

ఆంధ్రప్రదేశ్ కేంద్రీయ విశ్వవిద్యాలయం ఆంధ్రప్రదేశ్ కేంద్రీయ విశ్వవిద్యాలయం  
**CENTRAL UNIVERSITY OF ANDHRA PRADESH**  
(Established by an act of Parliament in 2019)

**SCHOOL OF INTERDISCIPLINARY AND APPLIED SCIENCES**  
**DEPARTMENT OF COMPUTER SCIENCE & ARTIFICIAL INTELLIGENCE**

**Postgraduate Programme Structure**  
**as per the UGC Credit Framework (NEP 2020)**



*Vidya Dadati Vinayam*  
(Education gives humility)

## ***M.Sc. Artificial Intelligence and Data Science***

*“Today’s AI is about new ways of connecting people to computers, people to knowledge, people to the physical world, and people to people.”*

*- Patrick Winston*



**Programme Structure**  
(With effect from AY 2025 - 26)

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**SCHOOL OF INTERDISCIPLINARY AND APPLIED SCIENCES**  
**DEPARTMENT OF COMPUTER SCIENCE & ARTIFICIAL INTELLIGENCE**  
**MASTER OF SCIENCE IN ARTIFICIAL INTELLIGENCE & DATA SCIENCE (M. Sc.)**

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**About the Master's Program in Artificial Intelligence & Data Science:**

M.Sc. Artificial Intelligence and Data Science is one of the new postgraduate programmes being offered by CUAP from 2023-24 academic year. Artificial Intelligence (AI) and Data Science (DS) are very close and fastest growing fields in contemporary scenario. AI is a branch of computer science that aims to create intelligence showcased by machines (computers and automation systems) in distinction to the natural intelligence of humans. The major goals of AI and Data Science are to attain success in knowledge reasoning, planning, machine learning, natural language processing, computer vision, data analytics and data engineering.

With a vision to impart knowledge of Artificial Intelligence and Data Science, the program focuses on training students to become analytical experts and critical thinkers in research and industry. The course is designed to encourage students to reason with data and build models which can predict future outcomes.

In this program, we aim to prepare students to work in various fields ranging from Artificial Intelligence, Data Science, Data Engineering and Data Analytics.

**Programme Objectives:**

- To impart knowledge of both fundamental and technical skills on various aspects of Artificial Intelligence and Data Science.
- To expose students to the developments in the area of Data Visualization, Data Cleaning, Machine Learning Models, Artificial Intelligence and their utilization in industry and research.
- To expose to techniques and developments in various domains where AI can be applied.
- A Student completing this programme will be capable of taking a career path in the domain of Artificial Intelligence and Data Science.

**Programme Outcomes:**

On successful completion of the programme student should be able to:

- Understand the fundamentals of Artificial Intelligence, Machine Learning, Inference Engines, Speech, Vision, Natural Language Understanding, Robotics, and Human Computer Interaction.
- Unify the knowledge of Human Cognition, AI, Machine Learning and Data Engineering for designing systems.
- Apply ideas and intuition behind modern machine learning methods as well as a more formal understanding of how, why, and when they work.
- Develop real-time and robust AI-based systems with specific software, hardware and data requirements.
- Upgrade knowledge and undertake further study and research in Artificial Intelligence according to the need of society.

**Program Structure:**

- M.Sc. AI & DS is a two-year program divided into four semesters with a total of around 102 credits.
- The program is designed with the combination of Core Courses, Discipline Specific Electives, Multidisciplinary Courses, and MOOCS.

- The program consists of discipline specific electives, comprising wide range of courses from the disciplines catering to the present industry requirement.
- In Semester II and III, 1 multi-disciplinary elective offered by other departments will be selected by the students.
- Students need to complete 1 MOOCS Course in each I, II and III Semester.
- Students will undergo for 2 months summer internship after II semester and submit internship in III semester.
- In semester IV students will undergo for 6 months Project Work.

**CENTRAL UNIVERSITY OF ANDHRA PRADESH**

**MSc AI & DS Semester and Course wise Credits**

Semester	Discipline Specific Core (DSC) (L+T+P)	Discipline Elective (DSE) / Elective (EL)	Project Work / Dissertation	common compulsory course(CCC)	Inter-Disciplinary Elective	Internship	Lab	Total Credits
I	DSC 1 (4) DSC 2 (4) DSC 3 (4) DSC 4 (4)	Elective-I by MOOC/Swayam(2) Elective-II (4)	-		IDE 1 (3) online/offline		System Building Lab- I(3) (DSC 2+ DSC 3+ DSC 4)	28
II	DSC 5 (4) DSC 6 (4) DSC 7(4) DSC 8(4)	Elective-III by MOOC/Swayam (2) Elective-IV (4)	-	Introduction to R Programming (4)	IDE 2 (3) online/offline		System Building Lab- II (3) (DSC 5 + DSC 6+ DSC 8)	32
III	DSC 9(4) DSC 10 (4) DSC 11(4)	Elective-V by MOOC/Swayam (2) Elective-VI (4)		CCC-1 Building Mathematical Ability & Financial Literacy (4)	IDE 3 (3) online/offline	Internship(2)	System Building Lab- III (2) (DSC 9 + DSC 10)	29
IV	-	-	Dissertation (16)				-	16
Total	44	18	16	8	9	2	8	105
Percentage	42	17.1	15.2	7.6	8.5	2	7.6	100



**CENTRAL UNIVERSITY OF ANDHRA PRADESH**  
**M. Sc. Artificial Intelligence and Data Science**

**Programme Structure**

S. No	Course Code	Title of the Course	Credits	Contact Hours		
				L*	T*	P*
<b>Semester – I</b>						
1.	MAI101	Mathematics for Data Science	4	3	1	0
2.	MAI102	Introduction to Artificial Intelligence	4	3	1	0
3.	MAI103	Advanced Data Structures and Algorithms	4	3	1	0
4.	MAI104	Fundamentals of Data Science through Python Programming	4	3	1	0
5.	MAI105	MOOC / Online/ Elective – I	2	2	-	-
<b>Any one of the following electives (Elective-II):</b>			4	3	1	0
6.	MAI111	Computer Networks				
		Recommender Systems				
		Operating Systems				
7.		Cyber Security				
	MAI112	IDE1	3	3	0	0
8.	MAI125	System Building Labs -I: (Based on MAI 102,103,104 carrying 1 credit for each)	3	-	-	3
<b>Total</b>			<b>28</b>	<b>20</b>	<b>5</b>	<b>3</b>
<b>Semester – II</b>						
S. No	Course Code	Title of the Course	Credits	Contact Hours		
				L*	T*	P*
1.	MAI201	Artificial Neural Networks (ANN)	4	3	1	0
2.	MAI202	Big Data Analytics	4	3	1	0
3.	MAI203	Natural Language Processing	4	3	1	0
4.	MAI204	Machine Learning	4	3	1	0
5.	MAI205	MOOC / Online/ Elective III	2	2	-	-
<b>Any one of the following electives: (Elective-IV)</b>			4	3	1	0
6.	MAI211	Blockchain & Cryptocurrency Fundamentals				

	MAI211	Computer Architecture				
		Data Preparation and Analysis				
		Digital Forensics				
7.	MAI212	IDE2	3	3	0	0
8.	MAI213	CCC: Introduction to R Programming	4	2	0	2
9.	MAI225	System Building Labs -II (Based on MAI 201,202,204 carrying 1 credit for each)	3	-	0	3
<b>Total</b>			<b>32</b>	<b>22</b>	<b>5</b>	<b>5</b>

S. No	Course Code	Title of the Course	Credits	Contact Hours		
				L*	T*	P*
<b>Semester – III</b>						
1.	MAI301	Introduction to Deep Learning	4	3	1	0
2.	MAI302	Scalable Systems for Data Science	4	3	1	0
3.	MAI303	Data Mining & Data Warehousing	4	3	1	0
4.	MAI304	MOOC / Online/ Elective –V	2	2	-	-
<b>Any one of the following electives: Elective- VI</b>			4	3	1	0
5.	MAI311	Research Methodology & IPR				
		Health Care Data Analytics				
		Digital Image Processing				
		Theory of Computation				
6.	MAI312	IDE3	3	3	0	0
7.	MAI313	CCC: Building Mathematical Ability and Financial Literacy	4	3	1	0
8.	MAI314	Internship	2			2
9.	MAI325	System Building Labs-III (Based on MAI 301,302 carrying 1 credit for each)	2	-	0	2
<b>Total</b>			<b>29</b>	<b>20</b>	<b>5</b>	<b>4</b>
<b>Semester – IV</b>						
1.	MAI401	Project Work/Dissertation	16	0	0	0
<b>Total</b>			<b>16</b>	<b>0</b>	<b>0</b>	<b>0</b>

L\* – Lectures      T\*– Tutorials      P\*– Practicals

**Note 1:** Project Dissertation Phase-I shall be identified and students must compulsorily make a presentation at the end of III Semester.

