview and history of NoSQL databases. Definition of the four types of NoSQL databases. The value of relational databases and limitations in handling modern applications. Issues such as persistent data management, concurrency, integration, and impedance mismatch. Application and integration databases. Emergence of NoSQL databases and key concepts.

Unit-II: **[09 Hours]**

NoSQL Models and Comparison with RDBMS: Comparison of relational databases with NoSQL stores. Key-Value, Document, Column-Family, and Graph data models. Aggregate-oriented databases. Introduction to MongoDB, Cassandra, HBase, and Neo4j. RDBMS approach vs NoSQL approach and associated challenges.

Unit-III: **[09 Hours]**

Data Distribution Techniques: Replication and sharding concepts in NoSQL databases. Distribution models: single server, sharding, master-slave replication, peer-to-peer replication. Combining sharding and replication.

Introduction to MapReduce in distributed databases.

Unit-IV: **[09 Hours]**

Document and Column-Family Databases: Key/Value databases using MongoDB. Document-oriented databases and their features. Consistency, transactions, availability, query features, and scaling. Column-oriented NoSQL databases using HBase and Cassandra. Column-family data store features and architecture. Use cases such as event logging, content management systems, blogging platforms, and analytics applications.

Unit-V: **[09 Hours]**

Key-Value and Graph Databases: Key-value databases using Riak. Key-value store features, consistency, transactions, query features, and scaling. Suitable use cases such as session management, user profiles, preferences, and shopping cart data. Graph databases using Neo4j. Features, consistency, transactions, availability, query features, and scaling. NoSQL database development tools and programming languages.

Suggested Readings:

1. Sadalage, P. & Fowler, NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence, Wiley Publications, 1st Edition, 2019.

STREAM 3 – NETWORK COMPUTING

Course Code : MCA**111** Course Type : **Specific Elective** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Principles of Distributed Computing**

Course Objectives:

- To understand concepts, architectures, and models of distributed systems.
- To study communication, synchronization, and transaction mechanisms.
- To explore distributed databases, file systems, and coordination services.

Course Outcomes (COs):

After completion of the course, students will be able to:

- **CO1**: Explain fundamental concepts and architectures of distributed systems.
- **CO2**: Analyze client–server models, naming, and communication mechanisms.
- **CO3**: Evaluate synchronization, transactions, and fault tolerance techniques.
- **CO4**: Analyze distributed object-based systems and middleware technologies.
- **CO5**: Apply distributed file systems and coordination services in applications.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	–	–	–	–	–	–	-
CO2	3	3	2	2	2	–	–	–	–	–	–	–
CO3	3	3	3	2	3	–	–	–	–	–	–	–
CO4	2	3	2	2	2	1	-	-	–	1	1	1
CO5	3	3	3	3	3	–	–	–	1	1	1	1

Course Outline:

Unit-I: **[09 Hours]**

Introduction to Distributed Systems: Definition, goals, hardware and software concepts, client–server model, communication techniques, layered protocols, RPC, remote objects, and message-oriented communication.

Unit-II: **[09 Hours]**

Client–Server Computing and Naming: Multithreading in client–server systems, code migration, software agents, naming services, and location of distributed and mobile entities.

Unit-III: **[09 Hours]**

Synchronization and Transactions: Clock synchronization, logical clocks, global states, election algorithms, mutual exclusion, consistency and replication, fault tolerance, distributed commit, and recovery.

Unit-IV: **[09 Hours]**

Distributed Object-Based Systems: Concepts of distributed object databases and middleware technologies.

Unit-V: **[09 Hours]**

Distributed File and Coordination Systems: Distributed file systems, distributed document systems, World Wide Web concepts, coordination services, and distributed service platforms.

