# V. E. S. Institute of Technology


# Department of Artificial Intelligence and Data Science

(Semester – III to VIII)
Second Year, Third Year and Final Year

# Autonomy Syllabus

**Effective A.Y. 2023-24**

**Program Structure for Second Year Artificial Intelligence and Data Science Engineering**
**Scheme for Autonomous Program**
**(With Effect from 2023-2024)**
**Semester III**

| Course Code | Course Name | Teaching Scheme (Contact Hours) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Pract. | Tut. | Theory | Pract. | Tut. | Total |
| ADC301 | Engineering Mathematics III | 4 | -- | 1* | 3 | -- | 1 | 4 |
| ADC302 | Discrete Structures and Graph Theory | 3 | -- | -- | 3 | -- | -- | 3 |
| ADC303 | Data Structure | 3 | -- | -- | 3 | -- | -- | 3 |
| ADC304 | Digital Logic & Computer Architecture | 3 | -- | -- | 3 | -- | -- | 3 |
| ADC305 | Computer Networks and Operating Systems | 3 | -- | -- | 3 | -- | -- | 3 |
| ADL301 | Data Structure Lab | -- | 2 | -- | -- | 1 | -- | 1 |
| ADL302 | Digital Logic & Computer Architecture Lab | -- | 2 | -- | -- | 1 | -- | 1 |
| ADL303 | Computer Networks and Operating Systems Lab | -- | 2 | -- | -- | 1 | -- | 1 |
| ADL304 | Object Oriented Programming with Java | -- | 2+2* | -- | -- | 2 | -- | 2 |
| ADS301 | Mobile App Development 1 | -- | 4$ | -- | -- | 2 | -- | 2 |
| | **Total** | **16** | **14** | **1** | **15** | **7** | **1** | **23** |

*Should be conducted class wise, $ indicates workload of Learner (Not Faculty)

| Examination Scheme | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Code | Course Name | Theory | | | | Term Work | Pract | Total |
| | | Internal Assessment | | End Sem Exam | Exam Duration (hrs.) | | | |
| | | Mid Term | Cont. Assess. | | | | | |
| ADC301 | Engineering Mathematics III | 20 | 20 | 60 | 2 | 25 | -- | 125 |
| ADC302 | Discrete Structures and Graph Theory | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADC303 | Data Structure | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADC304 | Digital Logic & Computer Architecture | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADC305 | Computer Networks and Operating Systems | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADL301 | Data Structure Lab | -- | -- | -- | -- | 25 | 25 | 50 |
| ADL302 | Digital Logic & Computer Architecture Lab | -- | -- | -- | -- | 25 | -- | 25 |
| ADL303 | Computer Networks and Operating Systems Lab | -- | -- | -- | -- | 25 | 25 | 50 |
| ADL304 | Object Oriented Programming with Java | -- | -- | -- | -- | 50 | 25 | 75 |
| ADS301 | Mobile App Development 1 | -- | -- | -- | -- | 50 | -- | 50 |
| **Total** | | **100** | **100** | **300** | **--** | **200** | **75** | **775** |

**Program Structure for Second Year Artificial Intelligence and Data Science Engineering**
**Scheme for Autonomous Program**
**(With Effect from 2023-2024)**
**Semester IV**

| Course Code | Course Name | Teaching Scheme (Contact Hours) | | | Credits Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Pract. | Tut. | Theory | Pract. | Tut. | Total |
| ADC401 | Engineering Mathematics-IV | 4 | -- | 1* | 3 | -- | 1 | 4 |
| ADC402 | Analysis of Algorithm | 3 | -- | -- | 3 | -- | -- | 3 |
| ADC403 | Database Management System | 3 | -- | -- | 3 | -- | -- | 3 |
| ADC404 | Theory of Computer Science | 3 | -- | -- | 3 | -- | -- | 3 |
| ADC405 | Internet of Things | 3 | -- | -- | 3 | -- | -- | 3 |
| ADL401 | Analysis of Algorithm Lab | -- | 2 | -- | -- | 1 | -- | 1 |
| ADL402 | Database Management System Lab | -- | 2 | -- | -- | 1 | -- | 1 |
| ADL403 | Internet of Things Lab | -- | 2 | -- | -- | 1 | -- | 1 |
| ADL404 | Python Programming | -- | 2+2* | -- | -- | 2 | -- | 2 |
| ADS401 | Mobile App Development 2 | -- | 4$ | -- | -- | 2 | -- | 2 |
| | **Total** | **16** | **14** | **1** | **15** | **7** | **1** | **23** |

*Should be conducted class wise, $ indicates workload of Learner (Not Faculty)

| Examination Scheme | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Course Code | Course Name | Theory | | | | Term Work | Pract | Total |
| | | Internal Assessment | | End Sem Exam | Exam Duration (hrs.) | | | |
| | | Mid Term | Cont. Assess. | | | | | |
| ADC401 | Engineering Mathematics-IV | 20 | 20 | 60 | 2 | 25 | -- | 125 |
| ADC402 | Analysis of Algorithm | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADC403 | Database Management System | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADC404 | Theory of Computer Science | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADC405 | Internet of Things | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADL401 | Analysis of Algorithm Lab | -- | -- | -- | -- | 25 | 25 | 50 |
| ADL402 | Database Management System Lab | -- | -- | -- | -- | 25 | 25 | 50 |
| ADL403 | Internet of Things Lab | -- | -- | -- | -- | 25 | -- | 25 |
| ADL404 | Python Programming | -- | -- | -- | -- | 50 | 25 | 75 |
| ADS401 | Mobile App Development 2 | -- | -- | -- | -- | 50 | -- | 50 |
| **Total** | | **100** | **100** | **300** | **--** | **200** | **75** | **775** |

| Course Code: | Course Title | Credit |
|---|---|---|
| ADC301 | Engineering Mathematics-III | 4 |

| | |
|---|---|
| **Prerequisite:** Engineering Mathematics-I, Engineering Mathematics-II | |
| **Course Objectives:** | |
| 1 | To build a strong foundation in mathematics, provide students with mathematics fundamentals necessary to formulate, solve and analyses complex engineering problems. |
| 2 | To prepare student to apply reasoning informed by the contextual knowledge to engineering practice, to work as part of teams on multi-disciplinary projects. |
| **Course Outcomes:** On successful completion, of course, learner/student will be able to: | |
| 1 | Apply Laplace transform and its properties to find the transform of a given function and evaluate some integrals of real value function. |
| 2 | Solve problems on finding inverse Laplace transform of given functions and apply to solve initial and boundary value problems associated with ordinary differential equations. |
| 3 | Expand a periodic function as a Fourier series in terms of sine and cosine functions. |
| 4 | Construct an analytic function from a harmonic function, obtain a family of orthogonal trajectories. Plot the image of a curve under a complex transformation from z-plane to w-plane. |
| 5 | Evaluate integration of complex variable functions using the knowledge of Cauchy integral formula, residue of singular points. Apply Cauchy residue theorem to evaluate some integrals of real value functions. |
| **6** | Find Z-transform of sequences using Properties and Inverse Z-transform using series expansion, partial fraction. |

| Module | | Content | Hrs |
|---|---|---|---|
| 1 | | **Laplace Transform** | 8 |
| | 1.1 | Definition and Condition of Existence of Laplace transform. | |
| | 1.2 | Laplace transform of standard functions like $e^{at}$, $\sin(at)$, $\cos(at)$, $\sinh(at)$, $\cosh(at)$ and $t^n, n \geq 0$. | |
| | 1.3 | Properties of Laplace transform: Linearity, First Shifting, Second Shifting, Change of Scale, Multiplication by t, Division by t, Laplace Transform of derivative, integral and convolution of two functions. | |
| | 1.4 | Evaluation of real improper integrals using Laplace transformation. | |
| 2 | | **Inverse Laplace Transform** | 6 |
| | 2.1 | Definition and Inverse Laplace transform of standard functions. | |
| | 2.2 | Inverse Laplace transform using Partial fractions, derivatives property. | |

| | | | |
|---|---|---|---|
| | 2.3 | Inverse Laplace transform using Convolution property. | |
| | 2.4 | Applications to solve initial and boundary value problems involving Ordinary differential equations. | |
| 3 | | **Fourier Series** | 6 |
| | 3.1 | Drichlet's conditions, Definition of Fourier series and Parseval's Identity. | |
| | 3.2 | Fourier series of periodic function with period $2\pi$ and $2L$ . | |
| | 3.3 | Fourier series of even and odd functions. | |
| | 3.4 | Half range Sine and Cosine Series. | |
| 4 | | **Complex Variables** | 6 |
| | 4.1 | Function of complex variable f(z), Limit, Continuity and Differentiability of f(z), Analytic function. Necessary and sufficient conditions for f(z) to be Analytic. Cauchy-Riemann equations in Cartesian and Polar coordinates. | |
| | 4.2 | Milne-Thomson method: Determine analytic function f(z) when real part (u), imaginary part (v) or its combination is given. | |
| | 4.3 | Harmonic function, Harmonic conjugate and Orthogonal trajectories. | |
| 5 | | **Complex Integration** | 7 |
| | 5.1 | Line Integral, Cauchy's Integral theorem for simple connected and multiply connected regions, Cauchy's Integral formula. | |
| | 5.2 | Taylor's and Laurent's series expansion. | |
| | 5.3 | Definition of Singularity, Zeroes, Poles of f(z), Residues, Cauchy's Residue Theorem. | |
| 6 | | **Z-Transform** | 6 |
| | 6.1 | Definition and Region of Convergence, Transform of Standard Functions:$\{k^n a^k\}$, $\{a^{\lvert k\rvert}\}$, $\{{}^{k+n}C_n . a^k\}$, $\{c^k \sin(\alpha k + \beta)\}$, $\{c^k \sinh \alpha k\}$, $\{c^k \cosh \alpha k\}$. | |
| | 6.2 | Properties of Z-Transform: Change of Scale, Shifting Property, Multiplication, and Division by k, Convolution theorem. | |
| | 6.3 | Inverse Z-Transform: Partial Fraction Method, Convolution Method. Inverse of Z-Transform by Series Expansion. | |
| | | **Total** | 39 |

| **Textbooks**: | |
|---|---|
| 1 | Higher Engineering Mathematics, Dr. B. S. Grewal, Khanna Publication |
| **Reference Books:** | |
| 1 | J H Mathews and R W Howell, Complex Analysis for Mathematics and Engineering, Narosa. |
| 2 | Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Narosa Publication. |
| 3 | Advanced Engineering Mathematics, Erwin Kreyszig, Wiley Eastern Limited. |
| 4 | Complex Variables and Applications, Brown and Churchill, McGraw-Hill Education. |

**Term work:**
Total 25 Marks Term work will be based on overall performance in the subject to be assessed via Tutorials/Assignment/Viva/ Mini Project based on application of the syllabus.

**Internal Assessment:**
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approximately 50% syllabus is completed. Duration of the midterm test shall be one hour.

**Continuous Assessment:**
Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered based on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

| **Sr. No.** | **Rubrics** | **Marks** |
|---|---|---|
| 1 | *Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2 | Content beyond syllabus presentation | 10 marks |
| 3 | Creating Proof of concept | 10 marks |
| 4 | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5 | Multiple Choice Questions (Quiz) | 5 marks |
| 6 | GATE Based Assignment/Tutorials etc | 10 marks |

*For sr. no. 1, the date of certification exam should be within the term and in case a student is unable to complete the certification, the grading has to be done accordingly.

| **End Semester Theory Examination:** | |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| Course Code | Course Name | Credits |
|---|---|---|
| ADC302 | Discrete Structures and Graph Theory | 3 |

| | |
|---|---|
| **Pre-requisite:** Basic Mathematics | |
| **Course Objectives:** The course aims: | |
| 1 | Cultivate clear thinking and creative problem solving. |
| 2 | Thoroughly train in the construction and understanding of mathematical proofs. Exercise common mathematical arguments and proof strategies. |
| 3 | To apply graph theory in solving practical problems. |
| 4 | Thoroughly prepare for the mathematical aspects of other Computer Engineering courses |
| **Course Outcomes:** On successful completion, of course, learner/student will be able to: | |
| 1 | Understand the notion of mathematical thinking, mathematical proofs and to apply them in problem solving. |
| 2 | Ability to reason logically. |
| 3 | Ability to understand relations, functions, Diagraph and Lattice. |
| 4 | Ability to understand and apply concepts of graph theory in solving real world problems. |
| 5 | Understand use of groups and codes in Encoding-Decoding |
| 6 | Analyze a complex computing problem and apply principles of discrete mathematics to identify solutions |

| Module | Detailed Contents | | Hours |
|---|---|---|---|
| 1 | **Logic** | | 6 |
| | 1.1 | Propositional Logic, Predicate Logic, Laws of Logic, Quantifiers, Normal Forms, Inference Theory of Predicate Calculus, Mathematical Induction. | |
| **2** | **Relations and Functions** | | **6** |
| | 2.1 | Basic concepts of Set Theory | |
| | **2.2** | **Relations:** Definition, Types of Relations, Representation of Relations, Closures of Relations, Warshall's algorithm, Equivalence relations and Equivalence Classes | |
| | **2.3** | **Function**s: Definition, Types of functions, Composition of functions, Identity and Inverse function | |
| **3** | **Posets and Lattice** | | **5** |
| | **3.1** | Partial Order Relations, Poset, Hasse Diagram, Chain and Anti chains, Lattice, Types of Lattice, Sub lattice | |
| **4** | **Counting** | | **6** |
| | **4.1** | Basic Counting Principle-Sum Rule, Product Rule, Inclusion-Exclusion Principle, Pigeonhole Principle | |
| | **4.2** | Recurrence relations, Solving recurrence relations | |
| **5** | **Algebraic Structures** | | **8** |
| | **5.1** | **Algebraic structures with one binary operation:** Semi group, Monoid, Groups, Subgroups, Abelian Group, Cyclic group, Isomorphism | |
| | **5.2** | **Algebraic structures with two binary operations:** Ring | |
| | **5.3** | **Coding Theory**: Coding, binary information and error detection, decoding and error correction | |
| **6** | **Graph Theory** | | **8** |
| | | Types of graphs, Graph Representation, Sub graphs, Operations on Graphs, Walk, Path, Circuit, Connected Graphs, Disconnected Graph, Components, Homomorphism and Isomorphism of Graphs, Euler and Hamiltonian Graphs, Planar Graph, Cut Set, Cut Vertex, | |

| | | | |
|---|---|---|---|
| | | Applications. | |
| **Total** | | | **39** |

| **Textbooks:** | |
|---|---|
| 1 | Bernad Kolman, Robert Busby, Sharon Cutler Ross, Nadeem-ur-Rehman, "Discrete Mathematical Structures", Pearson Education. |
| 2 | C. L. Liu "Elements of Discrete Mathematics", second edition 1985, McGraw-Hill Book Company. Reprinted 2000. |
| 3 | K. H. Rosen, "Discrete Mathematics and applications", fifth edition 2003, Tata McGraw Hill Publishing Company |
| **References:** | |
| 1 | Y N Singh, "Discrete Mathematical Structures", Wiley-India. |
| 2 | J. L. Mott, A. Kandel, T. P. Baker, "Discrete Mathematics for Computer Scientists and Mathematicians", Second Edition 1986, Prentice Hall of India. |
| 3 | J. P. Trembley, R. Manohar "Discrete Mathematical Structures with Applications to Computer Science", Tata McGraw Hill Publishing Company |
| 4 | Seymour Lipschutz, Marc Lars Lipson, "Discrete Mathematics" Schaum's Outline, McGraw Hill Education. |
| 5 | Narsing Deo, "Graph Theory with applications to engineering and computer science", PHI Publications. |
| 6 | P. K. Bisht, H. S. Dhami, "Discrete Mathematics", Oxford press. |

**Internal Assessment:**
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approximately 50% syllabus is completed. Duration of the midterm test shall be one hour.

**Continuous Assessment:**
Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered based on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

| Sr. No. | Rubrics | Marks |
|---|---|---|
| 1 | *Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2 | Content beyond syllabus presentation | 10 marks |
| 3 | Creating Proof of concept | 10 marks |
| 4 | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5 | Multiple Choice Questions (Quiz) | 5 marks |
| 6 | GATE Based Assignment/Tutorials etc | 10 marks |

*For sr. no. 1, the date of certification exam should be within the term and in case a student is unable to complete the certification, the grading has to be done accordingly.

| **End Semester Theory Examination:** | |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| **Useful Links** | |
|---|---|
| 1 | https://www.edx.org/learn/discrete-mathematics |
| 2 | https://www.coursera.org/specializations/discrete-mathematics |
| 3 | https://nptel.ac.in/courses/106/106/106106094/ |
| 4 | https://swayam.gov.in/nd1_noc19_cs67/preview |

| Course Code | Course Name | Credit |
|---|---|---|
| ADC303 | Data Structure | 03 |

| Pre-requisite: C Programming | |
|---|---|
| **Course Objectives:** The course aims: | |
| 1 | To understand the need and significance of Data structures as a computer Professional. |
| 2 | To teach concept and implementation of linear and Nonlinear data structures. |
| 3 | To analyze various data structures and select the appropriate one to solve a specific real-world problem. |
| 4 | To introduce various techniques for representation of the data in the real world. |
| 5 | To teach various searching techniques. |
| **Course Outcomes:** | |
| 1 | Students will be able to implement Linear and Non-Linear data structures. |
| 2 | Students will be able to handle various operations like searching, insertion, deletion and traversals on various data structures. |
| 3 | Students will be able to explain various data structures, related terminologies and its types. |
| 4 | Students will be able to choose appropriate data structure and apply it to solve problems in various domains. |
| 5 | Students will be able to analyze and implement appropriate searching techniques for a given problem. |
| 6 | Students will be able to demonstrate the ability to analyze, design, apply and use data structures to solve engineering problems and evaluate their solutions. |

| Module | | Detailed Content | Hours |
|---|---|---|---|
| **1** | | **Introduction to Data Structures** | 2 |
| | 1.1 | Introduction to Data Structures, Concept of ADT, Types of Data Structures-Linear and Nonlinear, Operations on Data Structures. | |
| **2** | | **Stack and Queues** | 8 |
| | 2.1 | Introduction, ADT of Stack, Operations on Stack, Array Implementation of Stack, Applications of Stack-Well form-ness of Parenthesis, Infix to Postfix Conversion and Postfix Evaluation, Recursion. | |
| | 2.2 | Introduction, ADT of Queue, Operations on Queue, Array Implementation of Queue, Types of Queue-Circular Queue, Priority Queue, Introduction of Double Ended Queue, Applications of Queue. | |
| **3** | | **Linked List** | 10 |
| | 3.1 | Introduction, Representation of Linked List, Linked List v/s Array, Types of Linked List - Singly Linked List, Circular Linked List, Doubly Linked List, Operations on Singly Linked List and Doubly Linked List, Stack and Queue using Singly Linked List, Singly Linked List Application-Polynomial Representation and Addition. | |
| **4** | | **Trees** | 11 |
| | 4.1 | Introduction, Tree Terminologies, Binary Tree, Binary Tree Representation, Types of Binary Tree, Binary Tree Traversals, Binary Search Tree, Operations on Binary Search Tree, Applications of Binary Tree-Expression Tree, Huffman Encoding, Search Trees-AVL, rotations in AVL Tree, operations on AVL Tree, Introduction of B Tree, B+ Tree. | |
| **5** | | **Graphs** | 4 |
| | 5.1 | Introduction, Graph Terminologies, Representation of Graph, Graph Traversals- | |

| | | | |
|---|---|---|---|
| | | Depth First Search (DFS) and Breadth First Search (BFS), Graph Application-Topological Sorting. | |
| **6** | | **Searching Techniques** | |
| | 6.1 | Linear Search, Binary Search, Hashing-Concept, Hash Functions, Collision resolution Techniques | |
| **Total** | | | **39** |

| **Textbooks:** | |
|---|---|
| 1 | Aaron M Tenenbaum, Yedidyah Langsam, Moshe J Augenstein, "Data Structures Using C", Pearson Publication. |
| 2 | Reema Thareja, "Data Structures using C", Oxford Press. |
| 3 | Richard F. Gilberg and Behrouz A. Forouzan, "Data Structures: A Pseudocode Approach with C", 2nd Edition, CENGAGE Learning. |
| 4 | Jean Paul Tremblay, P. G. Sorenson, "Introduction to Data Structure and Its Applications", McGraw-Hill Higher Education |
| 5 | Data Structures Using C, ISRD Group, 2nd Edition, Tata McGraw-Hill. |
| **References:** | |
| 1 | Prof. P. S. Deshpande, Prof. O. G. Kakde, "C and Data Structures", DreamTech press. |
| 2 | E. Balagurusamy, "Data Structure Using C", Tata McGraw-Hill Education India. |
| 3 | Rajesh K Shukla, "Data Structures using C and C++", Wiley-India |
| 4 | GAV PAI, "Data Structures", Schaum's Outlines. |
| 5 | Robert Kruse, C. L. Tondo, Bruce Leung, "Data Structures and Program Design in C", Pearson Edition |

**Internal Assessment:**
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approximately 50% syllabus is completed. Duration of the midterm test shall be one hour.