**Note 2:** One more MOOC course can be done by student to score additional credits. Any course that taken by student can be approved by the competent authority of the University.

**Note 3:** The Programme template &title of the courses are tentative; any change as required may be made.

### **Semester-Wise Credit Distribution**

<b>Semester</b>	<b>Total Credits</b>	<b>Cumulative credit at the end of the semester</b>
<b>I</b>	28	28
<b>II</b>	32	60
<b>III</b>	29	89
<b>IV</b>	16	105



# CENTRAL UNIVERSITY OF ANDHRA PRADESH

## M. Sc. Artificial Intelligence and Data Science

### Important Information to Students

1. Eligibility: With at least 50% marks in the Bachelor's degree with Mathematics and Physics as compulsory subjects or B.E/B. Tech in any Branch with 50% aggregate.
2. The minimum duration for completion of any PG Program is four semesters (two academic years) and the maximum duration is eight semesters (four academic years) or as per amendments made by the regulatory bodies from time to time.
3. A student should attend at least 75% of the classes, seminars, practical / lab in each course of study.
4. All theory courses in the programme carry a Continuous Internal Assessment (CIA) component of 40 marks and Semester-end component for 60 marks. The minimum pass marks for a course are 40%. 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 40%.
5. The student is given 3 Continuous Internal Assessment (CIA) tests per semester in each course from which the best 2 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 3 internal tests are conducted for 15 Marks each, out of the best 2 tests scores are considered for 30 marks. Out of the remaining 10 marks, 5 marks are awarded for assignments, class presentations and class participation of the students and the remaining 5 marks are awarded for punctuality, and attendance of the student.

#### Marks for the Attendance will be considered as follows:

S. No	Attendance (%)	Marks
1	95% or more	5
2	90-94%	4
3	85-89%	3
4	80-84%	2
5	75-79%	1

6. A student should pass separately in both CIA and the ESE, i.e., a student should secure 16 (40% of 40) out of 40 marks for theory and 24 (40% of 60) out of 60 marks for lab components in the CIA. Therefore, a student should secure 24 (40% of 60) out of 60 marks for theory and 16 (40% of 40) out of 40 marks for lab components in the End-semester examination (ESE).
7. Semester-end examination shall consist of Objective type questions, descriptive type questions, short answer questions and case studies or any other recommended by the BOS.
8. A student failing to secure the minimum pass marks in the CIA is not allowed to take the end semester 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 end semester examination.
9. Students failing a course due to lack of attendance should redo the course.
10. Re-evaluation is applicable only for theory papers and shall not be entertained for other components such as practical/ thesis/ dissertation/ internship etc.
11. An on- campus elective course is offered only if a minimum of ten or 40% of the students registered, whichever is higher.

# **SEMESTER-WISE DETAILED SYLLABUS**

# SEMESTER-I

Course Code : MAI101 Core/ Elective : Core No. of Credits : 4 No. of Hours : 60	Course Title <b>Mathematics for Data Science</b>
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## Course Objectives:

- To enable the understanding of the Mathematical and Logical Basis to many Modern Techniques in the Technology like Data Science, Artificial Intelligence, Machine Learning and Programming Language Design etc.
- To understand important characteristics of Matrices, Eigen Values, Eigen Vectors and Vector Spaces etc.
- To learn how to analyze and solve a linear system of equations.

## Learning Outcomes:

After completion of the course student will be able to:

- Understand the basic concepts of sets, vector space, subspace, basis and dimension
- Check linear dependency of vectors and identify Eigen values and Eigen Vectors Derivative of Matrix, which will form the basis for Principal Component Analysis.

## Course Outline:

### Unit-I

[ 15 Hours ]

Set Theory: Binary Operations, Functions and Relations, Recurrence relations and Generating Functions, Permutations and Combinations: Pigeon Hole Principle, Probability Theory, Propositional Calculus, Tautology & Contradiction, Boolean Algebra.

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

Differentiation: Logarithmic Differentiation, Partial differentiation, Euler's Theorem for Homogenous Functions, Maxima and Minima. Integration: Double Integration, Range of Order of Integration, Find Ideas; Vectors: Dot Product, Cross Product, Divergence and Convergence of a Vector.

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

Matrices & Determinants: Matrix, Def., types, Addition, Subtraction, Multiplication of Matrices, Singular and Non-Singular Matrices, Rank of a Matrix, Solution of Simultaneous Equations, Cayle Hamilton Theorem, Eigen Values & Eigen Vectors.

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

Matrix Algebra and Linear Algebra: Introduction of Groups, Rings and Vector Spaces. Linear Independence and Dependence of Vectors, Linear Combination. Basis and Dimension of Vector space.

**Suggested Readings:**

- Seymour Lipschutz, Marc Lipson, —*Linear Algebra*l, 6<sup>th</sup> Edition, Schaum Series,2018.
- Seymour Lipschutz, Marc Lipson, H. Patil, —*Discrete Mathematics*l, 3<sup>rd</sup> Edition,Schaum Series, 2017.

**References:**

- Elliott Mendelson, Frank Ayres, —*Calculus*l, 6<sup>th</sup> Edition, Schaum Series, 2012.
- Philip N. Klein, —*Coding the Matrix: Linear Algebra Through Applications to Computer Sciencel*, Newtonian Press, 2013.
- Sheldon Axler, —*Linear Algebra Done Right*l, 3<sup>rd</sup> Edition, Springer, 2015.

Course Code : <b>MAI102</b> Core/ Elective : <b>Core</b> No. of Credits : <b>4</b> No. of Hours: <b>60T+30L</b>	Course Title <b>Introduction to Artificial  Intelligence</b>
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### Course Objectives:

- To learn the differences between optimal reasoning vs human like reasoning.
- To understand basic principles of AI towards problem solving, inference perception, knowledge representation and learning.
- To understand the notions of state space representation, heuristic search, time and space complexities.
- To understand the applications of AI namely Intelligent Agents, Game Play, Expert Systems, Machine Learning and NLP.

### Learning Outcomes:

After completion of the course student will be able to:

- Able to demonstrate knowledge of building blocks of AI as presented in terms of Intelligent Agents.
- Attain the capability to represent various real-life problem domains using logic-based techniques and use this to perform inference and planning.

### Course Outline:

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

Introduction: What is AI? Foundations of AI, History of AI, Agents and Environments, the nature of the Environment, Problem Solving Agents, Problem Formulation, Search Strategies.

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

Knowledge and Reasoning: Knowledge-based Agents, Representation, Reasoning and Logic, Propositional logic, First-order logic, Using First-order Logic, Inference in First-order logic, forward and Backward Chaining

**Unit – III****[15 Hours]**

Learning: Learning from Observations, Forms of Learning, Inductive Learning, Learning Decision Trees, Why Learning Works, Learning in Neural and Belief networks.

**Unit -IV****[20 Hours]**

Practical Natural Language Processing: Practical applications, Efficient parsing, scaling up the lexicon, Scaling up the Grammar, Ambiguity, Perception, Image formation, Image processing operations for Early vision, Speech recognition and Speech Synthesis

**Suggested Readings:**

- Stuart Russell, Peter Norvig, —*Artificial Intelligence: A Modern Approach*, 2<sup>nd</sup> Edition, Pearson Education, 2007.
- B. Yagna Narayana, —*Artificial Neural Networks*, PHI, 2005.
- E. Rich and K. Knight, —*Artificial Intelligence*, 3<sup>rd</sup> Edition, TMH, 2017. Dan W. Patterson, —*Artificial Intelligence and Expert Systems*, PHI, 2015.

**References:**

- Giarrantana, Riley, —*Expert Systems: Principles and Programming*, 4<sup>th</sup> Edition, Course Technology Inc, 2004.
- Ivan Bratka, —*PROLOG Programming for Artificial Intelligence*, Pearson Education, 3<sup>rd</sup> Edition, 2012.

Course Code : <b>MAI103</b> Core/ Elective : <b>Core</b> No. of Credits : <b>4</b> No.of Hours: <b>60T+30L</b>	Course Title <b>Advanced Data Structures and Algorithms</b>
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### Course Objectives:

- To provide an overview of Data Structures and Algorithms commonly used in Computer Science.
- To solve complex problems by applying appropriate Data Structures and Algorithms.
- To critically analyze the complexity of various algorithms and to select appropriate design strategy to solve real world problems.