Suggested Readings:

1. Distributed Systems: Principles and Paradigms – Andrew S. Tanenbaum and Maarten van Steen.

Text/Reference Books:

1. Distributed Systems: Concepts and Design – George Coulouris et al.

Course Code : MCA**211** Course Type : **Specific Elective** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Introduction to Parallel Computing**

Course Objectives:

- To understand architectures and models of parallel computing.
- To learn parallel algorithm design and performance analysis.
- To study message passing and real-world parallel applications.

Course Outcomes (COs):

After completion of the course, students will be able to:

- **CO1**: Explain concepts and architectures of parallel computing systems.
- **CO2**: Analyze parallel algorithm design and decomposition techniques.
- **CO3**: Evaluate performance metrics and scalability of parallel systems.
- **CO4**: Apply message-passing programming using MPI concepts.
- **CO5**: Develop parallel algorithms for real-world computational problems.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	–	–	–	–	–	–	-
CO2	3	3	2	2	2	–	–	–	–	–	–	–
CO3	3	3	3	2	3	–	–	–	–	–	–	–
CO4	2	3	2	2	2	1	-	-	–	1	1	1
CO5	3	3	3	3	3	–	–	–	1	1	1	1

Course Outline:

Unit-I: **[09 Hours]**

Fundamentals of Parallel Computing: Motivation and scope of parallel computing, parallel platforms, memory limitations, communication cost, and interconnection networks.

Unit-II: **[09 Hours]**

Parallel Algorithm Design: Problem decomposition, task mapping and load balancing, interaction overhead, parallel algorithm models, and basic communication operations.

Unit-III: **[09 Hours]**

Performance Analysis: Overheads in parallel programs, performance metrics, granularity effects, scalability, and analytical modelling of parallel systems.

Unit-IV: **[09 Hours]**

Message Passing Programming: Principles of message passing, send/receive operations, MPI basics,

communication topologies, collective operations, and communicators.

Unit-V: [09 Hours]

Parallel Algorithms and Applications: Parallel matrix computations, solving linear equations, parallel sorting techniques, and applications of parallel algorithms.

Suggested Readings:

1. Introduction to Parallel Computing – Ananth Grama et al.

Text/Reference Books:

1. An Introduction to Parallel Programming – Peter S. Pacheco.
2. Algorithms and Parallel Computing – Fayez Gebali.

Course Code : MCA**211** Course Type : **Specific Elective** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Web Services Computing**

Course Objectives:

- To understand web services architecture and technologies.
- To learn SOAP, WSDL, and service discovery mechanisms.
- To study interoperability and security in SOA systems.

Course Outcomes (COs):

After completion of the course, students will be able to;

- **CO1**: Explain web services architecture and communication models.
- **CO2**: Analyze service-oriented architecture and service interaction patterns.
- **CO3**: Apply SOAP-based web services and message structures.
- **CO4**: Evaluate WSDL, UDDI, and service discovery mechanisms.
- **CO5**: Analyze interoperability and security issues in web services.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	–	–	–	–	–	–	-
CO2	3	3	2	2	2	–	–	–	–	–	–	–
CO3	3	3	3	2	3	–	–	–	–	–	–	–
CO4	2	3	2	2	2	1	-	-	–	1	1	1
CO5	3	3	3	3	3	–	–	–	1	1	1	1

Course Outline:

Unit-I: **[09 Hours]**

Introduction to Web Services: Definition, architecture, components, benefits, challenges, and communication models of web services.

Unit-II: **[09 Hours]**

Service-Oriented Architecture: SOA concepts, characteristics, benefits, service models, discovery mechanisms, security, and interaction patterns.

Unit-III: **[09 Hours]**

SOAP-Based Web Services: SOAP message structure, communication models, security features, and development of SOAP web services with limitations.

Unit-IV: **[09 Hours]**

WSDL and Service Discovery: WSDL structure and bindings, web service lifecycle, service discovery mechanisms, UDDI registries, and publishing and searching services.

Unit-V: **[09 Hours]**

Interoperability and Security: Interoperability issues across platforms, client development, XML security, encryption, digital signatures, certificates, and authentication frameworks.