**Continuous Assessment:**
Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered based on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

| Sr. No. | Rubrics | Marks |
|---|---|---|
| 1 | *Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2 | Content beyond syllabus presentation | 10 marks |
| 3 | Creating Proof of concept | 10 marks |
| 4 | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5 | Multiple Choice Questions (Quiz) | 5 marks |
| 6 | GATE Based Assignment/Tutorials etc | 10 marks |

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|---|---|
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| Useful Links | |
|---|---|
| 1 | https://nptel.ac.in/courses/106/102/106102064/ |
| 2 | https://www.coursera.org/specializations/data-structures-algorithms |
| 3 | https://www.edx.org/course/data-structures-fundamentals |
| 4 | https://swayam.gov.in/nd1_noc19_cs67/preview |

| Course Code | Course Name | Credit |
|---|---|---|
| ADC304 | Digital Logic & Computer Organization and Architecture | 3 |

| | |
|---|---|
| **Pre-requisite:** Knowledge on number systems | |
| **Course Objective:** | |
| 1 | To have the rough understanding of the basic structure and operation of basic digital circuits and digital computer. |
| 2 | To discuss in detail arithmetic operations in digital system. |
| 3 | To discuss generation of control signals and different ways of communication with I/O devices. |
| 4 | To study the hierarchical memory and principles of advanced computing. |
| **Course Outcome:** | |
| 1 | To learn different number systems and basic structure of computer system. |
| 2 | To demonstrate the arithmetic algorithms. |
| 3 | To understand the basic concepts of digital components and processor organization. |
| 4 | To understand the generation of control signals of computer. |
| 5 | To demonstrate the memory organization. |
| 6 | To describe the concepts of parallel processing and different Buses. |

| Module | | Detailed Content | Hours |
|---|---|---|---|
| **1** | | **Computer Fundamentals** | **6** |
| | 1.1 | Introduction to Number System and Codes | |
| | 1.2 | Number Systems: Binary, Octal, Decimal, Hexadecimal, | |
| | 1.3 | Codes: Grey, BCD, Excess-3, Boolean Algebra. | |
| | 1.4 | Logic Gates: AND, OR, NOT, NAND, NOR, EX-OR | |
| | 1.5 | Overview of computer organization and architecture. | |
| | 1.6 | Basic Organization of Computer and Block Level functional Units, Von-Neumann Model. | |
| **2** | | **Data Representation and Arithmetic algorithms** | **8** |
| | 2.1 | Binary Arithmetic: Addition, Subtraction, Multiplication, Division using Sign Magnitude, 1's and 2's compliment, BCD and Hex Arithmetic Operation. | |
| | 2.2 | Booths Multiplication Algorithm, Restoring and Non-restoring Division Algorithm. | |
| | 2.3 | IEEE-754 Floating point Representation. | |
| **3** | | **Processor Organization and Architecture** | **6** |
| | 3.1 | Introduction: Half adder, Full adder, MUX, DMUX, Encoder, Decoder (IC level). | |
| | 3.2 | Introduction to Flip Flop: SR, JK, D, T (Truth table). | |
| | 3.3 | Register Organization, Instruction Formats, Addressing modes, Instruction Cycle. | |
| **4** | | **Control Unit Design** | **6** |
| | 4.1 | Hardwired Control Unit: State Table Method, Delay Element Methods. | |
| | 4.2 | Microprogrammed Control Unit: Micro Instruction-Format, Sequencing and execution, Micro operations. | |
| **5** | | **Memory Organization** | **6** |
| | 5.1 | Introduction and characteristics of memory, Types of RAM and ROM, Memory Hierarchy, 2-level Memory Characteristic, | |
| | 5.2 | Cache Memory: Concept, locality of reference, Design problems based on | |
| | | mapping techniques, Cache coherence and write policies. | |

| | | | |
|---|---|---|---|
| **6** | | **Principles of Advanced Processor and Buses** | **7** |
| | 6.1 | Basic Pipelined Data path and control, data dependencies, data hazards, branch hazards, delayed branch, and branch prediction, Performance measures-CPI,Speedup, Efficiency, throughput. | |
| | 6.2 | Flynn's Classification, Introduction to multicore architecture. | |
| **Total** | | | **39** |

| | |
|---|---|
| **Textbooks:** | |
| 1 | R. P. Jain, "Modern Digital Electronic", McGraw-Hill Publication, 4th Edition. |
| 2 | William Stalling, "Computer Organization and Architecture: Designing and Performance", Pearson Publication 10TH Edition. |
| 3 | John P Hayes, "Computer Architecture and Organization", McGraw-Hill Publication, 3RD Edition. |
| 4 | Dr. M. Usha and T. S. Shrikanth, "Computer system Architecture and Organization", Wiley publication. |
| **References:** | |
| 1 | Andrew S. Tanenbaum, "Structured Computer Organization", Pearson Publication. |
| 2 | B. Govindarajalu, "Computer Architecture and Organization", McGraw-Hill Publication. |
| 3 | Malvino, "Digital computer Electronics", McGraw-Hill Publication, 3rd Edition. |
| 4 | Smruti Ranjan Sarangi, "Computer Organization and Architecture", McGraw-Hill Publication. |

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| **End Semester Theory Examination:** | |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| **Useful Links** | |
|---|---|
| 1 | https://www.classcentral.com/course/swayam-computer-organization-and-architecture-a-pedagogical- aspect-9824 |
| 2 | https://nptel.ac.in/courses/106/103/106103068/ |
| 3 | https://www.coursera.org/learn/comparch |
| 4 | https://www.edx.org/learn/computer-architecture |

| Course Code | Course Name | Credit |
|---|---|---|
| ADC305 | Computer Networks and Operating Systems | 3 |

| | |
|---|---|
| **Course Objectives:** | |
| 1 | To introduce basic concepts and functions of operating systems. |
| 2 | To understand the concept of process, thread and resource management. |
| 3 | To understand the concepts of process synchronization and deadlock. |
| 4 | To understand various Memory management techniques. |
| 5 | To introduce concepts of computer networks and working of various layers of OSI. |
| 6 | To understand various transport layer and application layer protocols |
| **Course Outcome:** | |
| 1 | Understand the objectives, functions and structure of OS |
| 2 | Analyze the concept of process management and evaluate performance of process scheduling algorithms. |
| 3 | Understand and apply the concepts of synchronization and deadlocks |
| 4 | Evaluate performance of Memory allocation |
| 5 | Explain related concepts and functions of Physical, Data Link Layer and Network Layer. |
| 6 | Explain related concepts and functions of Transport Layer and Application Layer. |

| Module | Detailed Content | | Hours |
|---|---|---|---|
| **1** | **Operating system Overview** | | **4** |
| | 1.1 | Introduction, Objectives, Functions and Evolution of Operating System | |
| | 1.2 | Operating system structures: Layered, Monolithic and Microkernel | |
| | 1.3 | Linux Kernel, Shell and System Calls | |
| **2** | **Process and Process Scheduling** | | **8** |
| | 2.1 | Concept of a Process, Process States, Process Description, Process Control Block. | |
| | 2.2 | Uniprocessor Scheduling-Types: Preemptive and Non-preemptive scheduling algorithms (FCFS, SJF, SRTN, Priority, RR) | |
| | 2.3 | Threads: Definition and Types, Concept of Multithreading | |
| **3** | **Process Synchronization and Deadlocks** | | **9** |
| | 3.1 | Concurrency: Principles of Concurrency, Inter-Process Communication, Process Synchronization. | |
| | 3.2 | Mutual Exclusion: Requirements, Hardware Support (TSL), Operating System Support (Semaphores), Producer and Consumer problem. | |
| | 3.3 | Principles of Deadlock: Conditions and Resource, Allocation Graphs, Deadlock Prevention, Deadlock Avoidance: Banker's Algorithm, Deadlock Detection and Recovery, Dining Philosophers Problem. | |
| **4** | **Memory Management** | | **4** |
| | 4.1 | Memory Management Requirements, Memory Partitioning: Fixed, Partitioning, Dynamic Partitioning, Memory Allocation Strategies: Best-Fit, First Fit, Worst Fit, Basics of Paging and Segmentation. | |
| **5** | **Physical, Data Link Layer and Network Layer** | | **7** |
| | 5.1 | Reference models: Layer details of OSI, TCP/IP models. Difference betweenOSI and TCP/IP. Physical Layer: Guided Transmission Media | |

| | | | |
|---|---|---|---|
| | | and Un Guided Transmission media | |
| | 5.2 | Data Link Layer: DLL Design Issues (Services, Framing, Error Control, Flow Control), Medium Access Control Sublayer Channel Allocation problem, Multiple access Protocol (CSMA/CD) | |
| | 5.3 | Network Layer: IPv4 Addressing (classful and classless), Subnetting, IPv4 Protocol, Network Address Translation (NAT), IPv6 addressing, IPv4 vs IPv6 addressing | |
| **6** | | **Transport Layer and Application Layer** | **7** |
| | 6.1 | Transport Layer: Service primitives, Sockets, Connection management (Handshake), UDP, TCP, TCP state transition, TCP timers, TCP Flow control(sliding Window) | |
| | 6.1 | Application Layer: HTTP, SMTP, Telnet, FTP, DHCP, DNS and Types of Name Server | |
| **Total** | | | **39** |

| **Textbooks:** | |
|---|---|
| 1 | A.S. Tanenbaum, Computer Networks, Pearson Education |
| 2 | B.A. Forouzan, Data Communications and Networking, McGraw Hill Education |
| 3 | William Stallings, Operating System: Internals and Design Principles, Prentice Hall, 8thEdition, 2014, ISBN-10: 0133805913 • ISBN-13: 9780133805918. |
| 4 | Abraham Silberschatz, Peter Baer Galvin and Greg Gagne, Operating System Concepts, John Wiley &Sons, Inc., 9thEdition, 2016, ISBN 978-81-265-5427-0 |
| **References:** | |
| 1 | Achyut Godbole and Atul Kahate, Operating Systems, McGraw Hill Education, 3rdEdition |
| 2 | Andrew Tannenbaum, Operating System Design and Implementation, Pearson, 3rdEdition. |
| 3 | Maurice J. Bach, "Design of UNIX Operating System", PHI |
| 4 | Sumitabha Das, "UNIX: Concepts and Applications", McGraw Hill, 4thEdition |
| 5 | James F. Kurose, Keith W. Ross, Computer Networking : A Top-Down Approach Featuring the Internet, Pearson Education |
| 6 | Behrouz A. Forouzan, Firouz Mosharraf, Computer Networks : A Top down Approach, McGraw Hill Education |

**Internal Assessment:**
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approximately 50% syllabus is completed. Duration of the midterm test shall be one hour.

**Continuous Assessment:**
Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered based on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

| **Sr. No.** | **Rubrics** | **Marks** |
|---|---|---|
| 1 | *Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2 | Content beyond syllabus presentation | 10 marks |
| 3 | Creating Proof of concept | 10 marks |
| 4 | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5 | Multiple Choice Questions (Quiz) | 5 marks |
| 6 | GATE Based Assignment/Tutorials etc | 10 marks |

*For sr. no. 1, the date of certification exam should be within the term and in case a student is unable to complete the certification, the grading has to be done accordingly.

| End Semester Theory Examination: | |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| Useful Links | |
|---|---|
| 1 | https://swayam.gov.in/nd1_noc19_cs50/preview |
| 2 | https://nptel.ac.in/courses/117/106/117106113/ |
| 3 | https://www.classcentral.com/course/swayam-introduction-to-operating-systems-6559 |

| Lab Code | Lab Name | Credit |
|---|---|---|
| **ADL301** | **Data Structures Lab** | **1** |

| **Prerequisite: C Programming Language.** | |
|---|---|
| **Lab Objectives:** | |
| 1 | To implement basic data structures such as arrays, linked lists, stacks and queues |
| 2 | Solve problem involving graphs, and trees |
| 3 | To develop application using data structure algorithms |
| 4 | Compute the complexity of various algorithms. |
| **Lab Outcomes:** | |
| 1 | Students will be able to implement linear data structures & be able to handle operations like insertion, deletion, searching and traversing on them. |
| 2 | Students will be able to implement nonlinear data structures & be able to handle operations like insertion, deletion, searching and traversing on them |
| 3 | Students will be able to choose appropriate data structure and apply it in various problems |
| 4 | Students will be able to select appropriate searching techniques for given problems. |

| **Suggested Experiments:** Students are required to complete at least 10 experiments. | |
|---|---|
| Star (*) marked experiments are compulsory. | |
| **Sr. No.** | **Name of the Experiment** |
| 1* | Implement Stack ADT using array. |
| 2* | Convert an Infix expression to Postfix expression using stack ADT. |
| 3* | Evaluate Postfix Expression using Stack ADT. |
| 4 | Applications of Stack ADT. |
| 5* | Implement Linear Queue ADT using array. |
| 6* | Implement Circular Queue ADT using array. |
| 7 | Implement Priority Queue ADT using array. |
| 8* | Implement Singly Linked List ADT. |
| 9* | Implement Circular Linked List ADT. |
| 10 | Implement Doubly Linked List ADT. |
| 11* | Implement Stack / Linear Queue ADT using Linked List. |
| 12* | Implement Binary Search Tree ADT using Linked List. |

| | |
|---|---|
| 13* | Implement Graph Traversal techniques:<br>a) Depth First Search b) Breadth First Search |
| 14 | Applications of Binary Search Technique. |

| **Useful Links:** | |
|---|---|
| 1 | www.leetcode.com |
| 2 | www.hackerrank.com |
| 3 | www.cs.usfca.edu/~galles/visualization/Algorithms.html |
| 4 | www.codechef.com |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks based on evaluation of Experiments |
| **Evaluation Exam** | |
| 1 | Practical Exam based on syllabus of ADL301and ADC303 |

| Lab Code | Lab Name | Credit |
|---|---|---|
| ADL302 | Digital Logic & Computer Organization and Architecture Lab | 1 |

| Prerequisite: C Programming Language. | |
|---|---|
| **Lab Objectives:** | |
| 1 | To implement operations of the arithmetic unit using algorithms. |
| 2 | Design and simulate different digital circuits. |
| 3 | To design memory subsystem including cache memory. |
| 4 | To demonstrate CPU and ALU design. |
| **Lab Outcomes:** | |
| 1 | To understand the basics of digital components |
| 2 | Design the basic building blocks of a computer: ALU, registers, CPU and memory |
| 3 | To recognize the importance of digital systems in computer architecture |
| 4 | To implement various algorithms for arithmetic operations. |

| List of Experiments: | |
|---|---|
| **Sr. No.** | **Name of the Experiment** |
| 1 | To verify the truth table of various logic gates using ICs. |
| 2 | To realize the gates using universal gates |
| 3 | Code conversion. |
| 4 | To realize half adder and full adder. |
| 5 | To implement logic operation using MUX IC. |
| 6 | To implement logic operation decoder IC. |
| 7 | Study of flip flop IC. |
| 8 | To implement ripple carry adder. |
| 9 | To implement carry look ahead adder. |
| 10 | To implement Booth's algorithm. |
| 11 | To implement restoring division algorithm. |
| 12 | To implement non restoring division algorithm. |
| 13 | To implement ALU design. |
| 14 | To implement CPU design. |
| 15 | To implement memory design. |
| 16 | To implement cache memory design. |

| Note: | |
|---|---|
| 1 | Any Four experiments from Exp. No. 1 to Exp. No. 7 using hardware. |
| 2 | Any Six experiments from Exp. No. 8 to Exp. No. 16 using Virtual Lab, expect Exp. No 10,11 and 12. |
| 3 | Exp. No. 10 to Exp. No. 12 using Programming language. |
| **Digital Material:** | |
| 1 | Manual to use Virtual Lab simulator for Computer Organization and Architecture developed by the Department of CSE, IIT Kharagpur. |
| 2 | Link http://cse10-iitkgp.virtual-labs.ac.in/ |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks based on evaluation of Experiments |

| Lab Code | Lab Name | Credit |
|---|---|---|
| ADL303 | Computer Networks and Operating Systems Lab | 01 |

| | |
|---|---|
| **Prerequisite:** Knowledge on Operating system principles | |
| **Lab Objectives:** | |
| 1 | To gain practical experience with designing and implementing concepts of operating systems such as system calls, CPU scheduling, process management, memory management, file systems and deadlock handling using C language in Linux environment. |
| 2 | To familiarize students with the architecture of Linux OS. |
| 3 | To provide necessary skills for developing and debugging programs in Linux environment. |
| 4 | To learn programmatically to implement simple operation system mechanisms |
| 5 | To assess the strengths and weaknesses of various routing algorithms. |
| 6 | To understand various transport layer and application layer protocols |
| **Lab Outcomes:** At the end of the course, the students will be able to | |
| 1 | Demonstrate basic Operating system Commands, Shell scripts, System Calls and API wrt Linux |
| 2 | Implement various process scheduling algorithms and evaluate their performance. |
| 3 | Implement and analyze concepts of synchronization and deadlocks. |
| 4 | Implement various Memory Management techniques and evaluate their performance. |
| 5 | Design the network using IP addressing and sub netting / supernetting schemes. |
| 6 | Analyze transport layer and application layer protocols. |