### Learning Outcomes:

After completion of the course student will be able to:

- Identify and apply appropriate data structures to solve problems and improve their efficiency.
- Analyze and understand the complexity of data structures and associated methods.

### Course Outline:

#### **Unit – I [ 15 Hours]**

Linear Data Structures: Introduction - Abstract Data Types (ADT) – Stack – Queue – Circular Queue - Double Ended Queue - Applications of stack – Evaluating Arithmetic Expressions - Other Applications - Applications of Queue - Linked Lists - Singly Linked List - Circularly Linked List - Doubly Linked lists – Applications of linked list.

#### **Unit – II [ 15 Hours]**

Non-Linear Data Structures: Binary Tree – expression trees – Binary tree Traversals – Applications of Trees – Huffman Algorithm - Binary Search Tree - Balanced Trees - AVL Tree - B-Tree - Splay Trees – Heap- Heap operations- - Binomial Heaps - Fibonacci Heaps- Hash set.

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

Graphs: Graphs Terminology, Graph ADT, Representations, Graph Search Methods DFS and BFS, Applications of Graphs-Minimum Cost Spanning tree Using Kruskal's algorithm, Dijkstra's algorithm for Single Source Shortest Path Problem.

**Unit – IV****[ 15 Hours]**

Algorithm Analysis – Asymptotic Notations - Divide and Conquer – Merge Sort – Quick Sort - Binary Search - Greedy Algorithms – Knapsack Problem – Dynamic Programming – Optimal Binary Search Tree - Back Tracking- N Queen's Problem.

**Suggested Readings:**

- Mark Allen Weiss, —*Data Structures and Algorithm Analysis in C++*’, 2<sup>nd</sup> Edition, Pearson, 2004.
- M T Goodrich, Roberto Tamassia, —*Data Structures and Algorithms in Java*, 6<sup>th</sup> Edition, Wiley, 2014.

**References:**

- Sartaj Sahni, —*Data Structures, Algorithms and Applications in Java*, 2<sup>nd</sup> Edition, Universities Press, 2005.
- M T Goodrich, Roberto Tamassia, —*Algorithm Design*, John Wiley, 2002.

Course Code : <b>MAI104</b> Core/ Elective: <b>Core</b> No. of Credits: <b>4</b> No.of. Hours: <b>60T+30L</b>	Course Title <b>Fundamentals of Data Science          through Python Programming</b>
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### Course Objectives:

- To obtain a comprehensive knowledge of various tools and techniques for data transformation and visualization.
- To learn how to describe the data for the data science process
- To learn and utilize Python libraries for data wrangling.

### Learning Outcomes:

After completion of the course student will be able to:

- Apply preprocessing techniques to convert raw data to enable further analysis.
- Apply exploratory data analysis and create visualizations to identify patterns.

### Course Outline:

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

Data Science: Benefits and Uses – Facets of data - Data Science Process: Overview – Defining Research goals – Retrieving data – Data Preparation - Exploratory Data analysis – Build the model– Presenting Findings and Building Applications - Data Mining - Data Warehousing – Basic Statistical Descriptions of Data.

#### **Unit -II [10 Hours]**

Describing Data: Types of Data - Types of Variables -Describing Data with Tables and Graphs –Describing Data with Averages - Describing Variability - Normal Distributions and Standard (z) Scores

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

Describing Relationships: Correlation –Scatter plots –Correlation Coefficient for Quantitative Data –Computational formula for Correlation Coefficient –

Python Libraries for Data Wrangling: Basics of Numpy arrays – Aggregations – Computations on Arrays – Comparisons, Masks, Boolean Logic – Fancy Indexing – Structured Arrays – Data Manipulation with Pandas – Data Indexing and Selection – Operating on data – Missing Data – Combining Datasets – Aggregation and Grouping.

Data Visualization: Importing Matplotlib – Line plots – Scatter plots – Visualizing Errors – Density and Contour plots – Histograms – Legends – Colors – Subplots – Text and Annotation.

**Suggested Readings:**

- David Cielien, Arno D. B. Meysman, and Mohamed Ali, —*Introducing Data Science*, Manning Publications, 2016.
- Robert S. Witte and John S. Witte, —*Statistics*, Eleventh Edition, Wiley Publications, 2017.
- Jake VanderPlas, —*Python Data Science Handbook*, O’Reilly, 2016.

**References:**

- Adi Adhikari and John De Nero, —*Computational and Inferential Thinking: The Foundations of Data Science*, 1<sup>st</sup> edition, 2019.
- Jiawei Han, Micheline Kamber, Jian Pei, —*Data Mining Concepts and Techniques*, 3<sup>rd</sup> Edition, Elsevier, 2006.

Course Code : <b>MAI111</b> Core/ Elective : <b>Elective No.</b> of Credits : 4 No of Hours: <b>60</b>	Course Title <b>Computer Networks</b>
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### Course Objectives:

- To understand the layers of computer network architecture of TCP/IP and OSI model with their applications.
- To understand the performance and characteristics of basic protocols involved in wired/wireless communication process.

### Learning Outcomes:

After completion of the course student will be able to:

- Have the knowledge of various functions of each layer of OSI, TCP/IP model and administrate the network and flow of information

### Course Outline:

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

Introduction: Network-Uses of Networks- Types of Networks- Reference Models: TCP/IP Model- the OSI Model- Comparison of the OSI and TCP/IP reference Model-Architecture of Internet. Physical Layer: Guided Transmission Media- Wireless Transmission Media, Switching.

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

Data Link Layer - Design Issues, Error Detection & Correction, Elementary Data Link Layer Protocols, Sliding Window Protocols-Multiple Access Protocols - ALOHA, CSMA- Collision Free Protocols- Ethernet- Physical Layer, Ethernet Mac Sub layer- Data link layer switching: Use of bridges- Learning Bridges - Spanning Treebridges- Repeaters, Hubs, Bridges, Switches, Routers and Gateways.

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

Network Layer: Network Layer Design issues, store and Forward Packet Switching Connection less and Connection-Oriented Networks-Routing algorithms-optimality Principle, Shortest Path, Flooding, Distance Vector Routing, Count to Infinity Problem, Link State Routing, Path Vector Routing, Hierarchical Routing; Congestion Control algorithms, IP addresses, CIDR, Supernetting, IPv4, Packet Fragmentation, IPv6 Protocol, Transition from IPv4 to IPv6, ARP, RARP.

**Unit-IV****[20 Hours]**

Transport Layer: Services provided to the upper layers elements of Transport Protocol addressing connection establishment, Connection release, Error Control & Flow Control, Crash Recovery. The Internet Transport Protocols: UDP, Introduction to TCP, The TCP Service Model, The TCP Segment Header, The Connection Establishment, The TCP Connection Release, The TCP Sliding Window, The TCP Congestion Control Algorithm. Application Layer- Introduction, providing services, Applications Layer Paradigms: Client Server Model, HTTP, E-mail, WWW, TELNET, DNS; RSA algorithm,

**Suggested Readings:**

- Andrew S Tanenbaum, —*Computer Networks*”, 6<sup>th</sup> Edition, Pearson, 2020.
- Behrouz A. Forouzan, —*Data Communications and Networking*”, 5<sup>th</sup> Edition TMH, 2013.

**References:**

- James F. Kurose, K. W. Ross —*Computer Networking: A Top-Down Approach* Featuring the Internet”, 6<sup>th</sup> Edition, Pearson Education, 2017.

Course Code : <b>MAI111</b> Core/ Elective : <b>Elective</b> No. of Credits : <b>4</b> No.of Hours: <b>60</b>	Course Title <b>Recommender Systems</b>
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### Course Objectives:

- To learn techniques for making recommendations, including non-personalized, content-based, and collaborative filtering.
- To automate a variety of choice-making strategies with the goal of providing affordable, personal, and high-quality recommendations.

### Learning Outcomes:

After completion of the course student will be able to:

- Design recommendation system for a particular application domain.
- Evaluate recommender systems on the basis of metrics such as accuracy, rank accuracy, diversity, product coverage, and serendipity

### Course Outline:

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

Introduction: Overview of Information Retrieval, Retrieval Models, Search and Filtering Techniques: Relevance Feedback, User Profiles, Recommender System Functions, Matrix Operations, Covariance matrices, Understanding Ratings, Applications of Recommendation Systems, Issues with Recommender System.