Suggested Readings:

1. Developing Java Web Services – R. Nagappan et al.
2. Understanding SOA with Web Services – Eric Newcomer and Greg Lomow.
3. Java Web Service Architecture – James McGovern et al.

Text/Reference Books:

1. Building Web Services with Java – S. Graham.
2. Java Web Services – D. A. Chappell and T. Jewell.

Course Code : MCA**311** Course Type : **Specific Elective** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Pervasive and Ubiquitous Computing**

Course Objectives:

- To understand pervasive computing concepts and technologies.
- To study design methodologies and real-world applications.
- To analyze security and emerging trends in pervasive systems.

Course Outcomes (COs):

After completion of the course, students will be able to:

- **CO1**: Explain concepts and evolution of pervasive computing systems.
- **CO2**: Analyze design methodologies and interaction models.
- **CO3**: Evaluate tools, technologies, and deployment challenges.
- **CO4**: Apply pervasive computing solutions in real-world applications.
- **CO5**: Analyze security, privacy issues, and emerging trends.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	–	–	–	–	–	–	-
CO2	3	3	2	2	2	–	–	–	–	–	–	–
CO3	3	3	3	2	3	–	–	–	–	–	–	–
CO4	2	3	2	2	2	1	-	-	–	1	1	1
CO5	3	3	3	3	3	–	–	–	1	1	1	1

Course Outline:

Unit-I: **[09 Hours]**

Fundamentals of Ubiquitous Computing: Introduction, history and evolution, ubiquitous portals, grid computing concepts, RFID technologies, and ambient intelligence.

Unit-II: **[09 Hours]**

Design and Development Methodologies: Design of pervasive applications, multimodal interaction systems, conceptual frameworks, workflow-based interfaces, and case studies.

Unit-III: **[09 Hours]**

Tools and Technologies: Embedding pervasive technologies, deployment challenges, educational applications, benefits, limitations, and practical issues.

Unit-IV: **[09 Hours]**

Applications of Pervasive Computing: Healthcare applications, RFID-based hospital systems, risk analysis, and frameworks for real-world pervasive solutions.

Unit-V: **[09 Hours]**

Security Issues and Emerging Trends: Privacy and security in RFID systems, database challenges in pervasive computing, emerging technologies, and case studies.

Suggested Readings:

1. Ubiquitous and Pervasive Computing: Concepts Methodologies Tools and Applications – Judith Symonds.

Text/Reference Books:

1. Ubiquitous and Pervasive Computing Architectures and Protocols – Mohamed Bakhouya.

Course Code : MCA**311** Course Type : **Specific Elective** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Cloud Computing**

Course Objectives:

- To understand cloud computing models and architectures.
- To study virtualization and cloud platforms.
- To learn cloud service management and security.

Course Outcomes (COs):

After completion of the course, students will be able to:

- **CO1**: Explain cloud computing concepts, models, and architectures.
- **CO2**: Analyze IaaS, virtualization, and resource provisioning.
- **CO3**: Evaluate PaaS, SaaS, and cloud application development.
- **CO4**: Apply cloud service management and data handling techniques.
- **CO5**: Analyze security, privacy, and trust issues in cloud computing.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	1	–	–	–	–	–	–	-
CO2	3	3	2	2	2	–	–	–	–	–	–	–
CO3	3	3	3	2	3	–	–	–	–	–	–	–
CO4	2	3	2	2	2	1	-	-	–	1	1	1
CO5	3	3	3	3	3	–	–	–	1	1	1	1

Course Outline:

Unit-I: **[09 Hours]**

Introduction to Cloud Computing: Computing paradigms, evolution of cloud computing, characteristics, service and deployment models, cloud architecture, and comparison with grid and cluster computing.

Unit-II: **[09 Hours]**

Infrastructure as a Service (IaaS): Virtualization concepts, hypervisors, virtual machines, resource provisioning, storage services, and overview of commercial IaaS platforms.