| **Suggested List of Experiments** | | |
|---|---|---|
| **Sr. No.** | | **Content** |
| **1** | | **Explore Linux Commands** |
| | 1.1 | **Explore usage of basic Linux Commands and system calls for file, directory and process management.**<br>For eg: (mkdir, chdir, cat, ls, chown, chmod, chgrp, ps etc.<br>system calls: open, read, write, close, getpid, setpid, getuid, getgid, getegid, geteuid. sort, grep, awk, etc.) |
| **2** | | **Linux shell script** |
| | 2.1 | Write shell scripts to do the following:<br>a. Display OS version, release number, kernel version<br>b. Display top 10 processes in descending order<br>c. Display processes with highest memory usage.<br>d. Display current logged in user and log name.<br>Display current shell, home directory, operating system type, current path setting, current working directory. |
| **3** | | **Linux- API** |
| | 3.1 | Implement any one basic commands of linux like ls, cp, mv and others using kernel APIs. |
| **4** | | **Linux- Process** |
| | 4.1 | a. Create a child process in Linux using the fork system call. From the child process obtain the process ID of both child and parent by using getpid and getppid system call.<br>b. Explore wait and waitpid before termination of process. |
| **5** | | **Process Management: Scheduling** |

| | | |
|---|---|---|
| | 5.1 | a. Write a program to demonstrate the concept of non-preemptive scheduling algorithms.<br>b. Write a program to demonstrate the concept of preemptive scheduling algorithms |
| **6** | | **Process Management: Synchronization** |
| | 6.1 | **a.** Write a C program to implement solution of Producer consumer problem through Semaphore |
| **7** | | **Process Management: Deadlock** |
| | 7.1 | a. Write a program to demonstrate the concept of deadlock avoidance through Banker's Algorithm<br>b. Write a program demonstrate the concept of Dining Philosopher's Problem |
| **8** | | **Memory Management** |
| | 8.1 | a. Write a program to demonstrate the concept of MVT and MFT memory management techniques<br>b. Write a program to demonstrate the concept of dynamic partitioning placement algorithms i.e. Best Fit, First Fit, Worst-Fit etc. |
| **9** | To design and simulate the environment for Dynamic routing using Cisco packet tracer/ GNS3 | |
| **10** | To design and Simulate VLANs on the switch/router using Cisco packet tracer/ GNS3 | |
| **11** | To design and Simulate NAT on the router using Cisco packet tracer/ GNS3 | |
| **12** | Simulation of Software Defined Network using Mininet | |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks based on evaluation of Experiments |
| **Evaluation Exam** | |
| 1 | Practical Exam based on syllabus of ADL303 and ADC305 |

| Lab Code | Lab Name | Credits |
|---|---|---|
| ADL304 | Object Oriented Programming with Java | 2 |

| | |
|---|---|
| **Prerequisite:** Structured Programming Approach | |
| **Lab Objectives:** | |
| 1 | To learn the basic concepts of object-oriented programming |
| 2 | To study JAVA programming language |
| 3 | To study various concepts of JAVA programming like multithreading, exception Handling, packages, etc. |
| 4 | To explain components of GUI based programming. |
| **Lab Outcomes:** At the end of the course, the students should be able to | |
| 1 | To apply fundamental programming constructs. |
| 2 | To illustrate the concept of packages, classes and objects. |
| 3 | To elaborate the concept of strings, arrays and vectors. |
| 4 | To implement the concept of inheritance and interfaces. |
| 5 | To implement the concept of exception handling and multithreading. |
| 6 | To develop GUI based application. |

| Module | | Detailed Content | Hours |
|---|---|---|---|
| **1** | | **Introduction to Object Oriented Programming** | **2** |
| | 1.1 | OOP concepts: Objects, class, Encapsulation, Abstraction, Inheritance, Polymorphism, message passing. | |
| | 1.2 | Java Virtual Machine | |
| | 1.3 | Basic programming constructs: variables, data types, operators, unsigned right shift operator, expressions, branching and looping. | |
| **2** | | **Class, Object, Packages and Input/output** | **6** |
| | 2.1 | Class, object, data members, member functions , Constructors, types, static members and functions Method overloading<br>Packages in java, types, user defined packages Input and output functions in Java, scanner class | |
| **3** | | **Array, String and Hashmap** | **3** |
| | 3.1 | Array, Strings, String Buffer, Hashmap | |
| **4** | | **Inheritance** | **4** |
| | 4.1 | Types of inheritance, Method overriding, super, abstract class and abstract method, final, Multiple inheritance using interface, extends keyword | |
| **5** | | **Exception handling and Multithreading** | **5** |
| | 5.1 | Exception handling using try, catch, finally, throw and throws, Multiple try and catch blocks, user defined exception<br>Thread lifecycle, thread class methods, creating threads using extends and implements keyword. | |
| **6** | | **GUI programming in JAVA** | **6** |
| | 6.1 | AWT: working with windows, using AWT controls for GUI design<br>Font and color class. Event handling using event class<br>Swing class in JAVA | |

| **Textbooks:** | |
|---|---|
| 1 | Herbert Schildt, “JAVA: The Complete Reference”, Ninth Edition, Oracle Press. |
| 2 | E. Balagurusamy, “Programming with Java”, McGraw Hill Education. |

| **References:** | |
|---|---|
| 1 | Ivor Horton, “Beginning JAVA”, Wiley India. |
| 2 | Dietal and Dietal, “Java: How to Program”, 8th Edition, PHI . |
| 3 | “JAVA Programming”, Black Book, Dreamtech Press. |
| 4 | “Learn to Master Java programming”, Staredu solutions |

| **Digital material:** | |
|---|---|
| 1 | www.nptelvideos.in |
| 2 | www.w3schools.com |
| 3 | www.tutorialspoint.com |
| 4 | https://starcertification.org/Certifications/Certificate/securejava |

| **Suggested List of Programming Assignments/laboratory Work:** | |
|---|---|
| **Sr. No.** | **Name of the Experiment** |
| 1 | Programs on Basic programming constructs like branching and looping |
| 2 | Program on accepting input through keyboard. |
| 3 | Programs on class and objects |
| 4 | Program on method and constructor overloading. |
| 5 | Program on Packages |
| 6 | Program on 2D array, strings functions |
| 7 | Program on String Buffer and Vectors |
| 8 | Program on types of inheritance |
| 9 | Program on Multiple Inheritance |
| 10 | Program on abstract class and abstract methods. |
| 11 | Program using super and final keyword |
| 12 | Program on Exception handling |
| 13 | Program on user defined exception |
| 14 | Program on Multithreading |
| 15 | Program on Graphics class |
| 16 | Program on applet class |
| 17 | Program to create GUI application |
| 18 | Mini Project based on the content of the syllabus (Group of 2-3 students) |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 15 experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 50 Marks<br>(Experiments: 30 Marks, Mini Project : 20 Marks) |
| **Evaluation Exam** | |
| 1 | Practical Exam based on syllabus of ADL304 |

| Course code | Course Name | Credits |
|---|---|---|
| ADS301 | Mobile Application Development 1 | 2 |

| | |
|---|---|
| **Prerequisite:** | |
| **Lab Objectives:** | |
| 1 | Learn the basics of Dart Programming Language. |
| 2 | Learn the basics of the Flutter framework. |
| 3 | Develop the App UI by incorporating widgets, layouts, gestures and animation |
| **Lab Outcomes:**<br>**At the end of the course, students will be able to —-** | |
| 1 | Use Dart Programming Language for mobile application development. |
| 2 | Understand cross platform mobile application development using Flutter framework |
| 3 | Design and Develop interactive Flutter App by using widgets, layouts, gestures and animation |

| Module | | Detailed Content |
|---|---|---|
| **1** | **Basics of Dart Programming** | |
| | 1.1 | Types and Casting in Dart, Null-aware Operators in Dart, Dart Programming - Loops, Collections in Dart, Dart Sets, Calsses and object, Classes and enums, Dart Exception Handling With Examples, Dart Future, async and await, |
| **2** | **Basics of Flutter Programming** | |
| | 2.1 | Introduction of Flutter, Understanding Widget, Lifecycle Events, Widget Tree and Element Tree, Basics of Flutter installation, Flutter Hello World App. |
| **3** | **Developing Flutter UI: Widgets, Layouts, Gestures** | |
| | 3.1 | USING COMMON WIDGETS: SafeArea, Appbar, Column, Row, Container, Buttons, Text, Richtext, Form, Images and Icon. |
| | 3.2 | BUILDING LAYOUTS: high level view of layouts, Creating the layout, Types of layout widgets |
| | 3.3 | APPLYING GESTURES: Setting Up GestureDetector, Implementing the Draggable and Dragtarget Widgets, Using the GestureDetector for Moving and Scaling |
| **4** | **Animation and Navigation** | |
| | 4.1 | ADDING ANIMATION TO AN APP: Using Animated Container, Using Animated CrossFade, Using Animated Opacity, Using Animation Controller, Using Staggered Animation |
| | 4.2 | CREATING AN APP'S NAVIGATION: Using the Navigator, Using the Named Navigator Route, Using the Bottom NavigationBar, Using the TabBar and TabBarView |

| **Suggested Experiments:** |
|---|
| **Student in group of 4 (max), will perform 5 Assignment / Activity / Experiment based on the above syllabus** |

| **Textbooks:** | |
|---|---|
| 1 | Beginning Flutter a Hands-on Guide to App Development, Marco L. Napoli, Wiley, 2020. |
| 2 | Beginning App Development with Flutter: Create Cross-Platform Mobile Apps, By Rap Payne, 2019. |
| **References:** | |
| 1 | Flutter in Action by Eric Windmill, MANING, 2019 |
| 2 | Google Flutter Mobile Development Quick Start Guide. Packt, 2019 |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 5 Assignment / Activity / Experiment |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 50 Marks based on evaluation of suggested Assignments / Activities / Experiments. |

| Course Code | Course Name | Credits |
|---|---|---|
| ADC401 | Engineering Mathematics-IV | 4 |

**Pre-requisite:** Engineering Mathematics-I, Engineering Mathematics-II, Engineering Mathematics-III.

**Course Objectives:**

| | |
|---|---|
| 1 | To build a strong foundation in mathematics, provide students with mathematics fundamentals necessary to formulate, solve and analyses complex engineering problems |
| 2 | To prepare student to apply reasoning informed by the contextual knowledge to engineering practice, to work as part of teams on multi-disciplinary projects. |

**Course Outcomes:** On successful completion, of course, learner/student will be able to:

| | |
|---|---|
| 1 | Find Eigen values, Eigen vectors of matrix, apply Caley Hamilton theorem to find a function of a matrix, distinguish derogatory matrix, and diagonalizable matrix. |
| 2 | Compute probability using probability distribution of discrete and continuous Random variable, Poisson and Normal distribution. |
| 3 | Apply Testing of Hypothesis associated with Sampling distribution of large sample, small sample and chi square distribution. |
| 4 | Apply the concept of Correlation and Regression, fitting of curve to the given data sets. |
| 5 | Formulate and solve some Linear programming problems using simplex method, Big M method and Duel simplex method. |
| 6 | Solve Non-Linear Optimization problems using Lagrange's multiplier method and Karush Kuhn Tucker Method. |

| Module | Detailed Contents | | Hours |
|---|---|---|---|
| 1 | **Linear Algebra (Theory of Matrices)** | | 6 |
| | 1.1 | Characteristic Equation, Eigenvalues and Eigenvectors, and properties | |
| | 1.2 | Cayley-Hamilton Theorem (without proof), verification and reduction of higher degree polynomials | |
| | 1.3 | Derogatory and non-derogatory matrices, Functions of Square Matrix | |
| | 1.4 | Similarity of matrices, diagonalizable and non-diagonalizable matrices | |
| 2 | **Probability** | | 8 |
| | 2.1 | Definition and basics of probability, conditional probability. Total Probability theorem and Bayes' theorem. | |
| | 2.2 | Discrete and continuous random variable with probability distribution and probability density function. | |
| | 2.3 | Expectation, Variance, Moment generating function, Raw and central Moments, Covariance, Correlation coefficient and their properties. | |
| | 2.4 | Probability Distribution: Binomial, Poisson and Normal distribution. | |
| 3 | **Probability Distribution and Sampling Theory** | | 8 |
| | 3.1 | Sampling distribution, Test of Hypothesis, Level of Significance, Critical region, One-tailed, and two-tailed test, Test of significance of mean and difference between the means of two samples for Large samples. | |
| | 3.2 | Degree of freedom, Student's t-distribution, Test of significance of mean and difference between the means of two samples for Small samples. | |
| | 3.3 | Chi-Square Test: Test of goodness of fit. Contingency table and Test of independence of attributes, Yate's Correction. | |
| 4 | **Statistical Techniques** | | 6 |
| | 4.1 | Karl Pearson's coefficient of correlation (r). | |
| | 4.2 | Spearman's Rank correlation coefficient (R) (with repeated and non-repeated ranks). | |

| | | | |
|---|---|---|---|
| | 4.3 | Fitting of first and second degree curves. | |
| | 4.4 | Lines of regression. | |
| 5 | **Linear Programming Problems** | | 6 |
| | 5.1 | Types of solutions, Standard and Canonical of LPP, Basic and Feasible solutions, slack variables, surplus variables, Simplex method. | |
| | 5.2 | Artificial variables, Big-M method (Method of penalty) | |
| | 5.3 | Duality, Dual of LPP and Dual Simplex Method. | |
| 6 | **Nonlinear Programming Problems** | | 5 |
| | 6.1 | NLPP with no constraint, one equality constraint (two or three variables) using the method of Lagrange's multipliers. | |
| | 6.2 | NLPP with two equality constraints. | |
| | 6.3 | NLPP with inequality constraint: Karush-Kuhn-Tucker (KKT) conditions. | |
| **Total** | | | 39 |

| **Text Books:** | |
|---|---|
| 1 | Advanced Engineering Mathematics, R. K. Jain and S. R. K. Iyengar, Narosa. |
| 2 | Gupta and Kapoor, Fundamental of Mathematical Statistics, S Chand |
| 3 | Operations Research, Hira and Gupta, S. Chand Publication. |

| **References:** | |
|---|---|
| 1 | Advanced Engineering Mathematics, Erwin Kreyszig, John Wiley & Sons. |
| 2 | Probability, Statistics and Random Processes, T. Veerarajan, McGraw-Hill Education. |
| 3 | Operations Research: An Introduction, Hamdy A Taha, Pearson. |

**Term work:**

Total 25 Marks Term work will be based on overall performance in the subject to be assessed via Tutorials/Assignment/Viva/ Mini Project based on application of the syllabus.

**Internal Assessment:**

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approximately 50% syllabus is completed. Duration of the midterm test shall be one hour.

**Continuous Assessment:**

Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered based on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

| Sr. No. | Rubrics | Marks |
|---|---|---|
| 1 | *Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2 | Content beyond syllabus presentation | 10 marks |
| 3 | Creating Proof of concept | 10 marks |
| 4 | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5 | Multiple Choice Questions (Quiz) | 5 marks |
| 6 | GATE Based Assignment/Tutorials etc | 10 marks |

*For sr. no. 1, the date of certification exam should be within the term and in case a student is unable to complete the certification, the grading has to be done accordingly.

| **End Semester Theory Examination:** | |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| Course Code | Course Name | Credit |
|---|---|---|
| ADC402 | Analysis of Algorithms | 3 |

| | |
|---|---|
| **Prerequisite:** Data structure concepts, Discrete structures | |
| **Course Objectives:** | |
| 1 | To provide mathematical approaches for Analysis of Algorithms |
| 2 | To understand and solve problems using various algorithmic approaches |
| 3 | To analyze algorithms using various methods |
| **Course Outcomes:** At the end of the course learner will be able to | |
| 1 | Analyze the running time and space complexity of algorithms. |
| 2 | Describe, apply and analyze the complexity of divide and conquer strategy. |
| 3 | Describe, apply and analyze the complexity of greedy strategy. |
| 4 | Describe, apply and analyze the complexity of dynamic programming strategy. |
| 5 | Explain and apply backtracking, branch and bound. |
| 6 | Explain and apply string matching techniques. |

| Module | | Detailed Contents | Hours |
|---|---|---|---|
| 1 | | **Introduction** | 8 |
| | 1.1 | Performance analysis, space and time complexity, Growth of function, Big-Oh, Omega, Theta notation.<br>Complexity class: Definition of P, NP, NP-Hard, NP-CompleteAnalysis of selection sort, insertion sort. | |
| | 1.2 | Recurrences: The substitution method, Recursion tree method, Master method | |
| 2 | | **Divide and Conquer Approach** | 6 |
| | 2.1 | General method, Merge sort, Quick sort, Finding minimum and maximum algorithms and their Analysis, Analysis of Binary search. | |
| 3 | | **Greedy Method Approach** | 6 |
| | 3.1 | General Method, Single source shortest path: Dijkstra Algorithm Fractional Knapsack problem, Job sequencing with deadlines, Minimum cost spanning trees: Kruskal and Prim's algorithms | |
| 4 | | **Dynamic Programming Approach** | 9 |
| | 4.1 | General Method, Multistage graphs, Single source shortest path:Bellman Ford Algorithm All pair shortest path: Floyd Warshall Algorithm, Problem 0/1 knapsack Problem, Travelling Salesperson problem, Longest common subsequence | |
| 5 | | **Backtracking and Branch and bound** | 6 |
| | 5.1 | General Method, Backtracking: N-queen problem, Sum of subsets, Graph coloring | |
| | 5.2 | Branch and Bound: Travelling Salesperson Problem, 15 Puzzle problem | |
| 6 | | **String Matching Algorithms** | 4 |
| | 6.1 | The Naïve string-matching algorithm, The Rabin Karp algorithm, The Knuth-Morris-Pratt algorithm | |
| **Total** | | | **39** |

| **Textbooks:** | |
|---|---|
| 1 | T. H. Cormen, C.E. Leiserson, R. L. Rivest, and C. Stein, "Introduction to algorithms", 2nd Edition, PHI Publication 2005. |
| 2 | Ellis Horowitz, Sartaj Sahni, S. Rajsekaran. "Fundamentals of computer algorithms" University Press. |

| References: | |
|---|---|
| 1 | Sanjoy Dasgupta, Christos Papadimitriou, Umesh Vazirani, “Algorithms”, Tata McGraw-Hill Edition. |
| 2 | S. K. Basu, “Design Methods and Analysis of Algorithm”, PHI |

**Internal Assessment:**
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approximately 50% syllabus is completed. Duration of the midterm test shall be one hour.