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

Content-based Filtering: High Level Architecture of Content-Based Systems, Advantages and drawbacks of Content-based Filtering, Item Profiles, Discovering features of Documents, Pre-processing and Feature Extraction, Obtaining item features from tags, Methods for learning User Profiles, Similarity Based Retrieval, Classification algorithms.

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

Collaborative Filtering: User-based recommendation, Item-based recommendation, Model based approaches, Matrix factorization, Attacks on collaborative recommender systems.

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

Hybrid approaches: Opportunities for Hybridization, Monolithic Hybridization Design: Feature combination, Feature augmentation, Parallelized hybridization design: Weighted, Switching, Mixed, Pipelined Hybridization Design: Cascade Meta-level, Limitations of Hybridization Strategies.

**Suggested Readings:**

- Jannach D., Zanker M., Fel Fering A., —*Recommender Systems: An Introduction*l, 1<sup>st</sup> Edition, Cambridge University Press, 2011.
- Charu C. Aggarwal, —*Recommender Systems: The Textbook*l, 1<sup>st</sup> Edition, Springer,(2016).

**References:**

- Ricci F., Rokach L., Shapira D., Kantor B.P., —*Recommender Systems Handbook*l, Springer, 2011.
- Manouselis N., Drachsler H., Verbert K., Duval E., —*Recommender Systems for Learning*l, Springer, 2013.

Course Code : <b>MAI111</b> Core/ Elective : <b>Elective</b> No. of Credits : <b>4</b> No.of Hours: <b>60</b>	Course Title <b>Operating Systems</b>
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**Course Objectives:**

- To make aware of different types of Operating System and their services.
- To learn different process scheduling algorithms and synchronization techniques to achieve better performance of a computer system.
- Understand issues related to Process Synchronization and focus on principles of Deadlock and related problems.

**Learning Outcomes:**

After completion of the course student will be able to:

- Understands the different services provided by Operating System at different level and they learn real life applications of Operating System in every field.
- Understands the use of different process scheduling algorithm and synchronization techniques to avoid deadlock.

**Course Outline:**

**Unit-I [15 Hours]**

Evolution of Operating Systems: Types of operating systems - Different views of the Operating Systems – Principles of Design and Implementation. The Process concept – System programmer’s view of processes – Operating System’s Views of processes – Operating System Services for process Management. Process Scheduling – Schedulers – Scheduling Algorithms.

**Unit-II [15 Hours]**

Structural overview, Concept of process and Process synchronization, Process Management and Scheduling, Hardware requirements: protection, context switching, privileged mode; Threads and their Management; Tools and Constructs for Concurrency, Detection and Prevention of Deadlocks, Mutual Exclusion: Algorithms, Semaphores.

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

Memory Management Paging, virtual memory management, Contiguous allocation – static, dynamic partitioned memory allocation – segmentation. Non-contiguous allocation – paging –Virtual Memory, Dynamic Resource Allocation.

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

File Systems: A Simple file system – General model of a file system – Symbolic file System –Access control verification – Logical file system – Physical file system — Disk scheduling, Design of IO systems, File Management.

**Suggested Readings:**

- Abraham Silberschatz, Peter Baer Galvin, Greg Gagne, —*Operating System Concepts*”, 10<sup>th</sup> edition, Wiley-India, 2018.

**References:**

- Andrew S. Tanenbaum, —*Modern Operating Systems*” 5<sup>th</sup> Edition, PHI, 2022.  
Elmasri, Carrick, Levine, —*Operating Systems: A Spiral Approach*l, TMH Edition

Course Code : <b>MAI111</b> Core/ Elective : <b>Elective</b> No. of Credits : <b>4</b> No. of Credits : <b>60</b>	Course Title <b>Cyber Security</b>
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### Course Objectives:

- To understand the concept of security, types of attack experienced, encryption and authentication for deal with attacks
- To understand the concepts of Intrusion prevention, detection and firewall and attack detection and prevention.

### Learning Outcomes:

After completion of the course student will be able to:

- Have the knowledge of plaintext, cipher text, RSA and other cryptographic algorithm, Key Distribution, Intrusion detection, Attacks and their prevention.

### Course Outline:

#### **Unit-I [15 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 [10 Hours]**

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

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

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

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.

**Suggested Readings:**

- William Stallings, —*Cryptography and Network Security: Principles and Practice*l,6<sup>th</sup> Edition, PHI,2014.
- Michael E. Whitman and Herbert J Mattord, —*Principles of Information Security*l,6<sup>th</sup> Edition, Vikas Publishing House, 2017.

**References:**

- Bill Nelson, Amelia Phillips, F. Einfinger and Christopher Stuart, —*Guide to Computer Forensics and Investigations*l, 4<sup>th</sup> Edition, Thomson Course Technology,2010.
- Matt Bishop, —*Computer Security: Art and Science*l, 1<sup>st</sup> Edition, Addison-WesleyProfessional, 2015.

## SEMESTER-II

Course Code : **MAI201**  
Core/ Elective : **Core**  
No. of Credits : **4**  
No. of Hours : **60T+30L**

Course Title  
**Artificial Neural Networks(ANN)**

### Course Objectives:

- To understand fundamentals of neural networks.
- To understand algorithms and models.
- To design the required and related systems.

### Learning Outcomes:

After completion of the course student will be able to:

- Demonstrate ANN structure and activation Functions.
- Define foundations, learning mechanisms and state-space concepts.
- Identify structure and learning of perceptions, Explain Feed forward, multi-layer feed forward networks and Back propagation algorithms

### Course Outline:

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

Introduction: History of Neural Networks, Structure and Functions of Biological and Artificial Neuron, Neural Network Architectures, Characteristics of ANN, Basic Learning Laws and Methods.

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

SUPERVISED LEARNING: Single Layer Neural Network and architecture, McCulloch-Pitts Neuron Model, Learning Rules, Perceptron Model, Perceptron Convergence Theorem, Delta learning rule, ADALINE, Multi-Layer Neural Network and architecture, MADALINE, Back Propagation learning, Back Propagation Algorithm.

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

UNSUPERVISED LEARNING-1: Outstar Learning, Kohonen Self Organization Networks, Hamming Network And MAXNET, Learning Vector Quantization, Mexican hat.

**Unit-IV****[20 Hours]**

UNSUPERVISED LEARNING-2: Counter Propagation Network -Full Counter Propagation network, Forward Only Counter Propagation Network, Adaptive Resonance Theory (ART) - Architecture, Algorithms.

**Suggested Readings:**

- B.Yegnanarayana, —*Artificial Neural Networks* PHI, 2006.
- S.N.Sivanandam, S.N.Deepa, —*Introduction to Neural Networks using MATLAB6.0*, 2<sup>nd</sup> Reprint, TATA MCGraw- Hill, 2006.
- J.M. Zurada , —*Introduction to Artificial Neural Systems* -Jaico publishing,1994.
- S.Rajasekaran and G.A.Vijayalakshmi Pai, —*Neural Networks, Fuzzy Logic and Genetic Algorithms*, PHI, 2013.

**References:**

- James A Freeman and Davis Skapura, —*Neural Networks Algorithm, Applications and Programming Techniques*, Pearson Education, 2002.
- Simon Hakens, —*Neural Networks*, 3<sup>rd</sup> Edition, Pearson Education, 2009.

Course Code : <b>MAI202</b> Core/ Elective : <b>Core</b> No. of Credits : <b>4</b> No.of Hours: <b>60T+30L</b>	Course Title <b>Big Data Analytics</b>
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### Course Objectives:

- Understand big data for business intelligence and learn business case studies for big data analytics.
- Understand no sql big data management.
- Perform map-reduce analytics using Hadoop and related tools.

### Learning Outcomes:

After completion of the course student will be able to:

- Describe big data and use cases from selected business domains.
- Explain NoSQL big data management.
- Perform map-reduce analytics using Hadoop and use Hadoop related tools such as HBase, Cassandra, Pig, and Hive for big data analytics.

### Course Outline:

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

Introduction-What is big data, why big data, convergence of key trends, Unstructured data, industry examples of big data, web analytics, big data and Marketing, fraud and Big Data, Risk and Big data, credit risk management, Big Data and algorithmic trading, big data and healthcare, big data in Medicine, Advertising and big data, big data technologies, introduction to Hadoop, Open-source Technologies, Cloud and Big Data, mobile business Intelligence, Crowd Sourcing Analytics, Inter and Trans firewall Analytics.

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

Introduction to NoSQL, aggregate data models, aggregates, key-value and Document data models, relationships, graph databases, schema less databases, Materialized views, distribution models, Sharding, master-slave replication, Peer topeer replication, Sharding and replication, consistency, relaxing Consistency, version stamps, map-reduce, partitioning and combining, Composing map-reduce calculations.