Unit-III: **[09 Hours]**

Platform and Software as a Service: PaaS and SaaS concepts, SOA in cloud platforms, application development environments, web services, and case studies of cloud platforms.

Unit-IV: **[09 Hours]**

Cloud Service Management: Service level agreements, billing and accounting, scalability, cloud data management, distributed data stores, and large-scale data processing.

Unit-V: **[09 Hours]**

Cloud Security: Infrastructure and application security, data privacy, identity and access management, trust and authentication, and business considerations in cloud adoption.

Suggested Readings:

1. Cloud Computing: Principles and Paradigms – Rajkumar Buyya et al.
2. Cloud Security: A Comprehensive Guide to Secure Cloud Computing – Ronald L. Krutz and Russell Dean Vines.

Text/Reference Books:

1. Mastering Cloud Computing – Rajkumar Buyya et al.
2. Cloud Computing Principles Systems and Applications – Nikos Antonopoulos and Lee Gillam.
3. Cloud Computing Bible – Barrie Sosinsky.

Course Code : MCA**311** Course Type : **Specific Elective** No. of Credits : **3.00** No. of Hours : **45**	**Course Title** **Wireless Sensor Networks**

Course Objectives:

- To understand wireless communication concepts and technologies.
- To learn ad hoc and wireless sensor network architecture.
- To study MAC and routing protocols in wireless networks.
- To understand QoS and energy management techniques.
- To develop knowledge of efficient wireless data communication.

Course Outcomes (COs):

After completion of the course, students will be able to:

- **CO1**: Explain wireless communication and networking concepts.
- **CO2**: Analyze ad hoc and wireless sensor network architecture.
- **CO3**: Evaluate MAC protocols used in wireless networks.
- **CO4**: Analyze routing protocols in wireless sensor networks.
- **CO5**: Apply QoS and energy management techniques in wireless networks.

COs /POs Mapping:

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	1	2	–	–	–	–	–	–	-
CO2	3	3	2	2	2	–	–	–	–	–	–	1
CO3	3	3	3	2	3	–	–	1	–	–	–	1
CO4	3	3	3	3	3	-	1	-	1	–	1	1
CO5	2	3	2	2	3	1	3	1	1	1	1	1

Course Outline:

Unit-I: [09 Hours]

Introduction: Fundamentals of wireless communication technology, the electromagnetic spectrum radio propagation, characteristics of wireless channels, modulation techniques, multiple access techniques, wireless LANs, PANs, WANs, and MANs, Wireless Internet.

Unit-II: [09 Hours]

Introduction to adhoc/sensor networks: Key definitions of adhoc/ sensor networks, unique constraints and challenges, advantages of ad-hoc/sensor network, driving applications, issues in adhoc wireless networks, issues in design of sensor network, sensor network architecture, data dissemination and gathering.

Unit-III: [09 Hours]

MAC Protocols : Issues in designing MAC protocols for adhoc wireless networks, design goals, classification of MAC protocols, MAC protocols for sensor network, location discovery, quality, other issues, S-MAC, IEEE 802.15.4.

Unit-IV: **[09 Hours]**

Routing Protocols: Issues in designing a routing protocol, classification of routing protocols, table-driven, on-demand, hybrid, flooding, hierarchical, and power aware routing protocols.

Unit-V: **[09 Hours]**

QoS and Energy Management: Issues and Challenges in providing QoS, classifications, MAC, network layer solutions, QoS frameworks, need for energy management, classification, battery, transmission power, and system power management schemes.

Suggested Readings:

1. C. Siva Ram Murthy, and B. S. Manoj, "AdHoc Wireless networks ", Pearson Education - 2008.

Text/Reference Books:

1. Feng Zhao and Leonides Guibas, "Wireless sensor networks ", Elsevier publication - 2004.
2. Jochen Schiller, "Mobile Communications", Pearson Education, 2nd Edition, 2003.
3. William Stallings, "Wireless Communications and Networks ", Pearson Education – 2004.