**Continuous Assessment:**
Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered based on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

| Sr. No. | Rubrics | Marks |
|---|---|---|
| 1 | *Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2 | Content beyond syllabus presentation | 10 marks |
| 3 | Creating Proof of concept | 10 marks |
| 4 | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5 | Multiple Choice Questions (Quiz) | 5 marks |
| 6 | GATE Based Assignment/Tutorials etc | 10 marks |

*For sr. no. 1, the date of certification exam should be within the term and in case a student is unable to complete the certification, the grading has to be done accordingly.

| End Semester Theory Examination: | |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| Useful Links | |
|---|---|
| 1 | https://nptel.ac.in/courses/106/106/106106131/ |
| 2 | https://swayam.gov.in/nd1_noc19_cs47/preview |
| 3 | https://www.coursera.org/specializations/algorithms |
| 4 | https://www.mooc-list.com/tags/algorithms |

| Course Code: | Course Title | Credit |
|---|---|---|
| ADC403 | Database Management System | 3 |

| | |
|---|---|
| **Prerequisite: Data Structures** | |
| **Course Objectives:** | |
| 1 | Develop entity relationship data model and its mapping to relational model |
| 2 | Learn relational algebra and Formulate SQL queries |
| 3 | Apply normalization techniques to normalize the database |
| 4 | Understand concept of transaction, concurrency control and recovery techniques. |
| **Course Outcomes:** | |
| 1 | Recognize the need of database management system |
| 2 | Design ER and EER diagram for real life applications |
| 3 | Construct relational model and write relational algebra queries. |
| 4 | Formulate SQL queries |
| 5 | Apply the concept of normalization to relational database design. |
| 6 | Describe the concept of transaction, concurrency and recovery. |

| Module | | Content | Hrs |
|---|---|---|---|
| **1** | | **Introduction Database Concepts** | **3** |
| | 1.1 | Introduction, Characteristics of databases, File system v/s Database system, Data abstraction and data Independence, DBMS system architecture, Database Administrator | |
| **2** | | **Entity–Relationship Data Model** | **6** |
| | 2.1 | The Entity-Relationship (ER) Model: Entity types: Weak and strong entity sets, Entity sets, Types of Attributes, Keys, Relationship constraints: Cardinality and Participation, Extended Entity-Relationship (EER) Model: Generalization, Specialization and Aggregation | |
| **3** | | **Relational Model and relational Algebra** | **8** |
| | 3.1 | Introduction to the Relational Model, relational schema and concept of keys. Mapping the ER and EER Model to the Relational Model, Relational Algebra-operators, Relational Algebra Queries. | |
| **4** | | **Structured Query Language (SQL)** | **6** |
| | 4.1 | Overview of SQL, Data Definition Commands, Integrity constraints: key constraints, Domain Constraints, Referential integrity, check constraints, Data Manipulation commands, Data Control commands, Set and string operations, aggregate function-group by, having, Views in SQL, joins, Nested and complex queries, Triggers | |
| **5** | | **Relational-Database Design** | **6** |
| | 5.1 | Pitfalls in Relational-Database designs, Concept of normalization, Function Dependencies, First Normal Form, 2NF, 3NF, BCNF. | |
| **6** | | **Transactions Management and Concurrency and Recovery** | **10** |
| | 6.1 | Transaction concept, Transaction states, ACID properties, Transaction Control Commands, Concurrent Executions, Serializability-Conflict and View, Concurrency Control: Lock-based, Timestamp-based protocols, Recovery System: Log based recovery, Deadlock handling | |
| **Total** | | | **39** |

| **Textbooks:** | |
|---|---|
| 1 | Korth, Slberchatz, Sudarshan, Database System Concepts, 6thEdition, McGraw Hill |
| 2 | Elmasri and Navathe, Fundamentals of Database Systems, 5thEdition, Pearson Education |
| 3 | Raghu Ramkrishnan and Johannes Gehrke, Database Management Systems, TMH |
| **References:** | |
| 1 | Peter Rob and Carlos Coronel, Database Systems Design, Implementation and Management‖, Thomson Learning, 5thEdition. |
| 2 | Dr. P.S. Deshpande, SQL and PL/SQL for Oracle 10g, Black Book, Dreamtech Press. |
| 3 | G. K. Gupta, Database Management Systems, McGraw Hill, 2012 |

**Internal Assessment:**
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approximately 50% syllabus is completed. Duration of the midterm test shall be one hour.

**Continuous Assessment:**
Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered based on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

| Sr. No. | Rubrics | Marks |
|---|---|---|
| 1 | *Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2 | Content beyond syllabus presentation | 10 marks |
| 3 | Creating Proof of concept | 10 marks |
| 4 | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5 | Multiple Choice Questions (Quiz) | 5 marks |
| 6 | GATE Based Assignment/Tutorials etc | 10 marks |

*For sr. no. 1, the date of certification exam should be within the term and in case a student is unable to complete the certification, the grading has to be done accordingly.

| **End Semester Theory Examination:** | |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| **Useful Links** | |
|---|---|
| 1 | https://nptel.ac.in/courses/106/105/106105175/ |
| 2 | https://swayam.gov.in/nd1_noc19_cs46/preview |
| 3 | https://www.classcentral.com/course/swayam-database-management-system-9914 |
| 4 | https://www.mooc-list.com/tags/dbms |

| Course Code | Course Name | Credit |
|---|---|---|
| ADC404 | Theory of Computer Science | 3 |

**Prerequisites:**

**Course Objectives:**

| | |
|---|---|
| 1 | To learn fundamentals of Regular and Context Free Grammars and Languages |
| 2 | To understand the relation between Regular Language and Finite Automata and machines. |
| 3 | To learn how to design Automata's and machines as Acceptors, Verifiers and Translators. |
| 4 | To understand the relation between Contexts free Languages, PDA and TM. |
| 5 | To learn how to design PDA as acceptor and TM as Calculators. |
| 6 | To learn how to co-relate Automata with Programs and Functions. |

**Course Outcome:**

| | |
|---|---|
| 1 | Understand, design, construct, analyze and interpret Regular languages, Expression and Grammars. |
| 2 | Design different types of Finite Automata and Machines as Acceptor, Verifier and Translator. |
| 3 | Understand, design, analyze and interpret Context Free languages, Expression and Grammars. |
| 4 | Design different types of Push down Automata as Simple Parser. |
| 5 | Design different types of Turing Machines as Acceptor, Verifier, Translator and Basic computing machine. |
| 6 | Compare, understand and analyze different languages, grammars, Automata and Machines and appreciate their power and convert Automata to Programs and Functions |

| Module | Detailed Content | | Hours |
|---|---|---|---|
| **1** | Introduction and Regular Languages | | **6** |
| | 1.1 | Languages: Alphabets and Strings. | |
| | 1.2 | Regular Languages: Regular Expressions, Regular Languages, Regular Grammars, RL and LL grammars, Closure properties | |
| **2** | **Finite Automata and Machines** | | **9** |
| | 2.1 | Finite Automata: FA as language acceptor or verifier, NFA (with and without ε), DFA, RE to NFA, NFA to DFA, Reduced DFA, NFA-DFA equivalence, FA to RE. | |
| | 2.2 | Finite State Machines: machines with output | |
| | 2.3 | Moore and Mealy machines, Machines as translators. Melay and Moore machines conversion | |
| **3** | **Context Free Grammars** | | **8** |
| | 3.1 | Context Free Languages: CFG, Leftmost and Rightmost derivations, Ambiguity, | |
| | 3.2 | Simplification and Normalization (CNF) and Chomskey Hierarchy (Types 0 to 3) | |
| **4** | **Push Down Automata** | | **5** |
| | 4.1 | Deterministic (single stack) PDA, Equivalence between PDA and CFG. | |
| **5** | **Turing Machine** | | **7** |

| | | | |
|---|---|---|---|
| | 5.1 | Deterministic TM, Multi-track and Multi-tape TMs, concept of UTM and idea of system program. Issue and concept of Halting Problem | |
| **6** | **Applications of Automata** | | **4** |
| | 6.1 | Power and Limitations of Regular and Context Free Grammars and Machines | |
| | 6.2 | Decidability and Undecidability, Recursive and Recursively Enumerable Languages, Halting Problem, Rice's Theorem, Post Correspondence Problem. | |
| **Total** | | | **39** |

| **Textbooks:** | |
|---|---|
| 1 | J. C. Martin, "Introduction to languages and the Theory of Computation", TMH. |
| 2 | Kavi Mahesh, "Theory of Computation A Problem-Solving Approach", Wiley India |
| **References:** | |
| 1 | John E. Hopcroft, Rajeev Motwani, Jeffrey D. Ullman, "Introduction to Automata Theory, Languages and Computation", Pearson Education. |
| 2 | Daniel I. A. Cohen, "Introduction to Computer Theory", John Wiley & Sons. |
| 3 | Theory of Computation - By Vivek Kulkarni from Oxford University. |
| 4 | N. Chandrashekhar & K.L.P. Mishra, "Theory of Computer Science, Automata Languages & Computations", PHI publications. |

**Internal Assessment:**
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approximately 50% syllabus is completed. Duration of the midterm test shall be one hour.

**Continuous Assessment:**
Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered based on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

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| 1 | *Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2 | Content beyond syllabus presentation | 10 marks |
| 3 | Creating Proof of concept | 10 marks |
| 4 | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5 | Multiple Choice Questions (Quiz) | 5 marks |
| 6 | GATE Based Assignment/Tutorials etc | 10 marks |

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| **End Semester Theory Examination:** | |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
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| Course Code | Course Name | Credits |
|---|---|---|
| ADC405 | Internet of Things | 3 |

**Course objectives:**

| | |
|---|---|
| 1 | To comprehend Characteristics and Conceptual Framework of IoT |
| 2 | To understand levels of the IoT architectures |
| 3 | To correlate the connection of smart objects and IoT access technologies |
| 4 | To Interpret edge to cloud protocols |
| 5 | To explore data analytics and data visualization on IoT Data |
| 6 | To explore IoT applications |

**Course outcomes:** On successful completion of course, learner will be able to:

| | |
|---|---|
| 1 | Describe the Characteristics and Conceptual Framework of IoT |
| 2 | Differentiate between the levels of the IoT architectures |
| 3 | Analyze the IoT access technologies |
| 4 | Illustrate various edge to cloud protocol for IoT |
| 5 | Apply IoT analytics and data visualization |
| 6 | Analyze and evaluate IoT applications |

| Module | Detailed Contents | | Hours |
|---|---|---|---|
| 1 | **Introduction to IoT** | | **3** |
| | 1.1 | Introduction to IoT- Defining IoT, Characteristics of IoT, Conceptual Framework of IoT, Physical design of IoT, Logical design of IoT, Functional blocks of IoT, Brief review of applications of IoT. Smart Object – Definition, Characteristics and Trends | |
| **2** | **IoT Architecture** | | **6** |
| | 2.1 | Drivers Behind New Network Architectures: Scale, Security, Constrained Devices and Networks, Data Legacy Device Support | |
| | 2.2 | Architecture: The IoT World Forum (IoTWF) Standardized Architecture: Layer 1-7, IT and OT Responsibilities in the IoT Reference Model, Additional IoT Reference Models | |
| | 2.3 | A Simplified IoT Architecture, The Core IoT Functional Stack: Layer 1-3 , Analytics Versus Control Applications , Data Versus Network Analytics Data Analytics Versus Business Benefits , Smart Services, | |
| | 2.4 | IoT Data Management and Compute Stack: Fog Computing, Edge Computing ,The Hierarchy of Edge, Fog, and Cloud | |
| **3** | **Principles of Connected Devices and Protocols in IoT** | | **8** |
| | **3.1** | RFID and NFC (Near-Field Communication), Bluetooth Low Energy (BLE) roles, LiFi, WPAN std: 802.15 standards: Bluetooth, IEEE 802.15.4, Zigbee, Z-wave, Narrow Band IoT, Internet Protocol and Transmission Control Protocol, 6LoWPAN, WLAN and WAN , IEEE 802.11, Long-range Communication Systems and Protocols: Cellular Connectivity-LTE, LTE-A, LoRa and LoRaWAN. | |
| **4** | **Edge to Cloud Protocol** | | **8** |
| | **4.1** | HTTP, WebSocket, Platforms. HTTP - MQTT - Complex Flows: IoT Patterns: Real-time Clients, MQTT, MQTT-SN, Constrained Application Protocol (CoAP), Streaming Text Oriented Message Protocol (STOMP), Advanced Message Queuing Protocol (AMQP), Comparison of Protocols. | |
| **5** | **IoT and Data Analytics** | | **6** |
| | **5.1** | Defining IoT Analytics, IoT Analytics challenges, IoT analytics for the | |

| | | | |
|---|---|---|---|
| | | cloud, Strategies to organize Data for IoT Analytics, Linked Analytics Data Sets, Managing Data lakes, The data retention strategy, visualization and Dashboarding-Designing visual analysis for IoT data, creating a dashboard, creating and visualizing alerts. | |
| **6** | **IoT Application Design** | | **8** |
| | **6.1** | Prototyping for IoT and M2M, Case study related to: Home Automation (Smart lighting, Home intrusion detection), Cities (Smart Parking), Environment (Weather monitoring, weather reporting Bot, Air pollution monitoring, Forest fire detection, Agriculture (Smart irrigation), Smart Library. | |
| **Total** | | | **39** |

| **Textbooks:** | |
|---|---|
| 1 | Arsheep Bahga (Author), Vijay Madisetti, Internet Of Things: A Hands-On Approach Paperback, Universities Press, Reprint 2020 |
| 2 | David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, IoT Fundamentals Networking Technologies, Protocols, and Use Cases for the Internet of Things CISCO. |
| **References:** | |
| 1 | Analytics for the Internet of Things (IoT) Intelligent Analytics for Your Intelligent Devices. Andrew Minteer, Packet |
| 2 | Giacomo Veneri , Antonio Capasso, Hands-On Industrial Internet of Things: Create a powerful Industrial IoT infrastructure using Industry 4.0, Packt |

**Internal Assessment:**
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approximately 50% syllabus is completed. Duration of the midterm test shall be one hour.

**Continuous Assessment:**
Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered based on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

| **Sr. No.** | **Rubrics** | **Marks** |
|---|---|---|
| 1 | *Certificate course for 4 weeks or more: NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2 | Content beyond syllabus presentation | 10 marks |
| 3 | Creating Proof of concept | 10 marks |
| 4 | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5 | Multiple Choice Questions (Quiz) | 5 marks |
| 6 | GATE Based Assignment/Tutorials etc | 10 marks |

*For sr. no. 1, the date of certification exam should be within the term and in case a student is unable to complete the certification, the grading has to be done accordingly.

| | End Semester Theory Examination: |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| Course Name | Lab Name | Credit |
|---|---|---|
| **ADL401** | **Analysis of Algorithms Lab** | **1** |

| **Prerequisite: Basic knowledge of programming and data structure** | |
|---|---|
| **Lab Objectives:** | |
| 1 | To introduce the methods of designing and analyzing algorithms |
| 2 | Design and implement efficient algorithms for a specified application |
| 3 | Strengthen the ability to identify and apply the suitable algorithm for the given real-world problem. |
| 4 | Analyze worst-case running time of algorithms and understand fundamental algorithmic problems. |
| **Lab Outcomes:** At the end of the course, the students will be able to | |
| 1 | Implement the algorithms using different approaches. |
| 2 | Analyze the complexities of various algorithms. |
| 3 | Compare the complexity of the algorithms for specific problem. |

| **Description** | | |
|---|---|---|
| Implementation can be in any language. | | |
| **Suggested Practical List:** | | |
| **Sr No** | | **Suggested Experiment List** |
| **1** | | **Introduction** |
| | **1.1** | Selection sort, Insertion sort |
| **2** | | **Divide and Conquer Approach** |
| | **2.1** | Finding Minimum and Maximum, Merge sort, Quick sort, Binary search |
| **3** | | **Greedy Method Approach** |
| | **3.1** | Single source shortest path- Dijkstra<br>Fractional Knapsack problem<br>Job sequencing with deadlines<br>Minimum cost spanning trees-Kruskal and Prim's algorithm |
| **4** | | **Dynamic Programming Approach** |
| | **4.1** | Single source shortest path- Bellman Ford<br>All pair shortest path- Floyd Warshall<br>0/1 knapsack<br>Travelling salesperson problem<br>Longest common subsequence |
| **5** | | **Backtracking and Branch and bound** |
| | **5.1** | N-queen problem<br>Sum of subsets<br>Graph coloring |
| **6** | | **String Matching Algorithms** |
| | **6.1** | The Naïve string-matching Algorithms<br>The Rabin Karp algorithm<br>The Knuth-Morris-Pratt algorithm |

| | |
|---|---|
| **Term Work:** | |
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks based on evaluation of Experiments. |
| **Evaluation Exam** | |
| 1 | Practical Exam based on the syllabus of ADL401and ADC402 |

| Lab Code | Lab Name | Credit |
|---|---|---|
| ADL402 | Database Management System Lab | 1 |

| | |
|---|---|
| **Prerequisite:** Discrete Structures | |
| **Lab Objectives:** | |
| 1 | To explore design and develop of relational model |
| 2 | To present SQL and procedural interfaces to SQL comprehensively |
| 3 | To introduce the concepts of transactions and transaction processing |
| **Lab Outcomes:** At the end of the course, the students will be able to | |
| 1 | Design ER /EER diagram and convert to relational model for the realworld application. |
| 2 | Apply DDL, DML, DCL and TCL commands |
| 3 | Write simple and complex queries |
| 4 | UsePL / SQL Constructs. |
| 5 | Demonstrate the concept of concurrent transactions execution and frontend-backend connectivity |

| **Suggested List of Experiments** | |
|---|---|
| **Sr. No.** | **Title of Experiment** |
| 1 | Identify the case study and detail statement of problem. Design an Entity-Relationship (ER) / Extended Entity-Relationship (EER) Model. |
| 2 | Mapping ER/EER to Relational schema model. |
| 3 | Create a database using Data Definition Language (DDL) and apply integrity constraints for the specified System |
| 4 | Apply DML Commands for the specified system |
| 5 | Perform Simple queries, string manipulation operations and aggregate functions. |
| 6 | Implement various Join operations. |
| 7 | Perform Nested and Complex queries |
| 8 | Perform DCL and TCL commands |
| 9 | Implement procedure and functions |
| 10 | Implementation of Views and Triggers. |
| 11 | Demonstrate Database connectivity |
| 12 | Implementation and demonstration of Transaction and Concurrency control techniques using locks. |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks based on evaluation of Experiments |
| **Evaluation Exam** | |
| 1 | Practical Exam based on the syllabus of ADL402 and ADC403 |

| Lab Code | Lab Name | Credits |
|---|---|---|
| ADL403 | Internet of Things Lab | 1 |

| | |
|---|---|
| **Lab objectives:** | |
| 1 | To learn different types of sensors |
| 2 | To design the problem solution as per the requirement analysis done using sensors. |
| 3 | To study the basic concepts of programming/sensors/ emulators |
| 4 | To design and implement the mini project intended solution for project-based learning. |
| 5 | To build and test the mini project successfully. |
| 6 | To improve the team building, communication and management skills of the students. |
| **Lab outcomes:** On successful completion of course, learner will be able to: | |
| 1 | Identify the requirements for the real-world problems. |
| 2 | Conduct a survey of several available literatures in the preferred field of study. |
| 3 | Study and enhance software/ hardware skills. |
| 4 | Demonstrate and build the project successfully by hardware/sensor requirements, coding, emulating and testing. |
| 5 | To report and present the findings of the study conducted in the preferred domain |
| 6 | Demonstrate an ability to work in teams and manage the conduct of the research study |

**Prerequisite:** Basics of Java and Python Programming

**Guidelines**

1. The mini project work is to be conducted by a group of students
2. Each group will be associated with a subject Incharge/ mini project mentor. The group should meet with the concerned faculty during Laboratory hours and the progress of work discussed must be documented.
3. The students must understand the
    a. Concept
    b. Importance
    c. Interdisciplinary
    d. Challenges
    e. Various applications/smart objects
    f. Major Players/Industry Standards.
4. The students must understand the IoT Architecture:
    a. Node Structure: Sensing, Processing, Communication, Powering
    b. Networking: Topologies, Layer/Stack architecture
    c. Communication Technologies: Introduction to ZigBee, BLE, WiFi, LTE, IEEE 802.11ah, Discuss data rate, range, power, computations/bandwidth, QoS
    d. Smartness - Signal Processing/Analytics: Impact on Power/Energy savings, dynamic networks, simple case studies
    e. IoT Fabricator: Introduction to Embedded electronics, fabricating electronics, Communication Network requirements, Data processing challenges – recreation, IP/security, Challenges
    f. Hands-on in IoT: Projects based on some Hardware (Raspberry pi, Arduino, Intel, IITH Mote, Smartphones), Software (Contiki, TinyOS, Android), IoT Fabricator etc. can be used.
5. The students may visit different websites to identify their IOT topic for the mini project.
6. The students may do surveys for different applications using different types of sensors for their mini project.