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

Data format, analyzing data with Hadoop, scaling out, Hadoop streaming, Hadoop pipes, design of Hadoop distributed file system (HDFS), HDFS concepts, Java interface, data flow, Hadoop I/O, data integrity, compression, serialization, Avro, file-based data structures.

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

Mapreduce Workflows, Unit Tests with MRUnit, Test Data and Local tests, Anatomy of Mapreduce job run, classic Mapreduce, YARN, Failures in classic Mapreduce and YARN, Job scheduling, Shuffle and Sort, Task Execution, Mapreduce types, Input formats, Output formats.

**Suggested Readings:**

- Michael Minelli, Michelle Chambers, and Ambiga Dhiraj, —*Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses*l, 1<sup>st</sup> Edition, Wiley, 2013.
- P. J. Sadalage, M. Fowler, —*NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence*l, Addison-Wesley Professional, 2012.

**References:**

- Tom White, —*Hadoop: The Definitive Guide*l, 3<sup>rd</sup> Edition, O'Reilly, 2012.

Course Code : <b>MAI203</b> Core/ Elective : <b>Core</b> No. of Credits : <b>4</b> No.of Hours: <b>60</b>	Course Title <b>Natural Language Processing</b>
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### Course Objectives:

- To acquire basic understanding of linguistic concepts and natural language complexity, variability.
- To acquire basic understanding of machine learning techniques as applied to language.
- To implement N-grams Models.

### Learning Outcomes:

After completion of the course student will be able to:

- Able to understand Natural Language Processing.
- Applying Hidden Markov model and Speech Recognition.
- Able to implement probabilistic and language parsing.

### Course Outline:

#### **Unit-I [20 Hours]**

Introduction: Natural Language Processing, hands-on demonstrations. Ambiguity and uncertainty in language. The Turing test. Regular Expressions, Chomsky hierarchy, regular languages, and their limitations. Finite-state Automata, Practical regular expressions for finding and counting language Phenomena, exploring a large corpus with regex tools. An introduction to Programming in Python- Variables, numbers, strings, arrays, dictionaries, Conditionals, iteration. The NLTK (Natural Language Toolkit) String Edit Distance and Alignment Key algorithmic tool: dynamic programming, a simple Example, use in optimal alignment of sequences. String edit operations, edit Distance, and examples of use in spelling correction, and machine translation.

#### **Unit-II [10 Hours]**

Context Free Grammars Constituency, CFG definition, use and limitations.

Chomsky Normal Form, Top-down parsing, bottom-up parsing, Non-Probabilistic Parsing Efficient CFG parsing with CYK, another dynamic Programming algorithms. Early parser. Designing a little grammar, and parsing with it on some test data- Examples of applications in natural language. Information Theory The —Shannon game!- motivated by language! Entropy, Cross entropy, Information gain. Its application to some language phenomena.

### **Unit-III**

**[15 Hours]**

Language modelling and Naive Bayes Probabilistic language modeling and its Applications. Markov models. N-grams. Estimating the probability of a word, and smoothing. Generative models of language. Part of Speech Tagging and Hidden Markov Models, Viterbi Algorithm for Finding Most Likely HMM Path Dynamic programming with Hidden Markov Models, and its use for part-of-speech tagging, Chinese word segmentation, prosody, information Extraction, etc.

### **Unit-IV**

**[15 Hours]**

Probabilistic Context Free Grammars, Weighted context free grammars, Weighted CYK. Pruning and beam search, Parsing with PCFGs, A tree bank, The probabilistic version of CYK, how do humans parse, Experiments with Eye-tracking, Modern parsers, Maximum Entropy Classifiers, The maximum Entropy principle and its relation to maximum likelihood, Maximum entropy Classifiers and their application to document classification, sentence Segmentation, and other language tasks. Maximum Entropy Markov Models & Conditional Random Fields Part-of- speech tagging.

### **Suggested Readings:**

- Jurafsky and Martin, —*Speech and Language Processing*l, 2<sup>nd</sup> Edition, PrenticeHall, 2008.
- Manning and Schutze, —*Statistical Natural Language Processing*l, MIT Press,2001.
- James Allen, —*Natural Language Understanding*l, The Benajmins/CummingsPublishing Company,1998.

### **References:**

- Cover, T. M. and J. A. Thomas, —*Elements of Information Theory*l, 2<sup>nd</sup> Edition,Wiley, 2006.
- Charniak, E., —*Statistical Language Learning*l, The MIT Press,1994.
- Jelinek, F, —*Statistical Methods for Speech Recognition*l, 4<sup>th</sup> Edition, The MITPress,1998.

Course Code : <b>MAI204</b> Core/ Elective : <b>Core</b> No. of Credits : <b>4</b> No. of Hours : <b>60T+30L</b>	Course Title <b>Machine Learning</b>
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### Course Objectives:

- To learn the concept of how to learn patterns and concepts from data without being explicitly programmed in various IoT nodes.
- To design and analyse various machine learning algorithms and techniques with a modern outlook focusing on recent advances.
- Explore supervised and unsupervised learning paradigms of machine learning.
- To explore Deep learning technique and various feature extraction strategies.

### Learning Outcomes:

After completion of the course student will be able to:

- Extract features that can be used for a particular machine learning approach in various IoT applications.
- Compare and contrast pros and cons of various machine learning techniques and to get an insight of when to apply a particular machine learning approach.
- Mathematically analyse various machine learning approaches and paradigms.

### Course Outline:

#### **Unit-I [20 Hours]**

Supervised Learning (Regression/Classification): Basic methods: Distance-Based methods, Nearest-Neighbours, Decision Trees, Naive Bayes, Linear Models: Linear Regression, Logistic Regression, Generalized Linear Models, Support Vector Machines, Nonlinearity and Kernel Methods, Beyond Binary Classification: Multi- class/Structured Outputs, Ranking

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

Unsupervised Learning: Clustering: K-means/Kernel K-means, Dimensionality Reduction: PCA and kernel PCA, Matrix Factorization and Matrix Completion, Generative Models (mixture models and latent factor models)

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

Evaluating Machine Learning algorithms and Model Selection, Introduction to Statistical Learning Theory, Ensemble Methods (Boosting, Bagging, Random Forests)

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

Sparse Modelling and Estimation, Modelling Sequence/Time-Series Data, Deep Learning and Feature Representation Learning

**Suggested Readings:**

- Kevin Murphy, —*Machine Learning: A Probabilistic Perspective*, MIT Press, 2012.
- Trevor Hastie, Robert Tibshirani, Jerome Friedman, —*The Elements of Statistical Learning*, Springer, 2009.

**References:**

- Christopher Bishop, —*Pattern Recognition and Machine Learning*, Springer, 2007.

Course Code : <b>MAI211</b> Core/ Elective : <b>Elective</b> No. of Credits : <b>4</b> No. of Hours : <b>60</b>	Course Title <b>Blockchain and Cryptocurrency          Fundamentals</b>
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### Course Objectives:

- To understand Blockchain and its main application cryptocurrency.
- To explore various aspects of Blockchain technology like application in various domains.
- To provide the skills and knowledge necessary to implement private, public block chain and smart contract.

### Learning Outcomes:

After completion of this course, student will be able to.

- Understand and explore the working of Blockchain technology.
- Analyze the working of smart contracts.
- Understand how to store and use Bitcoins.

### Course Outline:

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

Blockchain definition: Bitcoin & Blockchain, Blockchain Structure, Basic Operations. Ethereum Blockchain: Smart Contracts, Ethereum Structure, Ethereum Operations.

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

Integrity of transactions and blocks in blockchain: Algorithms & Techniques: Public-Key Cryptography, Hashing, Transaction Integrity.

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

Introduction to Crypto and Cryptocurrencies: Cryptographic Hash Functions, Hash Pointers and Data Structures, Digital Signatures, Public Keys as Identities.

Mechanics of Bitcoin: components of the Bitcoin protocol, Bitcoin Transactions, Bitcoin Scripts, Applications of Bitcoin Scripts, Bitcoin Blocks, The Bitcoin Network. How to Store and Use Bitcoins/

**Suggested Readings:**

- Andreas Antonopoulos (2014), —*Mastering Bitcoin: Unlocking Digital Cryptocurrencies*l, O'Reilly, 1<sup>st</sup> Edition, 2014.

**References:**

- Melanie Swa, —*Blockchain*l, 1<sup>st</sup> Edition, O'Reilly, 2015. Bob Dill, David Smits, —*Zero to Blockchain - An IBM Redbooks course*l.