7. Each group will identify the Hardware (Motes from different Motes families) & sensor configuration and software requirements for their mini project problem statement.
8. Design your own circuit board using multiple sensors etc.
9. Installation, configure and manage your sensors in such a way so that they can communicate with each other.
10. Work with operating system, emulator like contiki cooja and do coding to for input devices on sensors
11. Create an interface using Mobile/Web to publish or remotely access the data on the Internet. 11. Each group along with the concerned faculty shall identify a potential problem statement, on which the study and implementation is to be conducted.
12. Analyze data collected from different sensors on platform like thinkspeak
13. Each group may present their work in various project competitions or paper presentations.
14. A detailed report is to be prepared as per guidelines given by the concerned faculty.

| **Suggested Experiments:** |
|---|
| **Student in group of 4 (max), will perform 5 Assignment / Activity / Experiment based on the entire syllabus of ADC405 (Internet of Things)** |

| **Textbooks:** | |
|---|---|
| 1 | Interconnecting Smart Objects with IP: The Next Internet, Jean-Philippe Vasseur, Adam Dunkels, Morgan Kuffmann |
| 2 | Designing the Internet of Things , Adrian McEwen (Author), Hakim Cassimally |
| 3 | Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems, Dr. Ovidiu Vermesan, Dr. Peter Friess, River Publishers |
| 4 | Internet of Things (A Hands-on-Approach) , Vijay Madisetti , Arshdeep Bahga |
| **References:** | |
| 1 | 6LoWPAN: The Wireless Embedded Internet, Zach Shelby, Carsten Bormann, Wiley |
| 2 | Building the internet of things with ipv6 and mipv6, The Evolving World of M2M Communications, Daniel Minoli John Wiley & Sons |
| 3 | Contiki Cooja User Guide. |
| 4 | Fundamentals of Sensor Network Programming: Applications and Technology, By S. Sitharama Iyengar, Nandan Parameshwaran, Vir V. Phoha, N. Balakrishnan, Chuka D. Okoye, Wiley publication. |
| 5 | Recent research/white papers |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 5 Assignment / Activity / Experiment |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks based on evaluation of suggested Assignments / Activities / Experiments. |

| Lab Code | Lab Name | Credit |
|---|---|---|
| **ADL404** | **Python Programming** | **2** |

| | |
|---|---|
| **Prerequisite:** Knowledge of some programming language like C, Java | |
| **Lab Objectives:** | |
| 1 | Basics of Python programming |
| 2 | Decision Making, Data structure and Functions in Python |
| 3 | Object Oriented Programming using Python |
| 4 | Web framework for developing |
| **Lab Outcomes:** At the end of the course, the students will be able to | |
| 1 | To understand basic concepts in python. |
| 2 | To explore contents of files, directories and text processing with python |
| 3 | To develop program for data structure using built in functions in python. |
| 4 | To explore django web framework for developing python-based web application. |
| 5 | To understand Multithreading concepts using python. |

| Module | | Detailed Content | Hours |
|---|---|---|---|
| **1** | | **Python basics** | **5** |
| | 1.1 | Data types in python, Operators in python, Input and Output, Control statement, Arrays in python, String and Character in python, Functions, List and Tuples, Dictionaries Exception, Introduction to OOP, Classes, Objects, Interfaces, Inheritance | |
| **2** | | **Advanced Python** | **4** |
| | 2.1 | Files in Python, Directories, Building Modules, Packages, Text Processing, Regular expression in python. | |
| **3** | | **Data Structure in Python** | **3** |
| | 3.1 | Link List, Stack, Queues, Dequeues | |
| **4** | | **Python Integration Primer** | **4** |
| | 4.1 | Graphical User interface, Networking in Python, Python database connectivity, Introduction to Django | |
| **5** | | **Multithreading** | **4** |
| | 5.1 | Thread and Process, Starting a thread, Threading module, Synchronizing threads, Multithreaded Priority Queue | |
| **6** | | **NumPy and Pandas** | **6** |
| | 6.1 | Creating NumPy arrays, Indexing and slicing in NumPy, creating multidimensional arrays, NumPy Data types, Array Attribute, Indexing and Slicing, Creating array views copies, Manipulating array shapes I/O | |
| | 6.2 | Basics of Pandas, Using multilevel series, Series and Data Frames, Grouping, aggregating, Merge Data Frames | |

| **Textbooks:** | |
|---|---|
| 1 | Dr. R. Nageswara Rao, “Core Python Programming”, Dreamtech Press |
| 2 | Beginning Python: Using Python 2.6 and Python 3.1. James Payne, Wrox Publication |
| 3 | Anurag Gupta, G. P. Biswas, “Python Programming”, McGraw-Hill |
| 4 | E. Balagurusamy, “Introduction to computing and problem-solving using python”, McGraw Hill Education |
| **References:** | |
| 1 | Learn Python the Hard Way, 3rd Edition, Zed Shaw's Hard Way Series |
| 2 | Laura Cassell, Alan Gauld, “Python Projects”, Wrox Publication |

| **Digital material:** | |
|---|---|
| 1 | "The Python Tutorial",http://docs.python.org/release/3.0.1/tutorial/ |
| 2 | Beginning Perl,https://www.perl.org/books/beginning-perl/ |
| 3 | http://spoken-tutorial.org |
| 4 | https://starcertification.org/Certifications/Certificate/python |

| **Suggested experiments using Python:** | |
|---|---|
| **Sr. No.** | **Title of Experiments** |
| **1** | Exploring basics of python like data types (strings, list, array, dictionaries, set, tuples) and control statements. |
| **2** | Creating functions, classes and objects using python. Demonstrate exception handling and inheritance. |
| **3** | Exploring Files and directories<br>a. Python program to append data to existing file and then display the entire file<br>b. Python program to count number of lines, words and characters in a file.<br>c. Python program to display file available in current directory |
| **4** | Creating GUI with python containing widgets such as labels, textbox, radio, checkboxes and custom dialog boxes. |
| **5** | Menu driven program for data structure using built in function for link list, stack and queue. |
| **6** | Program to demonstrate CRUD (**create, read, update and delete)** operations on database (SQLite/ MySQL) using python. |
| **7** | Creation of simple socket for basic information exchange between server and client. |
| **8** | Creating web application using Django web framework to demonstrate functionality of user login and registration (also validating user detail using regular expression). |
| **9** | Programs on Threading using python. |
| **10** | Exploring basics of NumPy Methods. |
| **11** | Program to demonstrate use of NumPy: Array objects. |
| **12** | Program to demonstrate Data Series and Data Frames using Pandas. |
| **13** | Program to send email and read content of URL. |

| | |
|---|---|
| **Term Work:** | |
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 50 Marks to be divided among the experiments. |
| **Evaluation Exam** | |
| 1 | Practical Exam based on the syllabus of ADL404. |

| Course code | Course Name | Credits |
|---|---|---|
| ADS401 | Mobile App Development 2 | 2 |

| | |
|---|---|
| **Prerequisite:** | |
| **Lab Objectives:** | |
| 1 | Learn the advanced concepts of the Flutter framework. |
| 2 | Develop the App UI by incorporating widgets, layouts, gestures and animation |
| 3 | Create a production ready Flutter App by including files and firebase backend service. |
| **Lab Outcomes:**<br>**At the end of the course, students will be able to —-** | |
| 1 | Understand cross platform mobile application development using Flutter framework |
| 2 | Design and Develop interactive Flutter App by using widgets, layouts, gestures and animation |
| 3 | Analyze and Build production ready Flutter App by incorporating backend services and deploying on Android / iOS |

| Module | Detailed Content | |
|---|---|---|
| **1** | **Working with files in Flutter** | |
| | 1.1 | Including libraries in Flutter app, including a file with the app, Reading/Writing to files, Using JSON. |
| **2** | **Using Firebase with Flutter** | |
| | 2.1 | Adding the Firebase and Firestore Backend, Configuring the Firebase Project, Adding a Cloud Firestore |
| **3** | **Creating Production Ready Apps** | |
| | 3.1 | Testing and Deploying of Flutter Application: Widget testing, Deploying Flutter Apps on Android / iOS |

| **Suggested Experiments:** |
|---|
| **Student in group of 4 (max), will perform 5 Assignment / Activity / Experiment based on the above syllabus** |

| | |
|---|---|
| **Textbooks:** | |
| 1 | Beginning Flutter a Hands-on Guide to App Development, Marco L. Napoli, Wiley, 2020. |
| 2 | Beginning App Development with Flutter: Create Cross-Platform Mobile Apps, By Rap Payne, 2019. |
| **References:** | |
| 1 | Flutter in Action by Eric Windmill, MANING, 2019 |
| 2 | Google Flutter Mobile Development Quick Start Guide. Packt, 2019 |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 5 Assignment / Activity / Experiment |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 50 Marks based on evaluation of suggested Assignments / Activities / Experiments. |

PROGRAM STRUCTURE FOR THIRD YEAR AI and DS

**Scheme for Autonomous Program** (With Effect from 2023-20234)

**Semester V**

| Course Code | Course Name | Teaching Scheme (Contact Hours) | | Credits Assigned | | |
|---|---|---|---|---|---|---|
| | | Theory | Pract. | Theory | Pract. | Total |
| ADC501 | Cloud Computing | 3 | -- | 3 | -- | 3 |
| ADC502 | Web Development | 3 | -- | 3 | | 3 |
| ADC503 | Artificial Intelligence | 3 | -- | 3 | -- | 3 |
| ADC504 | Data Warehousing & Mining | 3 | -- | 3 | -- | 3 |
| ADLO5 01X | Department Level Optional Course- 1 | 3 | -- | 3 | -- | 3 |
| ADL501 | Web Development L a b | -- | 2 | -- | 1 | 1 |
| ADL502 | Artificial Intelligence Lab | -- | 2 | -- | 1 | 1 |
| ADL503 | Data warehousing and Mining Lab | | 2 | -- | 1 | 1 |
| ADL504 | Professional Communication and Ethics-II | -- | 2*+2 | -- | 2 | 2 |
| ADS501 | Skill based Lab : Cloud Computing | -- | 4$ | -- | 2 | 2 |
| **Total** | | **15** | **14** | **15** | **07** | **22** |

| Course Code | Course Name | Examination Scheme | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | Term Work | Pract | Total |
| | | Internal Assessment | | End Sem Exam | Exam. Duration (in Hrs) | | | |
| | | Mid Term | CA | | | | | |
| ADC501 | Cloud Computing | 20 | 20 | 60 | 2 | - | -- | 100 |
| ADC502 | Web Development | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADC503 | Artificial Intelligence | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADC504 | Data Warehousing & Mining | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADLO5 01X | Department Level Optional Course- 1 | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADL 502 | Web Development Lab | | | | | 25 | 25 | 50 |
| ADL502 | Artificial Intelligence Lab | -- | -- | -- | -- | 25 | 25 | 50 |
| ADL503 | Data Warehousing and Mining Lab | -- | -- | -- | -- | 25 | 25 | 50 |
| ADL504 | Professional Communication and Ethics-II | -- | -- | -- | -- | 50 | -- | 50 |
| ADS501 | Skill based Lab : Cloud Computing Lab | | | | | 50 | -- | 50 |
| **Total** | | **100** | **100** | **300** | -- | **175** | **75** | **750** |

PROGRAM STRUCTURE FOR THIRD YEAR(AI and DS)

**Scheme for Autonomous Program**

**Semester VI**

| Course Code | Course Name | Teaching Scheme (Contact Hours) | | Credits Assigned | | |
|---|---|---|---|---|---|---|
| | | Theory | Pract. Tut. | Theory | Pract. | Total |
| ADC601 | Data Analytics and Visualization | 3 | -- | 3 | -- | 3 |
| ADC602 | Cryptography and System Security | 3 | -- | 3 | | 3 |
| ADC603 | Software Engineering and Project Management | 3 | -- | 3 | -- | 3 |
| ADC604 | Machine Learning | 3 | -- | 3 | -- | 3 |
| ADLO601X | Department Level Optional Course -2 | 3 | -- | 3 | -- | 3 |
| ADL601 | Data Analytics and Visualization Lab | -- | 2 | -- | 1 | 1 |
| ADL602 | Cryptography & System Security Lab | -- | 2 | -- | 1 | 1 |
| ADL603 | Software Engineering and Project Management Lab | -- | 2 | -- | 1 | 1 |
| ADL604 | Machine Learning Lab | -- | 2 | -- | 1 | 1 |
| ADL605 | R Programming / Tableau | -- | 2*+ 2 | -- | 2 | 2 |
| ADS601 | Skill based lab: AWS Essentials /Azure Data Engineer | -- | 4$ | -- | 2 | 2 |
| **Total** | | **15** | **16** | **15** | **08** | **23** |

| Course Code | Course Name | Examination Scheme | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | Term Work | Pract. | Total |
| | | Internal Assessment | | End Sem Exam | Exam. Duration (in Hrs) | | | |
| | | Mid Term | CA | | | | | |
| ADC601 | Data Analytics and Visualization | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADC602 | Cryptography and System Security | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADC603 | Software Engineering and Project Management | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADC604 | Machine Learning | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADLO601X | Department Level Optional Course -2 | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADL601 | Data Analytics and Visualization Lab | -- | -- | -- | -- | 25 | 25 | 50 |
| ADL602 | Cryptography & System Security Lab | -- | -- | -- | -- | 25 | -- | 25 |
| ADL603 | Software Engineering and Project Management Lab | -- | -- | -- | -- | 25 | 25 | 50 |
| ADL604 | Machine Learning Lab | -- | -- | -- | -- | 25 | 25 | 50 |
| ADL605 | R Programming / Tableau lab | -- | -- | -- | -- | 50 | -- | 50 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ADS601 | Skill based lab: AWS Essentials / Azure Data Engineer | -- | -- | -- | -- | 50 | -- | 50 |
| **Total** | | **100** | **100** | **300** | -- | **200** | **75** | **775** |

* Theory class to be conducted for full class and $ indicates workload of Learner (Not Faculty)

| **Department Optional Courses** | **Semester** | **Code & Subject** |
|---|---|---|
| Department Optional Course -1 | V | CSDLO5011 : Statistics for Artificial Intelligence & Data Science<br>CSDLO5012: Advanced Algorithms<br>CSDLO5013: Computer Graphics |
| Department Optional Course -2 | VI | CSDLO6011: High Performance Computing<br>CSDLO6012: Distributed Computing<br>CSDLO6013: Image processing and Computer Vision |

| Course Code | Course Name | Credit |
|---|---|---|
| ADC501 | Cloud Computing | 03 |

| | |
|---|---|
| **Pre-requisite: Operating System** | |
| **Course Objectives: To understand cloud computing techniques** | |
| 1 | To comprehend Characteristics and Concept of cloud techniques. |
| 2 | To understand levels of virtualization |
| 3 | To correlate the connection of cloud service providers |
| 4 | To understand cloud implementation |
| 5 | To explore security and risk involved with cloud computing |
| **Course Outcomes:** After successful completion of the course, student will be able to: | |
| 1 | Differentiate between different cloud computing techniques. |
| 2 | Understand virtualization and its key concepts |
| 3 | Compare various cloud computing providers/software. |
| 4 | Handle open source cloud implementation and administration. |
| 5 | Understand risks involved in cloud computing. |

| Module | | Detailed Content | Hours |
|---|---|---|---|
| 1 | | **Introduction to Cloud Computing** | 05 |
| | 1.1 | Introduction– Component of CC, Comparing CC with Virtualization, Grids, Utility Computing, client-server model, P to P Computing, Impact of CC on Business, Key Drivers for Cloud Computing, Cloud computing Service delivery model. Cloud Types – Private, Public and Hybrid, when to avoid public cloud, Cloud AP. | |
| 2 | | **Virtualization** | 06 |
| | 2.1 | Introduction & benefit of Virtualization, Implementation Levels of Virtualization, VMM Design Requirements and Providers, Virtualization at OS level, Middleware support for Virtualization, Virtualization structure/tools and mechanisms: Hypervisor and Xen Architecture, Binary Translation with full Virtualization, Para Virtualization with Compiler Support. Virtualization of CPU, Memory and I/O Devices, Hardware support for Virtualization in Intel x86 processor, CPU Virtualization, Memory Virtualization | |
| 3 | | **Cloud computing Services and business value** | 08 |
| | 3.1 | XaaS, IaaS, PaaS- Leveraging PaaS for Productivity Languages for PaaS- DBaaS(Database as a services) – SaaS (Software as a service) – Comparison of various cloud computing providers/ Softwares. | |
| | 3.2 | Key Business Drivers for CC- Cloud computing and out sourcing – Types of Scalability – Security issues in Cloud Computing- time to Market Benefits- Distribution over Internet – Three levels of Business value from Cloud computing. | |

| | | | |
|---|---|---|---|
| **4** | | **Cloud Deployment Techniques** | 07 |
| | 4.1 | Factors for Successful Cloud Deployment – Network Requirements – Potential Problem areas in a cloud Network and their Mitigation – Cloud Network Topologies – Automation and Self-service feature in a cloud –cloud performance.<br>Mobile Cloud Computing Introduction, Definition, Architecture, Benefits, challenges in mobile and at cloud shield. | |
| **5** | | **Security** | 07 |
| | 5.1 | Security for Virtualization Platform – Host security for SaaS, 4 PaaS and IaaS – Data Security – Data Security Concerns – Data Confidentiality and Encryption – Data Availability – Data Integrity – Cloud Storage Gateways – Cloud Firewall<br>Security as a service What can security as service offer- Benefits for Security as a service Issues with Security as a Service- Identity Management as a Service | |
| **6** | | **Architecture for Cloud Application:** | 06 |
| | 6.1 | Cloud Application requirements- Architecture for traditional Vs Cloud Applications Multi-ties Application Architecture SOA for Cloud applications – Resource oriented SOA – Method –oriented SOA and Event Driven SOA – Parallelization within Cloud Applications – Leveraging In memory Operations for Cloud Application. | |

| **Textbooks:** | |
|---|---|
| 1 | Cloud computing: concepts, Technology and architecture : The Pearson Service Technology Series from Thomas Erl) 1st Edition |
| 2 | Cloud computing for Dummies |

**References:**


| | |
|---|---|
| 1 | Rajkumar Buya,' Cloud computing principles and Paradigms', Wiley. |
| 2 | Kai Hwang,' Distributed and cloud computing', MK Publications. |
| 3 | Cloud computing, black book, Dreamtech publication. |
| 4 | Using Google Apps engine O'reilly Publication |

**Internal Assessment:**
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

**Continuous Assessment:-**
Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:-

| Sr.no | Rubrics | Marks |
|---|---|---|
| 1. | *Certificate course for 4 weeks or more:- NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2. | Content beyond syllabus presentation | 10 marks |
| 3. | Creating Proof of concept | 10 marks |
| 4. | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5. | Multiple Choice Questions (Quiz) | 5 marks |
| 6. | GATE Based Assignment /Tutorials etc | 10 marks |

For sr.no.1, the date of certification exam should be within the term and in case a student is unable to complete the certification , the grading has to be done accordingly.

**End Semester Theory Examination:**

| | |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| Course Code | Course Name | Credit |
|---|---|---|
| ADC502 | Web Development | 03 |

| Pre-requisite: | |
|---|---|
| **Course Objectives:** The course aims: | |
| 1 | To orient students to Web Programming fundamental. |
| 2 | To expose students to JavaScript to develop interactive web page development |
| 3 | To orient students to Basics of REACT along with installation |
| 4 | To expose students to node.js applications using express framework |
| 5 | To orient students to Fundamentals of node.js |
| 6 | To expose students to Advanced concepts in REACT |
| **Course Outcomes:** | |
| 1 | Select protocols or technologies required for various web applications |
| 2 | Apply JavaScript to add functionality to web pages. . |
| 3 | Design front end application using basic React. . |
| 4 | Construct web based Node.js applications using Express |
| 5 | Design front end applications using functional components of React. |
| 6 | Design back-end applications using Node.js |

| Module | | Detailed Content | Hours |
|---|---|---|---|
| **1** | | **Web programming fundamentals** | |
| | 1.1 | Working of web browser, HTTP protocol, HTTPS, DNS, TLS, XML introduction, Json introduction, DOM, URL, URI, REST API | 6 |
| **2** | | **Javascript** | 8 |
| | 2.1 | Introduction to JavaScript: JavaScript language constructs, Objects in JavaScript- Built in, Browser objects and DOM objects, event handling, form validation and cookies.Introduction to ES5,ES6, Difference between ES5 and E S6. Variables, Condition, Loops, Functions, Events, Arrow functions, Setting CSS Styles using JavaScript, DOM manipulation, Classes and Inheritance. Iterators andGenerators, Promise, Client-server communication, Fetch | |
| **3** | | **React Fundamentals** | 10 |
| | 3.1 | Installation, Installing libraries, Folder and file structure, Components, Component lifecycle, State and Props, React Router and Single page applications, UI design, Forms, Events, Animations, Best practices. | |
| **4** | | **Node.js** | 5 |
| | 4.1 | Environment setup, First app, Asynchronous programming, Callback concept,Event loops, REPL, Event emitter, Networking module, Buffers, Streams, Filesystem, Web module. | |
| **5** | | Express | 5 |
| | 5.1 | Introduction, Express router, REST API, Generator, Authentication,sessions, | |

| | | | |
|---|---|---|---|
| | | Integrating with React | |
| **6** | | **Advance React** | 5 |
| | 6.1 | Functional components- Refs, Use effects, Hooks, Flow architecture, Model-ViewController framework, Flux, Bundling the application. Webpack. | |

| **Textbooks:** | |
|---|---|
| 1 | Rediscovering JavaScript, Master ES6, ES7, and ES8, By Venkat Subramaniam · 2018 |
| 2 | Learning React Functional Web Development with React and Redux, Alex Banks and Eve Porcello, O'Reilly |
| 3 | Learning Redux, Daniel Bugl, Packt Publication |
| 4 | Learning Node.js Development, Andrew Mead, Packt Publishing |
| 5 | RESTful Web API Design with Node.js 10, Valentin Bojinov, Packt Publication |

**References:**

| | |
|---|---|
| 1 | –Web Development with Node and Express, Ethan Brown, O'Reilly |
| 2 | HTML5 Cookbook, By Christopher Schmitt, Kyle Simpson, O'Reilly Media |
| 3 | Core Python Applications Programming by Wesley J Chun Third edition Pearson Publication |

**Internal Assessment:**
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

**Continuous Assessment:-**
Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:-

| Sr.no | Rubrics | Marks |
|---|---|---|
| 1. | *Certificate course for 4 weeks or more:- NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2. | Content beyond syllabus presentation | 10 marks |
| 3. | Creating Proof of concept | 10 marks |
| 4. | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5. | Multiple Choice Questions (Quiz) | 5 marks |
| 6. | GATE Based Assignment /Tutorials etc | 10 marks |

*For sr.no.1, the date of certification exam should be within the term and in case a student is unable to complete the certification , the grading has to be done accordingly.

**End Semester Theory Examination:**

| | |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| Useful Links | |
|---|---|
| 1 | https://www.coursera.org/learn/html-css-javascript-for-web-developers?action=enroll |
| 2 | ttps://onlinecourses.swayam2.ac.in/ugc19_lb05/preview |
| 3 | https://reactjs.org/tutorial/tutorial.html |
| 4 | https://nptel.ac.in/courses/106105183 |

| Course Code | Course Name | Credit |
|---|---|---|
| ADC503 | Artificial Intelligence | 03 |

| Pre-requisite: C Programming | |
|---|---|
| **Course Objectives:** The course aims: | |
| 1 | To gain perspective of AI and its foundations. |
| 2 | To study different agent architectures and properties of the environment |
| 3 | To understand the basic principles of AI towards problem solving, inference, perception, knowledge representation, and learning. |
| 4 | To investigate probabilistic reasoning under uncertain and incomplete information. |
| 5 | To explore the current scope, potential, limitations, and implications of intelligent systems |
| **Course Outcomes:**<br>**After successful completion of the course students will be able to:** | |
| 1 | Identify the characteristics of the environment and differentiate between various agent architectures. |
| 2 | Apply the most suitable search strategy to design problem solving agents. |
| 3 | Represent a natural language description of statements in logic and apply the inference rules to design Knowledge Based agents. |
| 4 | Apply a probabilistic model for reasoning under uncertainty. |
| 5 | Comprehend various learning techniques. |
| 6 | Describe the various building blocks of an expert system for a given real word problem. |

| Module | | Detailed Content | Hours |
|---|---|---|---|
| **1** | | **Introduction to Artificial Intelligence** | 3 |
| | 1.1 | Artificial Intelligence (AI), AI Perspectives: Acting and Thinking humanly, Acting and Thinking rationally | |
| | 1.2 | History of AI, Applications of AI, The present state of AI, Ethics in AI | |
| **2** | | **Intelligent Agents** | 4 |
| | 2.1 | Introduction of agents, Structure of Intelligent Agent, Characteristics of Intelligent Agents | |
| | 2.2 | Types of Agents: Simple Reflex, Model Based, Goal Based, Utility Based Agents. | |
| | 2.2 | Environment Types: Deterministic, Stochastic, Static, Dynamic, Observable, Semi-observable, Single Agent, Multi Agent | |
| **3** | | **Solving Problems by Searching** | 12 |
| | 3.1 | Definition, State space representation, Problem as a state space search, Problem formulation, Well-defined problems | |
| | 3.2 | Solving Problems by Searching, Performance evaluation of search strategies,Time Complexity, Space Complexity, Completeness, Optimality | |

| | | | |
|---|---|---|---|
| | 3.3 | Uninformed Search: Depth First Search, Breadth First Search, Depth Limited Search, Iterative Deepening Search, Uniform Cost Search, Bidirectional Search | |
| | 3.4 | Informed Search: Heuristic Function, Admissible Heuristic, Informed Search Technique, Greedy Best First Search, A* Search, Local Search: Hill Climbing Search, Simulated Annealing Search. | |
| | 3.5 | Game Playing, Adversarial Search Techniques, Mini-max Search, Alpha-BetaPruning | |
| **4** | | **Knowledge and Reasoning** | 10 |
| | 4.1 | Definition and importance of Knowledge, Issues in Knowledge Representation, Knowledge Representation Systems, Properties of Knowledge<br>Representation Systems | |
| | 4.2 | Propositional Logic (PL),Predicate Logic: FOPL, Syntax, Semantics, Quantification, Inference rules inFOPL, | |
| | 4.3 | Forward Chaining, Backward Chaining and Resolution in FOPL | |
| | 4.4 | Ontological Engineering Categories and Objects, Events, Reasoning Systems for Categories. | |
| **5** | | **Reasoning Under Uncertainty** | 5 |
| | | Handling Uncertain Knowledge, Random Variables, Prior and Posterior Probability, Inference using Full Joint Distribution | |
| | | Bayes' Rule and its use, Bayesian Belief Networks, Reasoning in Belief Networks | |
| **6** | | **Planning and Learning** | 5 |
| | 6.1 | The planning problem, Partial order planning, total order planning. | |
| | 6.2 | Learning in AI, Learning Agent, Concepts of Supervised, Unsupervised, Semi<br>-Supervised Learning, Reinforcement Learning, Ensemble Learning. | |
| | | **Total** | 39 |


| **Textbooks:** | |
|---|---|
| 1 | Stuart J. Russell and Peter Norvig, 'Artificial Intelligence A Modern Approach —Second Edition' Pearson Education. |
| 2 | Elaine Rich and Kevin Knight —Artificial Intelligence‖ Third Edition, Tata McGraw-Hill Education Pvt. Ltd., 2008. |
| 3 | George F Luger –Artificial Intelligence Low Price Edition, Pearson Education., Fourth edition. |
| **References:** | |
| 1 | Ivan Bratko —PROLOG Programming for Artificial Intelligence, Pearson Education, Third Edition. |
| 2 | D. W. Patterson, Artificial Intelligence and Expert Systems, Prentice Hall. |
| 3 | Saroj Kaushik –Artificial Intelligence, Cengage Learning. |
| 4 | Davis E. Goldberg, –Genetic Algorithms: Search, Optimization and Machine Learning, Addison Wesley, N.Y., 1989. |
| 5 | Patrick Henry Winston, –Artificial Intelligence, Addison-Wesley, Third Edition. |
| 6 | N. P. Padhy, –Artificial Intelligence and Intelligent Systems, Oxford University Press. |

**Internal Assessment:**

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

**Continuous Assessment:-**

Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:-

| Sr.no | Rubrics | Marks |
|---|---|---|
| 1 | *Certificate course for 4 weeks or more:- NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2 | Content beyond syllabus presentation | 10 marks |
| 3 | Creating Proof of concept | 10 marks |
| 4 | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5 | Multiple Choice Questions (Quiz) | 5 marks |
| 6 | GATE Based Assignment /Tutorials etc | 10 marks |

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**End Semester Theory Examination:**

| | |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| **Useful Links** | |
|---|---|
| 1 | An Introduction to Artificial Intelligence - Course (nptel.ac.in) |
| 2 | NPTEL |
| 3 | https://www.classcentral.com/course/independent-elements-of-ai-12469 |
| 4 | https://tinyurl.com/ai-for-everyone |

| Course Code | Course Name | Credit |
|---|---|---|
| ADC504 | Data Warehousing and Mining | 03 |

| Pre-requisite: Database Management concepts | |
|---|---|
| **Course Objectives:** The course aims: | |
| 1 | To create awareness of how enterprise can organize and analyze large amounts of data by creating a Data Warehouse |
| 2 | To introduce the concept of data Mining as an important tool for enterprise data management and as a cutting edge technology for building competitive advantage. |
| 3 | To enable students to effectively identify sources of data and process it for data mining |
| 4 | To make students well versed in all data mining algorithms, methods of evaluation |
| 5 | To impart knowledge of tools used for data mining,and study web mining |
| **Course Outcomes:** | |
| 1 | Organize strategic data in an enterprise and build a data Warehouse. |
| 2 | Analyze data using OLAP operations so as to take strategic decisions and Demonstrate an understanding of the importance of data mining. |
| 3 | Organize and Prepare the data needed for data mining using pre preprocessing techniques |
| 4 | Implement the appropriate data mining methods like classification, clustering or Frequent Pattern mining on large data sets. |
| 5 | Define and apply metrics to measure the performance of various data mining algorithms |
| 6 | Understand Concepts related to Web mining |

| Module | | Detailed Content | Hours |
|---|---|---|---|
| **1** | | **Data Warehouse and OLAP** | |
| | | Data Warehousing, Dimensional Modeling and OLAP The Need for Data Warehousing; Data Warehouse Defined; Benefits of Data Warehousing ; Features of a Data Warehouse; Data Warehouse Architecture; Data Warehouse and Data Marts; Data Warehousing Design Strategies. Dimensional Model Vs ER Model; The Star Schema, The Snowflake Schema; Fact Tables and Dimension Tables; Fact less Fact Table; Updates To Dimension Tables, Primary Keys, Surrogate Keys & Foreign Keys; Aggregate Tables; Fact Constellation Schema or Families of Star Need for Online Analytical Processing; OLTP vs OLAP; OLAP Operations in a cube: Roll-up, Drilldown, Slice, Dice, Pivot ; OLAP Models: MOLAP, ROLAP, HOLAP. Major steps in ETL Process | 9 |
| **2** | | **Introduction to Data Mining ,Data Exploration and Data Preprocessing** | 8 |

| | | | |
|---|---|---|---|
| | | Data Mining Task primitives,Architecture,KDD process,Issues in data Mining,Types of Attributes; Statistical Description of Data; Data Visualization; Measuring similarity and dissimilarity. Why Preprocessing? Data Cleaning; Data Integration; Data Reduction: Attribute subset selection, Histograms, Clustering and Sampling; Data Transformation & Data Discretization: Normalization, Binning, Histogram Analysis and Concept hierarchy generation. | |
| **3** | | **Classification** | 6 |
| | | Basic Concepts; Classification methods: 1. Decision Tree Induction: Attribute Selection Measures, Tree pruning. 2. Bayesian Classification: Naïve Bayes' Classifier Accuracy and Error measures,Precision, Recall.Rule based classifier | |
| **4** | | **Clustering** | 4 |
| | | Cluster Analysis: Basic Concepts; Partitioning Methods: K-Means, K Mediods; Hierarchical Methods: Agglomerative, Divisive, DBSCAN outlier analysis Types, Challenges; Outlier Detection Methods: Supervised, Semi Supervised, Unsupervised, Proximity based, Clustering Based | |
| **5** | | **Frequent Pattern** | 8 |
| | | Market Basket Analysis, Frequent Item sets, Closed Item sets, and Association Rules; Frequent Pattern Mining, Efficient and Scalable Frequent Itemset Mining Methods, The Apriori Algorithm for finding Frequent Item sets Using Candidate Generation, Generating Association Rules from Frequent Item sets, Improving the Efficiency of Apriori, A pattern growth approach for mining Frequent Item sets; Mining Frequent item sets using vertical data formats; **Introduction to Mining Multilevel Association** Rules and Multidimensional Association Rules; From Association Mining to Correlation Analysis, lift, ; Introduction to Constraint-Based Association Mining | |
| 6 | | **Web Mining** | 4 |
| | | Introduction to Web content Mining, Crawlers, Personalization, Web structure mining, Page rank,, Clever, Web Usage Mining | |

| **Textbooks:** | |
|---|---|
| 1 | Han, Kamber, 'Data Mining Concepts and Techniques', Morgan Kaufmann 3nd Edition |
| 2 | P. N. Tan, M. Steinbach, Vipin Kumar, –Introduction to Data Mining, Pearson Education. |
| 3 | Paulraj Ponniah, –Data Warehousing: Fundamentals for IT Professionals, Wiley India. |
| 4 | Raghu Ramakrishnan and Johannes Gehrke, –Database Management Systems 3rd Edition - McGraw Hill |
| 5 | Elmasri and Navathe, –Fundamentals of Database Systems, 6th Edition, PEARSON Education |

| **References:** | |
|---|---|
| 1 | Theraja Reema, –Data Warehousing, Oxford University Press, 2009 |
| 2 | Ralph Kimball, Margy Ross, –The Data Warehouse Toolkit: The Definitive Guide To Dimensional Modeling, 3rd Edition. Wiley India. |

| | |
|---|---|
| 3 | Michael Berry and Gordon Linoff –Mastering Data Mining- Art & science of CRM, Wiley Student Edition |
| 4 | Michael Berry and Gordon Linoff –Data Mining Techniques, 2nd Edition Wiley Publications |

**Internal Assessment:**
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

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| 3. | Creating Proof of concept | 10 marks |
| 4. | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5. | Multiple Choice Questions (Quiz) | 5 marks |
| 6. | GATE Based Assignment /Tutorials etc | 10 marks |

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**End Semester Theory Examination:**

| | |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| **Useful Links** | |
|---|---|
| 1 | https://www.coursera.org/learn/data-warehousing-business-intelligence |
| 2 | https://www.coursera.org/specializations/data-mining-foundations-practice |
| 3 | https://onlinecourses.nptel.ac.in/noc20_cs12/preview |
| 4 | https://nptel.ac.in/courses/106105174 |

| Course Code | Course Name | Credit |
|---|---|---|
| ADLO5011 | Statistics for Artificial Intelligence Data Science | 03 |

| Prerequisite: C Programming | |
|---|---|
| **Course Objectives:** The course aims: | |
| 1 | To Perform exploratory analysis on the datasets |
| 2 | To Understand the various distribution and sampling |
| 3 | To Perform Hypothesis Testing on datasets |
| 4 | To Explore different techniques for Summarizing Data |
| 5 | To Perform the Analysis of Variance |
| 6 | To Explore Linear Least Squares |
| **Course Outcomes:** Learner will be able to | |
| 1 | Illustrate Exploratory Data Analysis |
| 2 | Describe Data and Sampling Distributions |
| 3 | Solve Statistical Experiments and Significance Testing |
| 4 | Demonstrate Summarizing Data |
| 5 | Interpret the Analysis of Variance |
| 6 | Use Linear Least Squares |