Course Code : <b>MAI211</b> Core/ Elective : <b>Elective</b> No. of Credits : <b>4</b> No. of Hours: <b>60</b>	Course Title <b>Computer Architecture</b>
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- To understand the design of various functional units and components of computers.
- To understand the function of each element of a memory hierarchy.
- To understand digital logic design and their use in combinational and sequential logic circuit design.

### Learning Outcomes:

After completion of the course student will be able to:

- Understand and apply computer architecture concepts related to design of modern processors.

### Course Outline:

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

Basic Structure of a Computer System: Functional Units — Basic Operational Concepts — Performance — Instructions: Language of the Computer — Operations, Operands — Instruction representation — Logical operations — decision making — MIPS Addressing.

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

Arithmetic for Computers: Addition and Subtraction — Multiplication — Division — Floating Point Representation — Floating Point Operations — Sub word Parallelism

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

Processor and Control Unit: A Basic MIPS implementation — Building a Datapath — Control Implementation Scheme — Pipelining — Pipelined Datapath and Control — Handling Data Hazards & Control Hazards — Exceptions.

Parallel processing challenges — Flynn's classification — SISD, MIMD, SIMD, SPMD, and Vector Architectures — Hardware multithreading — multi-core Processors and other Shared Memory Multiprocessors - MEMORY & I/O SYSTEMS Memory Hierarchy — memory technologies — cache memory — measuring and improving cache performance — virtual memory, TLB's — Accessing I/O Devices — Interrupts — Direct Memory Access — Bus structure — Bus operation — Arbitration — Interface circuits — USB.

**Suggested Readings:**

- M. Morris Mano, —*Computer System Architecture*, Pearson, 3<sup>rd</sup> edition, 2019 .

**References:**

- William Stallings, —*Computer Organization and Architecture*, Pearson, 11<sup>th</sup> edition, 2022

Course Code : <b>MAI211</b> Core/ Elective : <b>Elective</b> No. of Credits : <b>4</b> No.of Hours: <b>60</b>	Course Title <b>Data Preparation and Analysis</b>
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### Course Objective:

- To prepare the data for analysis and develop meaningful data Visualization using latest technologies.

### Learning Outcomes:

After completion of the course student will be able to:

- Extract the data for performing the Analysis.

### Course Outline

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

Data Gathering and Preparation: Data formats, parsing and transformation, Scalability and real-time issues.

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

Data Cleaning: Consistency checking, Heterogeneous and missing data, Data Transformation and segmentation.

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

Exploratory Analysis: Descriptive and Comparative Statistics, Clustering and Association, Hypothesis Generation.

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

Visualization: Designing visualizations, Time series, Geolocated data, Correlations and Connections, Hierarchies and Networks, Interactivity. Visualizations using R or Python.

### Suggested Readings:

- Glenn J. Myatt, —Making sense of Data: A practical Guide to Exploratory Data Analysis and Data Mining, 2<sup>nd</sup> Edition, John Wiley Publishers, 2014.

### References:

- Data Preparation for Data Mining (The Morgan Kaufmann Series in Data Management Systems, by Dorian Pyle)

Course Code : <b>MAI211</b> Core/ Elective : <b>Elective</b> No. of Credits : <b>4</b> No. of Hours: <b>60</b>	Course Title <b>Digital Forensics</b>
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### Course Objectives:

- To provide an in-depth study of the rapidly changing and fascinating field of computer forensics.
- To combine both the technical expertise and the knowledge required to investigate, detect and prevent digital crimes.
- To provide Knowledge on digital forensics legislations, digital crime, forensics processes and procedures, data acquisition and validation, e-discovery tools.
- To understand E-evidence collection and preservation, investigating operating systems and file systems, network forensics, art of steganography and mobile device forensics.

### Learning Outcomes:

After completion of the course student will be able to:

- Understand relevant legislation and codes of ethics., Computer forensics and digital detective and various processes, policies and procedures.
- Understand E-discovery, guidelines and standards, E-evidence, tools and environment, Email and web forensics and network forensics.

### Course Outline:

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

Computer forensics fundamentals, Benefits of forensics, computer crimes, Computer forensics evidence and courts, legal concerns and private issues.

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

Understanding Computing Investigations - Procedure for corporate High- Tech investigations, understanding data recovery work station and software, conducting and investigations.

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

Data acquisition - Understanding storage formats and digital evidence, determining the best acquisition method, acquisition tools, validating data Acquisitions, performing RAID data acquisitions, remote network acquisition Tools, other forensics acquisition tools. Processing crimes and incident scenes, securing a computer incident or crime, seizing digital evidence at scene, Storing digital evidence, obtaining Digital Hash, Reviewing case.

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

Current computer forensics tools - software, hardware tools, validating and testing forensic software, addressing data-hiding techniques, performing Remote acquisitions, E-Mail investigations.

**Suggested Readings:**

- Bill Nelson, Amelia Phillips, F.Enfinger and Christopher Stuart, —*Guide to Computer Forensics and Investigations*l, 4<sup>th</sup> Edition., Thomson Course Technology, 2010.
- Anthony T. S. Ho and Shujun Li, —*Handbook of Digital Forensics of MultimediaData and Devices*l, IEEE Press, John Wiley & Sons, 2015.

**References:**

- Warren G. Kruse II and Jay G. Heiser, —*Computer Forensics: Incident ResponseEssentials*l, Addison Wesley, 2002.
- Bill Nelson, Amelia Phillips, F.Enfinger and Christopher Stuart, —*Guide to Computer Forensics and Investigations*l, 2<sup>nd</sup> Edition. Thomson Course Technology, 2006.
- John R. Vacca, —*Computer Forensics: Computer Crime Scene Investigation*l, 2<sup>nd</sup>Edition, Charles River Media, 2005.

Course Code: <b>MAI213</b> Core/Elective: Compulsory No. of Credits: <b>4</b> No. of Hours: <b>30T + 60L</b>	Course Title <b>Introduction to R Programming</b>
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**Course Objectives:**

- This course introduces R, which is a popular statistical programming language. The course covers data reading and its manipulation using R, which is widely used for data analysis internationally.
- The course also covers different control structures and design of user-defined functions. Loading, installing, and building packages are covered.

**Learning Outcomes:** After completion of the course students will be able to do:

- Develop an R script and execute it
- Install, load and deploy the required packages, and build new packages for sharing and reusability
- Extract data from different sources using API and use it for data analysis
- Visualize and summarize the data
- Design application with database connectivity for data analysis

**Course Outline:**

**Unit I: [15 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: [15 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, centring, scaling and normalizing the data values, converting types of Values, using string in-built functions.

**Unit III: [15 Hours]**

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

**Unit IV: [15 Hours]**

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

**Suggested Readings:**

- Cotton, R., Learning R: a step-by-step function guide to data analysis. 1st edition. O'Reilly Media Inc

**References:**

- Bharti Motwani, Data analytics with R, (1st Edition), Wiley, 2019  
Michael J Crawley, The R Book, (2nd Edition), Wiley, 2018
- 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 : <b>MAI301</b> Core/ Elective : <b>Core</b> No. of Credits : <b>4</b> No.of Hours: <b>60T+30L</b>	Course Title <b>Introduction to DeepLearning</b>
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### Course Objectives:

- To understand the theoretical foundations, algorithms and methodologies of Neural Network.
- To design and develop an application using specific deep learning models.
- To provide the practical knowledge in handling and analysing real world applications.

### Learning Outcomes:

After completion of the course student will be able to:

- Recognize the characteristics of deep learning models that are useful to solve real-world problems.
- Identify and apply appropriate deep learning algorithms for analyzing the data for variety of problems.
- Implement different deep learning algorithms.

### Course Outline:

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

Introduction to Deep Learning: Definition, Applications, Neural Networks, Machine Learning vs Deep Learning, Deep Learning Libraries (Tensorflow, Keras, PyTorch), Types (Supervised Learning, Unsupervised Learning, Reinforcement Learning) and their Comparison. Datasets: Numerical Data, Categorical Data, Data Quality, Data Remediation, Data Preprocessing (Dimensionality Reduction, Feature Transformation, Feature Subset Selection).

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

Neural Networks: Basics, Types, Intuitions, Neurons, Kernels, Biases, Weights, Initialization, Gradient Descent, Heuristics, Training (Holdout Method, K-Fold Cross-Validation Method, Bootstrap Sampling, Lazy vs Eager Learner), Evaluation (Regression, Classification and Clustering), Perceptrons, Derivatives, Computation graph, Vectorization, Broadcasting, Propagation (Forward and Back), Parameters vs Hyperparameters.

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

Deep Feedforward Network: Feed-forward Networks, Gradient-based Learning, Hidden Units, Architecture Design, Computational Graphs, Back-Propagation, Regularization, Parameter Penalties, Data Augmentation, Multi-task Learning, Bagging, Dropout and Adversarial Training and Optimization.

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

Convolution Networks: Convolution Operation, Pooling, Basic Convolution Function, Convolution Algorithm, Unsupervised Features and Neuroscientific for convolution Network.

Sequence Modelling: Recurrent Neural Networks (RNNs), Bidirectional RNNs, Encoder Decoder Sequence-to-Sequence Architectures, Deep Recurrent Network, Recursive Neural Networks and Echo State networks.

**Suggested Readings:**

- Goodfellow L., Bengio Y. and Courville A., —*Deep Learning*], MIT Press, 2016.
- Patterson J. and Gibson A., —*Deep Learning: A Practitioner's Approach*], O'Reilly 1<sup>st</sup> Edition, 2017.
- Haykin S., —*Neural Network and Machine Learning*], Prentice Hall Pearson 3<sup>rd</sup> Edition, 2009.

**References:**

- Geron A., —*Hands-on Machine Learning with Sci-kit and TensorFlow*], O'Reilly Media, 2017.

Course Code : <b>MAI302</b> Core/ Elective : <b>Core</b> No. of Credits : <b>4</b> No. of Hours: <b>60T+30L</b>	Course Title <b>Scalable Systems for DataScience</b>
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### Course Objectives:

- To introduce systems and approaches for large scale data science problems.
- To understand handling large data sets.
- To learn how large-scale machine learning and distributed machine learning approaches work

### Learning Outcomes:

After completion of the course student will be able to:

- Understand handling large data sets
- Learn approaches for solving large scale data science problems link analysis and finding similar items
- Understand real-world problems which need scalable systems for large scale data science such as web advertising and recommendation systems
- Learn the basic principles of large-scale machine learning and distributed machine learning
- Implement models using programming languages to solve large scale data science projects

### Course Outline:

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

Overview of Data Mining and map-reduce, Hash Functions - Indexes, Shingling LSH, Mining Data Streams - Finding similar items near-neighbor search, shingling of documents, Similarity-Preserving Summaries of Sets, Locality-Sensitive Hashing for Documents, Distance Measures, Link-analysis Page Rank, Link spam, Hubs and authorities.

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

Frequent Item sets Market based model, A-Priori Algorithm, Handling larger Data sets in memory, Limited-pass algorithms.

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

Clustering Hierarchical clustering, k-means, CURE, Clustering in Non-Euclidean Spaces, Clustering for Streams and Parallelism.

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

Advertising on the web Matching problem, ad-words problem, Recommendation systems - Content-Based Recommendations, Collaborative Filtering, Dimensionality Reduction.

**Suggested Readings:**

- Jure Leskovec, Anand Rajaraman, Jerrey David Ullman, —*Mining of Massive Datasets*, Cambridge University Press, 2014.
- Jimmy Lin and Chris Dyer, —*Data-Intensive Text Processing with MapReduce*, 1<sup>st</sup> Edition, Morgan and Claypool Publishers, 2010.

**References:**

- Sandy Ryza, Uri Laserson, Sean Owen, Josh Wills, —*Advanced Analytics with Spark: Patterns for Learning from Data at Scale*, Oreilly, 2015.
- Ankit Jain, —*Mastering Apache Storm: Processing big data streaming in real time*, Packt Publishing, 2017.

Course Code : <b>MAI303</b> Core/ Elective : <b>Core</b> No. of Credits : <b>4</b> No. of Hours : <b>60</b>	Course Title <b>Data Mining &amp; Data Warehousing</b>
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### Course Objectives

- Identify the scope and necessity of Data Mining & warehousing for the society
- Describe various Data models and design methodologies of Data Warehousing destined to solve the root problems
- To understand various tools of Data mining and their techniques to solve the real time problems.

### Learning Outcomes:

After completion of the course student will be able to:

- analyze the data, identify the problems, and choose the relevant algorithms to apply.
- Understand To assess the Pros and cons of various algorithms and analyze their behavior on real datasets.
- Understand the consequence of applying various Data Mining tools.
- Create and understand about the way the Data mining tools are used and the domain of application.

### Course Outline:

#### **Unit – I [15 Hours]**

Introduction – Steps in KDD – System Architecture – Types of Data- Data Mining functionalities- Classification of Data mining systems –Integration of data mining system with a data warehouse – Issues- Data Processing –Data Mining Application.

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

Data warehousing components- Building a data warehouse- Multi Dimensional Data Model –OLAP Operation in the Multi-Dimensional Model

– Three Tier Data Warehouse Architecture – Schemas for Multidimensional Data Model – Online Analytical Processing(OLAP) –OLAP vs OLTP integrated OLAM and OLAP Architecture.

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

Mining frequent patterns – Associations and correlations – Mining methods – Finding Frequent itemset using Candidate Generation – Generating Association rules from Frequent Item sets – Mining Frequent itemset without candidate Generation- Mining various kinds of association Rules – Mining Multi level Association rule- Mining Multi Dimensional Association Rule- Mining Correlation analysis- Constraint based association mining.

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

Mining Classification and prediction – Issues regarding Classification and Prediction – Classification by Decision Tree Induction –Bayesian classification- Naïve Bayesian Classification - Linear Regression frequent patterns – Associations and correlations-Cluster analysis – Types of data in Cluster Analysis- Social Impacts of Data Mining-Recent trends in Data Mining.

**Suggested Readings:**

- Sandy Ryza, Uri Laserson, Sean Owen, Josh Wills, —*Advanced Analytics withSpark: Patterns for Learning from Data at Scale*, O'Reilly, 2015.

**References:**

- Ankit Jain, —*Mastering Apache Storm: Processing big data streaming in real time*,Packt Publishing, 2017.

Course Code : <b>MAI311</b> Core/ Elective :Elective No. of Credits : <b>4</b> No. of Hours : <b>60</b>	Course Title <b>Research Methodology and IPR</b>
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### Course Objectives

- To understand the research problem and to know the literature studies, plagiarism and ethics.
- To get the knowledge about technical writing.
- To analyze the nature of intellectual property rights and new developments.

### Learning Outcomes:

After completion of the course student will be able to:

- Understand research problem formulation, Analyze research related information and follow research ethics.
- Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasize the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.

### Course Outline:

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

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

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

Effective literature studies approach, analysis Plagiarism and Research ethics.

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

Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

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

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, Development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT. Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

**Suggested Readings:**

- Stuart Melville and Wayne Goddard, —*Research methodology: An Introduction for Science and Engineering Students*l, Tata Mc Graw Hill India, 2013.
- Ranjit Kumar, —*Research Methodology: A Step by Step Guide for beginners*l, 2/e, Prentice Hall of India, 2013.
- Halbert, —*Resisting Intellectual Property*l, Taylor and Francis Limited, 2007.

**References:**

- Robert P. Merges, Peter S. Menell (2016), Mark A. Lemley, —*Intellectual Property in New Technological Age*l, 2016.
- T. Ramappa, —*Intellectual Property Rights Under WTO*l, S. Chand Publishers, 2008.

Course Code : <b>MAI311</b> Core/ Elective : <b>Elective</b> No. of Credits : <b>4</b> No. of Hours : <b>60</b>	Course Title <b>HealthCare Data Analytics</b>
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### Course Objectives:

- To explore the various forms of electronic health care information.
- To learn the techniques adopted to analyze health care data.
- To understand the predictive models for clinical data.

### Learning Outcomes:

After completion of the course student will be able to:

- Analyze health care data using appropriate analytical techniques.
- Apply analytics for decision making in healthcare services.
- Apply data mining to integrate health data from multiple sources and develop efficient clinical decision support systems.

### Course Outline

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

Introduction: Introduction to Healthcare Data Analytics - Electronic Health Records- Components of EHR - Coding Systems- Benefits of EHR - Barrier to Adopting HER Challenges - Phenotyping Algorithms.

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

Analysis: Biomedical Image Analysis - Mining of Sensor Data in Healthcare - Biomedical Signal Analysis - Genomic Data Analysis for Personalized Medicine.

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

Analytics: Natural Language Processing and Data Mining for Clinical Text - Mining the Biomedical - Social Media Analytics for Healthcare.

Advanced Data Analytics: Advanced Data Analytics for Healthcare - Review of Clinical Prediction Models - Temporal Data Mining for Healthcare Data - Visual Analytics for Healthcare - Predictive Models for Integrating Clinical and Genomic Data - Information Retrieval for Healthcare - Privacy-Preserving Data Publishing Methods in Healthcare. Applications and Practical Systems for Healthcare.