**Prerequisite:** Discrete Structures and Graph Theory

| Module | | Detailed Content | Hours |
|---|---|---|---|
| 1 | | **Exploratory Data Analysis** | 5 |
| | 1.1 | Elements of Structured Data ,Further Reading ,Rectangular Data ,Data Frames and Indexes ,Nonrectangular Data Structures , Estimates of Location ,Mean ,Median and Robust Estimates , Estimates of Variability, Standard Deviation and Related Estimates, Estimates Based on Percentiles , Exploring the Data Distribution ,Percentiles and Boxplots ,Frequency Tables and Histograms ,Density Plots and Estimates. | |
| | 1.2 | Exploring Binary and Categorical Data,Mode, Expected Value, Probability, Correlation, Scatterplots ,Exploring Two or More Variables ,Hexagonal Binning andContours (Plotting Numeric Versus Numerical Data) ,Two Categorical Variables, Categorical and Numeric Data ,Visualizing Multiple Variables. | |
| 2 | | **Data and Sampling Distributions** | 6 |
| | 2.1 | Random Sampling and Sample Bias ,Bias ,Random Selection ,Size Versus Quality, Sample Mean Versus Population Mean ,Selection Bias ,Regression to the Mean, Sampling Distribution of a Statistic ,Central Limit Theorem ,Standard Error ,TheBootstrap ,Resampling Versus Bootstrapping . | |
| | 2.2 | Confidence Intervals, Normal Distribution, Standard Normal and QQ-Plots, Long-Tailed Distributions ,Student‘s t-Distribution ,Binomial Distribution ,Chi-SquareDistribution ,F-Distribution, Poisson Distributions. | |
| 3 | | **Statistical Experiments and Significance Testing** | 8 |
| | 3.1 | A/B Testing ,Hypothesis Tests ,The Null Hypothesis ,Alternative Hypothesis ,One-WayVersus Two-Way Hypothesis Tests ,Resampling ,Permutation Test, Statistical Significance and p-Values ,p-Value ,Alpha ,Type 1 and Type 2 Error | |

| | | | |
|---|---|---|---|
| | 3.2 | Data Science and p-Values, t-Tests, Multiple Testing, Degrees of Freedom ANOVA F-Statistic, Two-Way ANOVA. | |
| 4 | | **Summarizing Data** | 6 |
| | 4.1 | Methods Based on the Cumulative Distribution Function, The Empirical Cumulative Distribution Function, The Survival Function, Quantile-Quantile Plots, Histograms, Density Curves, and Stem-and-Leaf Plots, Measures of Location. | |
| | 4.2 | The Arithmetic Mean ,The Median , The Trimmed Mean , M Estimates , Comparison of Location Estimates, Estimating Variability of Location Estimates by the Bootstrap, Measures of Dispersion , Boxplots , Exploring Relationships with Scatterplots . | |
| 5 | | **The Analysis of Variance** | 6 |
| | 5.1 | The One-Way Layout, Normal Theory; the F Test, The Problem of Multiple Comparisons, A Nonparametric Method—The Kruskal-Wallis Test, The Two-WayLayout , Additive Parametrization , Normal Theory for the Two-Way Layout Randomized Block Designs , A Nonparametric Method—Friedman‘s Test . | |
| 6 | | **Linear Least Squares** | 8 |
| | 6.1 | Simple Linear Regression, Statistical Properties of the Estimated Slope and Intercept , Assessing the Fit , Correlation and Regression , The Matrix Approach to Linear Least Squares , Statistical Properties of Least Squares Estimates , Vector-Valued Random Variables , Mean and Covariance of Least Squares Estimates , Estimation of $\sigma 2$, Residuals and Standardized Residuals , Inference about $\beta$ , Multiple Linear Regression—An Example | |


| **Textbooks:** | |
|---|---|
| 1 | Bruce, Peter, and Andrew Bruce. Practical statistics for data scientists: 50 essential concepts. Reilly Media,2017. |
| 2 | Mathematical Statistics and Data Analysis John A. Rice University of California, Berkeley,Thomson HigherEducation |
| **References:** | |
| 1 | Dodge, Yadolah, ed. Statistical data analysis and inference. Elsevier, 2014. |
| 2 | Ismay, Chester, and Albert Y. Kim. Statistical Inference via Data Science: A Modern Dive into R and theTidyverse. CRC Press, 2019. |
| 3 | Milton. J. S. and Arnold. J.C., ‘Introduction to Probability and Statistics’, Tata McGraw Hill, 4th Edition,2007. |
| 4 | Johnson. R.A. and Gupta. C.B., ‘Miller and Freund‘s Probability and Statistics for Engineers’, PearsonEducation, Asia, 7th Edition, 2007. |
| 5 | A. Chandrasekaran, G. Kavitha, ―Probability, Statistics, Random Processes and Queuing Theory, DhanamPublications, 2014. |

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| 5. | Multiple Choice Questions (Quiz) | 5 marks |
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**End Semester Theory Examination:**

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|---|---|
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| **Useful Links** | |
|---|---|
| 1 | https://www.edx.org/course/introduction-probability-science-mitx-6-041x-2 |
| 2 | https://www.coursera.org/learn/statistical-inference |
| 3 | https://www.datacamp.com/community/open-courses/statistical-inference-and-data-analysis |

| Course Code | Course Name | Credit |
|---|---|---|
| **ADL05012** | **Advanced Algorithms** | **03** |

| **Pre-requisite:** | |
|---|---|
| **Course Objectives:** The course aims: | |
| 1 | To provide mathematical approaches for problem solving using advanced concepts of Algorithms |
| 2 | To understand and solve problems using various algorithmic approaches like Randomized algorithms, approximation algorithms, Local search and Amortized algorithms. |
| 3 | To discuss and apply the Combinatorial Analysis techniques to solve various mathematical and statistical problems |
| **Course Outcomes:** | |
| 1 | Analyze the classification of problems into various NP classes and their Computational Intractability |
| 2 | Describe, apply and analyze the complexity of Approximation Algorithms. |
| 3 | Describe, apply and analyze the complexity of Randomized Algorithms. |
| 4 | Describe, apply and analyze the complexity of Local Search Algorithms. |
| 5 | Design and Apply the concepts of String and Amortized Analysis |
| 6 | To Understand Combinatorial Analysis techniques |

| **Module** | | **Detailed Content** | **Hours** |
|---|---|---|---|
| **1** | | **NP and Computational Intractability** | |
| | 1.1 | Polynomial-Time Reductions, NP Completeness: Overview, Class P– Class NP<br>– NP Hardness, NP Completeness, Cook Levine Theorem, Characteristics of NP Complete Problems, The Satisfiability Problem, NP-Complete Problems, Sequencing Problems Partitioning Problems, Graph Coloring, Numerical Problems, Co-NP and the Asymmetry of NP, A Partial Taxonomy of Hard Problems. Reduction of standard NP Complete Problems: SAT, 3SAT, Clique, Vertex Cover, Set Cover, Hamiltonian Cycle. | 8 |
| **2** | | **Approximation Algorithms** | 9 |

| | | | |
|---|---|---|---|
| | 2.1 | Approximation algorithms for known NP hard problems, Inapproximability, Approximation algorithms with small additive error: Edge Coloring, Bin Packing, Randomized rounding and linear programming, Problems having polynomial approximation schemes, Optimization problems with constant-factor approximations, Hard-to-approximate problems, Analysis of Approximation Algorithms. | |
| **3** | | **Randomized Algorithms** | 9 |
| | 3.1 | Introduction to randomized algorithm, Finding the Global Minimum Cut, Random Variables and Their Expectations, A Randomized Approximation Algorithm for MAX 3-SAT, Randomized Divide and Conquer: Median-Finding and Quicksort, Hashing: A Randomized Implementation of Dictionaries, Finding the Closest Pair of Points: A Randomized Approach, Randomized Caching, Chernoff Bounds, Load Balancing, Packet Routing, Las Vegas Algorithm, Monte Carlo Algorithm. | |
| **4** | | **Local Search** | 5 |
| | 4.1 | The Landscape of an Optimization Problem, The Metropolis Algorithm and Simulated Annealing, An Application of Local Search to Hopfield Neural Networks, Maximum-Cut Approximation via Local Search, Choosing a Neighbour Relation, Classification via Local Search, Best-Response Dynamics and Nash Equilibria. | |
| **5** | | **String and Amortized Analysis** | 4 |
| | 5.1 | String Sort, Tries, Substring Search, Regular Expressions, Data Compression, String Matching Algorithms: Introduction to String matching, The Knuth-Morris-Pratt algorithm, Aho- Korasik algorithm, Z-algorithm, Amortized Analysis: Aggregate analysis, The accounting method, The potential method Dynamic tables. | |
| **6** | | Combinatorial Analysis | 4 |
| | 6.1 | Introduction, Next subset of n-Set problems, Random Subset of n-Setproblems, Sequencing, Ranking and selection algorithms for general combinatorial families. | |

| **Textbooks:** | |
|---|---|
| 1 | Jon Kleinberg, Eva Tardos, –Algorithm Design, Cornell University, Pearson Publications |
| 2 | Robert Sedgewick, Kevin Wayne, –Algorithms, Princeton, fourth edition, AddisonWessely. |
| 3 | Thomas H. Cormen , Charles E., Ronald l., Clifford Stein, –Introduction to Algorithms,Third Edition, The MIT Press Cambridge. |

| | |
|---|---|
| 4 | Albert Nijenhuis, Herbert Wilf, –Combinatorial Algorithms for computers and calculators,Second edition, Academic Press |
| 5 | George Heineman, Gary Pollice, Stanley Selkow, –Algorithms in a Nutshell, Oreilly Press. |
| **References:** | |
| 1 | Anany Levitin, Introduction to The design and analysis of algorithms, 3rd Edition, Pearson publication. |
| 2 | Peter J. Cameron, –Combinatorics: Topics, Techniques, Algorithms, Cambridge University Press |

**Internal Assessment:**
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| 3. | Creating Proof of concept | 10 marks |
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| 5. | Multiple Choice Questions (Quiz) | 5 marks |
| 6. | GATE Based Assignment /Tutorials etc | 10 marks |

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**End Semester Theory Examination:**

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| **Useful Links** | |
|---|---|
| 1 | https://www.binghamton.edu/watson/continuing-education/data-science/advanced-algorithms.html |
| 2 | https://nptel.ac.in/courses/106104019 |
| 3 | https://www.coursera.org/learn/advanced-algorithms-and-complexity |

| Course Code | Course Name | Credit |
|---|---|---|
| ADLO5013 | Computer Graphics | 03 |

| | |
|---|---|
| **Prerequisite:** Knowledge of C Programming and Basic Mathematics**.** | |
| **Course Objectives** | |
| 1 | To equip students with the fundamental knowledge and basic technical competence in thefield of Computer Graphics. |
| 2 | To emphasize on implementation aspect of Computer Graphics Algorithms. |
| 3 | To prepare the student for advance areas and professional avenues in the field of Computer Graphics |
| **Course Outcomes:** At the end of the course, the students should be able to | |
| 1 | Describe the basic concepts of Computer Graphics. |
| 2 | Demonstrate various algorithms for basic graphics primitives. |
| 3 | Apply 2-D geometric transformations on graphical objects. |
| 4 | Use various Clipping algorithms on graphical objects |
| 5 | Explore 3-D geometric transformations, curve representation techniques and projectionsmethods. |
| 6 | Explain visible surface detection techniques and Animation. |

| Module | | Detailed Content | Hours |
|---|---|---|---|
| **1** | | **Introduction and Overview of Graphics System:** | **02** |
| | 1.1 | Definition and Representative uses of computer graphics, Overview of coordinate system, Definition of scan conversion, rasterization and rendering. | |
| | 1.2 | Raster scan & random scan displays, Architecture of raster graphics system with display processor, Architecture of random scan systems. | |
| **2** | | **Output Primitives:** | **10** |
| | 2.1 | Scan conversions of point, line, circle and ellipse: DDA algorithm and Bresenham algorithm for line drawing, midpoint algorithm for circle, midpoint algorithm for ellipse drawing (Mathematical derivation for above algorithms is expected) | |
| | 2.2 | Aliasing, Antialiasing techniques like Pre and post filtering, super sampling, and pixel phasing). | |
| | 2.3 | Filled Area Primitive: Scan line Polygon Fill algorithm, inside outside tests, Boundary Fill and Flood fill algorithm. | |
| **3** | | **Two Dimensional Geometric Transformations** | **6** |
| | 3.1 | Basic transformations: Translation, Scaling, Rotation | |
| | 3.2 | Matrix representation and Homogeneous Coordinates | |
| | 3.3 | Composite transformation | |
| | 3.4 | Other transformations: Reflection and Shear | |
| **4** | | **Two-Dimensional Viewing and Clipping** | **7** |
| | 4.1 | Viewing transformation pipeline and Window to Viewport coordinate transformation | |

| | | | |
|---|---|---|---|
| | 4.2 | Clipping operations: Point clipping, Line clipping algorithms: Cohen-Sutherland, Liang: Barsky, Polygon Clipping Algorithms: Sutherland-Hodgeman, Weiler-Atherton. | |
| **5** | | **Three Dimensional Geometric Transformations, Curves andFractal Generation** | **8** |
| | 5.1 | 3D Transformations: Translation, Rotation, Scaling and Reflection | |
| | 5.2 | Composite transformations: Rotation about an arbitrary axis | |
| | 5.3 | Projections – Parallel, Perspective. (Matrix Representation) | |
| | 5.4 | Bezier Curve, B-Spline Curve, Fractal-Geometry: Fractal Dimension, Koch Curve. | |
| 6 | | Visible Surface Detection and Animation | 6 |
| | 6.1 | Visible Surface Detection: Classification of Visible Surface Detection algorithm, Back Surface detection method, Depth Buffer method, Area Subdivision method | |
| | 6.2 | Animation: Introduction to Animation, Traditional Animation Techniques, Principles of Animation, Key framing: Character and Facial Animation, Deformation, Motion capture. | |


| **Textbooks:** | |
|---|---|
| 1 | Hearn & Baker, 'Computer Graphics C version', 2nd Edition, Pearson Publication |
| 2 | James D. Foley, Andries van Dam, Steven K Feiner, John F. Hughes, 'Computer Graphics Principles and Practice in C', 2nd Edition, Pearson Publication |
| 3 | Samit Bhattacharya, 'Computer Graphics', Oxford Publication |
| **References:** | |
| 1 | D. Rogers, 'Procedural Elements for Computer Graphics', Tata McGraw-Hill Publications. |
| 2 | Zhigang Xiang, Roy Plastock, 'Computer Graphics', Schaum's Outlines McGraw-HillEducation |
| 3 | Rajesh K. Maurya, 'Computer Graphics', Wiley India Publication. |
| 4 | F. S. Hill, 'Computer Graphics using OpenGL', Third edition, Pearson Publications. |

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| **Useful Links** | |
|---|---|
| 1 | https://www.classcentral.com/course/interactivegraphics-2067 |
| 2 | https://swayam.gov.in/nd2_ntr20_ed15/preview |
| 3 | https://nptel.ac.in/courses/106/106/106106090/ |
| 4 | https://www.edx.org/course/computer-graphics-2 |

| Lab Code | Lab Name | Credit |
|---|---|---|
| **ADL501** | **Web Development Lab** | **1** |

| **Prerequisite: Operating System, Basics of Java and Python Programming.** | |
|---|---|
| **Lab Objectives:** | |
| 1 | To orient students to HTML for making webpages |
| 2 | To expose students to CSS for formatting web pages |
| 3 | To expose students to developing responsive layout |
| 4 | To expose students to JavaScript to make web pages interactive |
| 5 | To orient students to React for developing front end applications |
| 6 | To orient students to Node.js for developing backend applications |
| **Lab Outcomes:** | |
| 1 | Identify and apply the appropriate HTML tags to develop a webpage |
| 2 | Identify and apply the appropriate CSS tags to format data on webpage |
| 3 | Construct responsive websites using Bootstrap |
| 4 | Use JavaScript to develop interactive web pages. |
| 5 | Construct front end applications using React and back end using Node.js/express |

| **Suggested Experiments:** Students are required to complete at least 10 experiments. | |
|---|---|
| Star (*) marked experiments are compulsory. | |
| **Sr. No.** | **Name of the Experiment** |
| 1 | HTML:Elements, Attributes, Head, Body, Hyperlink, Formatting, Images, Tables, List, Frames, Forms, Multimedia |
| 2 | CSS3.Syntax, Inclusion, Color, Background, Fonts, Tables, lists,CSS3 selectors, Pseudo classes, Pseudo elements . |
| 3 | Bootstrap:BootstrapGrid system, Forms, Button, Navbar, Breadcrumb, Jumbotron |
| 4 | Javascript:Variables, Operators, Conditions, Loops, |
| 5 | Java Script : FunctionsValidations, Arrays, String, Date |
| 6 | Java Script :Events, Classes and Objects, Error handling, |
| 7 | React:Installation and Configuration. JSX, Components, Props, State, Forms, Events, Routers, Refs, Keys. |
| 8 | Advance React: Concepts and Practical. |

| Useful Links: | |
|---|---|
| 1 | www.leetcode.com |
| 2 | www.hackerrank.com |
| 3 | www.cs.usfca.edu/~galles/visualization/Algorithms.html |
| 4 | www.codechef.com |

| Term Work: | |
|---|---|
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks based on evaluation of Experiments. |
| **Evaluation exam** | |
| | Practical Exam based on lab syllabus of ADL501 |

| Lab Code | Lab Name | Credit |
|---|---|---|
| **ADL502** | **Artificial Intelligence Lab** | **1** |

| **Prerequisite: C Programming Language.** | |
|---|---|
| **Lab Objectives:** | |
| 1 | To design suitable Agent Architecture for a given real world AI problem |
| 2 | To implement knowledge representation and reasoning in AI language |
| 3 | To design a Problem-Solving Agent |
| 4 | To incorporate reasoning under uncertainty for an AI agent |
| **Lab Outcomes:**<br>**At the end of the course, students will be able to —-** | |
| 1 | Identify suitable Agent Architecture for a given real world AI problem |
| 2 | Implement simple programs using Prolog. |
| 3 | Implement various search techniques for a Problem-Solving Agent. |
| 4 | Represent natural language description as statements in Logic and apply inference rules to it. |
| 5 | Construct a Bayesian Belief Network for a given problem and draw probabilistic inferences from it |

| **Suggested Experiments:** Students are required to complete at least 10 experiments. | |
|---|---|
| | |
| **Sr. No** | **Name of the Experiment** |
| 1. | Write simple programs using PROLOG as an AI programming Language |
| 2. | Implement any one of the Uninformed search techniques |
| 3. | Implement any one of the Informed search techniques<br>E.g. A-Star algorithm for 8 puzzle problem |
| 4. | Implement adversarial search using min-max algorithm. |
| 5. | Implement any one of the Local Search techniques.<br>E.g. Hill Climbing, Simulated Annealing, Genetic algorithm |
| 6. | Define an ontology in first-order logic for tic-tac-toe/ building Pizza ontology |
| 7. | Create a Bayesian Network for the given Problem Statement and draw inferences from it. (You can use any Belief and Decision Networks Tool for modeling Bayesian Networks) |
| 8. | Implement a Planning Agent |
| 9. | Design a prototype of an AI based Game |
| 10. | Case study of any existing successful AI system |

| Useful Links: | |
|---|---|
| 1 | An Introduction to Artificial Intelligence - Course (nptel.ac.in) |
| 2 | https://tinyurl.com/ai-for-everyone |
| 3 | https://ai.google/education/ |
| 4 | https://openai.com/research/ |
| 5 | https://protege.stanford.edu/publications/ontology_development/ontology101-noy-mcguinness.html |

| Term Work: | |
|---|---|
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks based on evaluation of Experiments. |
| **Evaluation Exam** | |
| | Practical Exam based on lab syllabus of ADL502 |

| Lab Code | Lab Name | Credit |
|---|---|---|
| ADL503 | Data warehousing and Mining Lab | 1 |

| | |
|---|---|
| **Prerequisite: Java and Python Programming.** | |
| **Lab Objectives:** | |
| 1 | To create awareness of how enterprise can organize and analyze large amounts of data by creating a Data Warehouse |
| 2 | To introduce the concept of data Mining as an important tool for enterprise data management and as a cutting edge technology for building competitive advantage |
| 3 | To enable students to effectively identify sources of data and process it for data mining |
| 4 | To make students well versed in all data mining algorithms, methods, and tools.. |
| **Lab Outcomes:** | |
| 1 | Build a data warehouse |
| 2 | Analyze data using OLAP operations so as to take strategic decisions. |
| 3 | Demonstrate an understanding of the importance of data mining |
| 4 | Organize and Prepare the data needed for data mining using pre preprocessing techniques |
| 5 | Perform exploratory analysis of the data to be used for mining. |
| 6 | Implement the appropriate data mining methods like classification, clustering or Frequent Pattern mining on large data sets. |