**Suggested Readings:**

- Chandan K. Reddy and Charu C Aggarwal, —*Healthcare data analytics*l, 1<sup>st</sup> Edition, Taylor & Francis, 2015

**References:**

- Hui Yang and Eva K. Lee, —*Healthcare Analytics: From Data to Knowledge to Healthcare Improvement*l, 1<sup>st</sup> Edition, Wiley, 2016.

Course Code : <b>MAI311</b> Core/ Elective : <b>Elective</b> No. of Credits : <b>4</b> No. of Hours: <b>60</b>	Course Title <b>Digital Image Processing</b>
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**Course Objectives:**

- To describe and explain basic principles of digital image processing.
- To design and implement algorithms that perform basic image processing (e.g. noise removal and image enhancement).
- To design and implement algorithms for advanced image analysis (e.g. image compression, image segmentation).

**Learning Outcomes:**

After completion of the course student will be able to:

- Demonstrate the components of image processing, Explain various filtration techniques.
- Apply image compression techniques.
- Discuss the concepts of wavelet transforms and analyze the concept of morphological image processing.

**Course Outline:**

**Unit-I [15 Hours]**

Digital Image Processing: Definition, Examples of Fields that use Digital Image Processing, Fundamental Steps in Digital Image Processing, Components of an Image Processing System.

Digital Image Fundamentals: Image Sensing, and Acquisition, Image Sampling and Quantization, Basic Relationship between Pixels, Distance Measures, Linear and Non-linear Operations.

**Unit-II [15 Hours]**

Intensity Transformations and Spatial Filtering: Basic Gray Level Transformations, Histogram Processing, Enhancements using Arithmetic/ Logic Operations, Basics of Spatial Filtering, Smoothing, Spatial Filters, Sharpening Spatial Filters, Combining Spatial Enhancement Methods.

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

Filtering in the Frequency Domain: Fourier Series, Fourier transform of Functions of One Continuous Variable, Discrete Fourier Transform (DFT) of one variable and Its Inverse, 2-D Discrete Fourier Transform and Its inverse, Properties of 2-D DFT, Image Smoothing using Frequency Domain Filters, Image Sharpening Using Frequency Domain Filters, Laplacian in Frequency Domain, Homomorphic Filtering, Band reject and Bandpass Filters, Notch Filters, The Fast Fourier Transform in 1-D .

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

Image Restoration: Noise Models, Restoration in the Presence of Noise Only- Spatial Filtering, Periodic Noise Reduction by Frequency Domain Filtering, Linear, Position-Invariant Degradations, Estimating the Degradation Function, Inverse Filtering, Minimum Mean Square Error (Wiener) Filtering, Constrained Least Squares Filtering, Geometric Mean Filter, Geometric Transformations. Colour Image Processing: Colour Models, Pseudo colour Image Processing, Basics of Full Colour Image Processing. Colour Transformations, Smoothing and Sharpening. Colour Segmentation.

**Suggested Readings:**

- R. C. Gonzalez, R. E. Woods, —*Digital Image Processing*l, 4<sup>th</sup> Edition, PHI, 2018.

**References:**

- A.K. Jain, —*Fundamentals of Digital Image Processing*l, PHI, 1988.

Course Code: **MAI311**  
Core/ Elective: **Elective**  
No. of Credits: **4**  
No. of Hours: **60**

Course Title  
**Theory of Computation**

**Course Objectives:**

- To give an overview of the theoretical foundations of computer science from the perspective of formal languages.
- To illustrate finite state machines to solve problems in computing.
- To familiarize Regular grammars, context free grammar.

**Learning Outcomes:**

After completion of the course student will be able to:

- Use basic concepts of formal languages of finite automata techniques.
- Design Finite Automata's for different Regular Expressions and Languages.
- Construct context free grammar for various languages.
- Solve various problems of applying normal form techniques, push down automata and Turing Machines.

**Course Outline:**

**Unit-I [15 Hours]**

Finite Automata: Deterministic finite Automata, Non deterministic finite Automata, Equivalence of NFA and DFA, Finite Automata with Epsilon-moves. 2-Way Finite Automata, Crossing sequences, Moore and Mealy Machine, Application of finite automata i.e. Lexical Analyzers, text editors.

**Unit-II [15 Hours]**

Regular Expression and Languages: Regular expression, Equivalence of finite Automata and Regular expressions, Conversion between regular expressions and finite automata: Application of Regular Expressions: Regular Expression in UNIX, Lexical analysis, Finding pattern in text.

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

Regular Languages and Regular sets: Pumping lemma for regular sets, Applications of pumping lemma. Minimization of finite Automata.

Context free Grammar and Languages: Context Free Grammars: Derivation Trees, Leftmost and rightmost derivations, Ambiguity. Normal forms for context free grammars.

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

Pushdown Automata: Deterministic Push Down Automata; Equivalence of Push Down Automata and Context free grammar. Turning Machine (TM).

**Suggested Readings:**

- J.E. Hopcroft, R. Motwani and J.D. Ullamn, —*Introduction to Automata Theory, Languages and Computation*l, 3<sup>rd</sup> Edition, Pearson Education Asia, 2007.
- Daniel I.A. Cohen, —*Introduction to Computer Theory*l, 2<sup>nd</sup> Edition, Wiley, 1996.

**References:**

- A.M. Moret, —*The Theory of Computation*l, 2<sup>nd</sup> Edition, Pearson Education Asia.
- H.R. Lewis and C.H. Papa dimitriou, —*Elements of the theory of Computation*l, 2<sup>nd</sup> Edition, Pearson Education Asia, 1998.

Course Code : <b>MAI313</b> Core/ Elective : <b>CCC</b> No. of Credits : <b>4</b> No.of Hours: <b>60</b>	Course Title <b>Building Mathematical Ability and Financial Literacy</b>
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### Course Objectives:

- To familiarize with fundamental mathematical concepts including set theory, permutations and combinations.
- To understand the logical reasoning for efficient problem-solving, analysis of propositions and conditional statements

### Learning Outcomes:

After completion of the course student should be able to:

- Analyzing financial instruments like stocks, shares, loans, insurance and income tax liabilities.
- Ability to compute measures of central tendency, dispersion, correlation and regression.

### Course Outline

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

Mathematics: Basic set theory - Permutations and combinations - Mathematical Logic: Introduction - proposition and truth values - logical connectives, Tautology and contradiction - logical equivalences - converse, inverse and Contra positive of a conditional statement.

#### **Unit-II [13 Hours]**

Commercial Mathematics: Cost price - selling price - profit and loss - Simple Interest - compound interest (reducing balance and flat rate of interest) - stocks and shares. Housing loan - insurance - simple equated monthly installments (EMI) calculation - Income tax: simple calculation of individual tax liability.

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

Statistics: Sources of data: primary and secondary - types of data, graphical Representation of data - Population, sample, variable - parameter. Statistic, Simple random sampling - use of random number tables - Measures of central Tendency: arithmetic mean, median and mode; measures of dispersion: range - Variance - standard deviation and coefficient of variation - Bivariate data: Scatter plot, Pearson's correlation coefficient, simple line regression.

**Unit-IV****[17 Hours]**

Financial Literacy: Money Market: Money and its functions –The Concepts and definitions of money-Measurements of money supply – Advantages of money. Indian Financial System and Institutions: Banking and non-Banking financial institutions, Scheduled and Non-scheduled Banks- Commercial Banks, recent innovations in Banking, Merging of Indian Banks, CIBIL, role and functions of Reserve Bank of India. Capital Markets: primary market, secondary market, role and functions of SEBI.

***Suggested Readings:***

- Medhi, J. (2006). *Statistical Methods: An Introductory Text*. Wiley Eastern Ltd.
- Building Mathematical Ability, Foundation Course, University of Delhi, S. Chand Publications.
- Lewis, M.K. and p. d. (2000) *Monetary Economics*. Oxford University press, New york,.

***References:***

- C Rangarajan: *Indian Economy : Essays in Money and Finance*, 1999
- Brahmaiah, B. and P. Subbarao , *Financial Futures and Options*, Himalaya Publishing House .

## SEMESTER-IV

Course Code : <b>MAI401</b> Core/Elective: <b>Core (Compulsory)</b> No. of Credits : <b>16</b>	Course Title <b>Project Work/Dissertation</b>
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### **Objective:**

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 Artificial Intelligence and Data science for solving a wide variety of real-world problems. 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.