**Suggested Experiments:** Students are required to complete all experiments from the list given below.

| Sr. No. | Name of the Experiment |
|---|---|
| 1 | Data Warehouse Construction a) Real life Problem to be defined for Warehouse Design b) Construction of star schema and snow flake schema c) ETL Operations. |
| 2 | Construction of Cubes , OLAP Operations, OLAP Queries |
| 3 | Tutorials a) Solving exercises in Data Exploration b) Solving exercises in Data preprocessing |
| 4 | Using open source tools Implement Classifiers |
| 5 | Using open source tools Implement Association Mining Algorithms |
| 6 | Using open source tools Implement Clustering Algorithms |
| 7 | Implementation of any one classifier using languages like JAVA/ python |
| 8 | Implementation of any one clustering algorithm using languages like JAVA/ python |
| 9 | Implementation of any one association mining algorithm using languages like JAVA/ python . |

| Useful Links: | |
|---|---|
| 1 | www.leetcode.com |
| 2 | www.hackerrank.com |
| 3 | www.cs.usfca.edu/~galles/visualization/Algorithms.html |
| 4 | www.codechef.com |

| Term Work: | |
|---|---|
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks based on evaluation of Experiments. |
| **Evaluation Exam** | |
| | Practical Exam based on lab syllabus of ADL503 |

| Course Code | Course Name | Credit |
|---|---|---|
| ADL504 | Professional Communication and Ethics-II | 02 |

| | |
|---|---|
| **Prerequisite:** Professional Communication and Ethics-I | |
| **Course Objectives:** | |
| 1 | To discern and develop an effective style of writing important technical/business documents. |
| 2 | To investigate possible resources and plan a successful job campaign. |
| 3 | To understand the dynamics of professional communication in the form of group discussions, meetings, etc. required for career enhancement. |
| 4 | To develop creative and impactful presentation skills. |
| 5 | To analyze personal traits, interests, values, aptitudes and skills. |
| **6** | To understand the importance of integrity and develop a personal code ofethics. |
| **Course Outcomes:** | |
| 1 | Plan and prepare effective business/ technical documents which will inturn provide solid foundation for their future managerial roles. |
| 2 | Strategize their personal and professional skills to build a professionalimage and meet the demands of the industry. |
| 3 | Emerge successful in group discussions, meetings and result-orientedagreeable solutions in group communication situations. |
| 4 | Deliver persuasive and professional presentations. |
| 5 | Develop creative thinking and interpersonal skills required for effective professional communication. |
| **6** | Apply codes of ethical conduct, personal integrity and norms of organizational behaviour. |

| Module | | Topics | Hours |
|---|---|---|---|
| 1 | | **Advanced technical writing : project/problem based learning (pbl)** | |

| | | | |
|---|---|---|---|
| | 1.1 | **Purpose and Classification of Reports:Classification on the basis of:**<br>- Subject Matter (Technology, Accounting, Finance, Marketing,etc.)<br>- Time Interval (Periodic, One-time, Special)<br>- Function (Informational, Analytical, etc.)<br>- Physical Factors (Memorandum, Letter, Short & Long | **6** |
| | 1.2 | **Parts of a Long Formal Report:**<br>- Prefatory Parts (Front Matter)<br>- Report Proper (Main Body)<br>- Appended Parts (Back Matter) | |
| | 1.3 | **Language and Style of Reports**<br>- Tense, Person & Voice of Reports<br>- Numbering Style of Chapters, Sections, Figures, Tables and<br>- Equations<br>- Referencing Styles in APA & MLA Format<br>- Proofreading through Plagiarism Checkers | |
| | 1.4 | **Definition, Purpose & Types of Proposals**<br>- Solicited (in conformance with RFP) & Unsolicited Proposals<br>- Types (Short and Long proposals) | |
| | 1.5 | **Parts of a Proposal**<br>- Elements<br>- Scope and Limitations<br>- Conclusion | |
| 2 | | **EMPLOYMENT SKILLS** | **6** |
| | 2.1 | **Cover Letter & Resume**<br>- Parts and Content of a Cover Letter<br>- Difference between Bio-data, Resume & CV<br>- Essential Parts of a Resume<br>- Types of Resume (Chronological, Functional & Combination) | |
| | 2.2 | **Statement of Purpose**<br>- Importance of SOP<br>- Tips for Writing an Effective SOP | |
| | 2.3 | **Group Discussions**<br>- Purpose of a GD<br>- Parameters of Evaluating a GD<br>- Types of GDs (Normal, Case-based & Role Plays)<br>- GD Etiquettes | |
| | 2.4 | **Personal Interviews**<br>- Planning and Preparation<br>- Types of Questions<br>- Types of Interviews (Structured, Stress, Behavioural, Problem<br>- Solving & Case-based)<br>- Modes of Interviews: Face-to-face (One-to one and Panel)<br>- Telephonic, Virtual | |

| | | | |
|---|---|---|---|
| 3 | | **BUSINESS MEETINGS** | **2** |
| | 3.1 | **Conducting Business Meetings**<br>□ Types of Meetings<br>□ Roles and Responsibilities of Chairperson, Secretary andMembers<br>□ Meeting Etiquette | |
| | 3.2 | **Documentation**<br>• Notice<br>• Agenda<br>• Minutes | |
| 4 | | **TECHNICAL/ BUSINESS PRESENTATIONS** | **2** |
| | 4.1 | **Effective Presentation Strategies**<br>□ Defining Purpose<br>□ Analyzing Audience, Location and Event<br>□ Gathering, Selecting &Arranging Material<br>□ Structuring a Presentation<br>□ Making Effective Slides<br>□ Types of Presentations Aids<br>□ Closing a Presentation<br>□ Platform skills | |
| | 4.2 | **Group Presentations**<br>□ Sharing Responsibility in a Team<br>□ Building the contents and visuals together<br>□ Transition Phases | |
| 5 | | **INTERPERSONAL SKILLS** | **8** |
| | 5.1 | **Interpersonal Skills**<br>□ Emotional Intelligence<br>□ Leadership & Motivation<br>□ Conflict Management & Negotiation<br>□ Time Management<br>□ Assertiveness<br>□ Decision Making | |
| 6 | | **CORPORATE ETHICS** | **2** |
| | | **6.1 Intellectual Property Rights**<br>• Copyrights<br>• Trademarks<br>• Patents<br>• Industrial Designs | |
| | | **Case Studies**<br>• Cases related to Business/ Corporate Ethics | |
| | | **Total** | **26** |

| | |
|---|---|
| **Textbooks:** | |
| 1 | Fred Luthans, 'Organisational Behavior' , McGraw Hill, edition |
| 2 | Robbins Stephen judge timothy 'Organisational Behavior' Pearson |
| 3 | R.C Sharma and Krishna Mohan, 'Business Correspondence and Report Writing' |
| 4 | Foundation course in Human values and Professional Ethics L R R Gaur, R. Asthana, G.P.Bagaria |
| **Reference Books:** | |
| 1 | Lesiker and Petit, 'Report Writing for Business' , McGraw Hill, edition |
| 2 | Wallace and Masters, 'Personal Development for Life and Work' , Thomson Learning,12th edition |
| 3 | B N Ghosh, 'Managing Soft Skills for Personality Development', Tata McGraw Hill.Lehman, |

**Internal Assessment:**

Internal assessment will be for 50 Marks as given below

| Sr No | Headings | | Marks |
|---|---|---|---|
| A | Assignments | | 10 Marks |
| B | Continuous Assessment | | 20 Marks |
| C | a)Report | 10 Marks | 10 Marks |
| | b)Presentation | 10 Marks | |
| D | Group Discussion | | 10 Marks |
| | Total | | 50 Marks |

A) Assignments: List of assignments are as given below. The assignments have to be discussed in the group and approach approved by faculty. Each student in the group willhave to write the assignments individually ( 10 Marks)

| Sr No | List of Assignments |
|---|---|
| 1. | Proposal |
| 2. | Resume and Cover Letter /SOP |
| 3. | Notice ,Agenda and Minutes of Meeting |
| 4 | Case Study /Role Play on Interpersonal Skills |
| 5 | Case study on Ethics |

B) Continuous Assessment:-

Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:-

| Sr.no | Rubrics | Marks |
|---|---|---|
| 1. | *Certificate course for 4 weeks or more:- NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2. | Content beyond syllabus presentation | 10 marks |
| 3. | Creating Proof of concept | 10 marks |
| 4. | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |

| | | |
|---|---|---|
| 5. | Multiple Choice Questions (Quiz) | 5 marks |
| 6. | GATE Based Assignment /Tutorials etc | 10 marks |

C) Report on presentation: A detail typed report has to be prepared of minimum 25 pagesand maximum 30 pages in the given format.

D) A final Group Discussion Round will be conducted and every student must participate inthe group discussion

Tutorials will be conducted batch wise*

| Lab Code | Lab Name | Credit |
|---|---|---|
| ADS501 | Skill Based Lab course: Cloud Computing | 2 |

| | |
|---|---|
| **Prerequisite: Computer Networks** | |
| **Lab Objectives:** | |
| 1 | To make students familiar with key concepts of virtualization. |
| 2 | To make students familiar with various deployment models of cloud such as private, public, hybrid and community so that they start using and adopting appropriate types of cloud for their application. |
| 3 | To make students familiar with various service models such as IaaS, SaaS, PaaS, Security as a Service (SECaaS) and Database as a Service. |
| 4 | To make students familiar with security and privacy issues in cloud computing and how to address them. |
| **Lab Outcomes:** | |
| 1 | Implement different types of virtualization techniques. |
| 2 | Analyze various cloud computing service models and implement them to solve the given problems. |
| 3 | Design and develop real world web applications and deploy them on commercial cloud(s). |
| 4 | Explain major security issues in the cloud and mechanisms to address them. |
| 5 | Explore various commercially available cloud services and recommend the appropriate one for the given application. |
| 6 | Implement the concept of containerization |

**Lab:**

| | | |
|---|---|---|
| 1 | **Title:** To study and Implement Infrastructure as a Service using AWS/Microsoft Azure.<br>**Objective:** To demonstrate the steps to create and run virtual machines inside a Public cloud platform. This experiment should emphasize on creating and running Linux/Windows Virtual machines inside Amazon EC2 or Microsoft Azure Compute and accessing them using RDP or VNC tools. | 4 |
| 2 | **Title:** To study and Implement Platform as a Service using AWS Elastic Beanstalk/ Microsoft Azure App Service.<br>**Objective:** To demonstrate the steps to deploy Web applications or Web services written in different languages on AWS Elastic Beanstalk/ Microsoft Azure App Service. | 4 |

| | | |
|---|---|---|
| 3 | To study and Implement Storage as a Service using Own Cloud/ AWS S3, Glaciers/ Azure Storage. | 2 |
| 4 | To study and Implement Database as a Service on SQL/NOSQL databases like AWS RDS, AZURE SQL/ MongoDB Lab/ Firebase. | 2 |
| 5 | **Title:** To study and Implement Security as a Service on AWS/Azure **Objective:** To understand the Security practices available in public cloud platforms and to demonstrate various Threat detection, Data protection and Infrastructure protection services in AWS and Azure. | 3 |
| 6 | **Title:** To study and implement Identity and Access Management (IAM) practices on AWS/Azure cloud. **Objective:** To understand the working of Identity and Access Management IAM in cloud computing and to demonstrate the case study based on Identity and Access Management (IAM) on AWS/Azure cloud platform. | 2 |
| 7 | **Title:** To study and Implement Containerization using Docker **Objective:** To know the basic differences between Virtual machine and Container. It involves demonstration of creating, finding, building, installing, and running Linux/Windows application containers inside a local machine or cloud platform. | 4 |
| 8 | **Title:** To study and implement container orchestration using Kubernetes **Objective:** To understand the steps to deploy Kubernetes Cluster on local systems, deploy applications on Kubernetes, creating a Service in Kubernetes, develop Kubernetes configuration files in YAML and creating a deployment in Kubernetes using YAML, | 2 |
| 9 | **Mini-project:** Design a Web Application hosted on a public cloud platform [It should cover the concept of IaaS, PaaS, DBaaS, Storage as a Service, Security as a Service etc.] | 4 |

| **Suggested Experiments:** Students are required to complete the above experiments. | |
|---|---|
| **Sr. No.** | **Assignment** |
| 1 | Assignment based on selection of suitable cloud platform solution based on requirement analysis considering given problem statement |
| 2 | Assignment on recent trends in cloud computing and related technologies |
| 3 | Assignment on comparative study of different computing technologies [Parallel, Distributed, Cluster, Grid, Quantum) |
| 4 | Comparative study of different hosted and bare metal Hypervisors with suitable parameters along with their use in public/private cloud platform |
| 5 | Assignment on explore and compare the similar type of services provided by AWS and Azure [Any ten services] |

| **Useful Links:** | |
|---|---|
| 1 | https://docs.aws.amazon.com/ |
| 2 | https://docs.microsoft.com/en-us/azure |
| 3 | https://kubernetes.io/docs/home/ |
| 4 | https://docs.docker.com/get-started/ |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 50 Marks<br>(Experiments: 30 Marks , Mini Project: 10, Assingnment:10) |

| Course Code | Course Name | Credit |
|---|---|---|
| ADC601 | Data Analytics and Visualization | 03 |

| | |
|---|---|
| **Prerequisite: Basic statistics and Maths, Python programming** | |
| **Course Objectives:** The course aims: | |
| 1 | To Introduce the concept of Data Analytics Lifecycle. |
| 2 | To Develop Mathematical concepts required for advance regression. |
| 3 | To Understand data modeling in time series and its process. |
| 4 | To create awareness about Text analytics and its applications. |
| 5 | To provide overview of Data analytics and visualization with R. |
| 6 | To provide overview of Data analytics and visualization with Python. |
| **Course Outcomes: After successful completion of the course students will be able to:** | |
| 1 | Comprehend basics of data analytics and visualization. |
| 2 | Apply various regression models on given data set and perform prediction. |
| 3 | Demonstrate advance understanding of Time series concepts and analysis of data using various time series models. |
| 4 | Analyze Text data and gain insights. |
| 5 | Experiment with different analytics techniques and visualization using R. |
| 6 | Experiment with different analytics techniques and visualization using Python. |

| Module | | Detailed Content | Hours |
|---|---|---|---|
| 1 | | **Introduction to Data analytics and life cycle** | 5 |
| | 1.1 | Data Analytics Lifecycle overview:Key Roles for a Successful Analytics, Background and Overview of Data Analytics Lifecycle Project<br>**Phase 1**: Discovery: Learning the Business Domain, Resources Framing the Problem, Identifying Key Stakeholders. Interviewing the Analytics Sponsor, Developing Initial Hypotheses Identifying Potential Data Sources<br>**Phase 2**: Data Preparation: Preparing the Analytic Sandbox, Performing ETLT, Learning About the Data, Data Conditioning, Survey and visualize, Common Tools for the Data Preparation Phase<br>**Phase 3**: Model Planning: Data Exploration and Variable Selection, Model Selection ,Common Tools for the Model Planning Phase<br>**Phase 4**: Model Building: Common Tools for the Model Building Phase<br>**Phase 5:** Communicate Results<br>**Phase 6:** Operationalize | |
| 2 | | **Regression Models** | 6 |

| | | | |
|---|---|---|---|
| | 2.1 | Introduction to SLR and MLR model, polynomial regression models; interaction models; qualitative predictor variables.<br>Model selection procedures Leverage; influence measures; diagnostics. Weighted least squares; ridge regression; loess regression; bootstrapping. | |
| | 2.2 | Logistic Regression: Logistic Response function and logit, Logistic Regression and GLM, Generalized Linear model, Predicted values from Logistic Regression, Interpreting the coefficients and odds ratios, Linear and Logistic Regression: similarities and Differences, Assessing the models. | |
| 3 | | **Time Series** | 7 |
| | | Definition of time series, Times series forecasting. Time series components, Decomposition – additive and multiplicative.<br>Exponential smoothing, Holt winters method.<br>Time Series Analysis - Box-Jenkins Methodology, ARIMA Model Autocorrelation Function (ACF, PACF) Autoregressive Models ,Moving Average Models ,ARMA and ARIMA Models , Building and Evaluating an ARIMA Model. | |
| 4 | | **Introduction to Data Visualization** | 8 |
| | 4.1 | Acquiring and Visualizing Data, Simultaneous acquisition and visualization, Applications of Data Visualization, Keys factors of Data Visualization , Exploring the Visual Data Spectrum: charting Primitives (Data Points, Line Charts, Bar Charts, Pie Charts, Area Charts), Exploring advanced Visualizations (Candlestick Charts, Bubble Charts, Surface Charts, Map Charts) ; Narrative visualization and digital story Telling ,infographics and interactive dashboards | |
| **5** | | **Introduction to D3.js:** | 7 |
| | 5.1 | Getting setup with D3, Making selections, changing selection's attribute, Loading and filtering External data : Building a graphic that uses all of the population distribution data, Data formats you can use with D3, Creating a server to upload your data, D3's function for loading data, Dealing with Asynchronous requests, Loading and formatting Large Data Sets | |
| **6** | | **Data analytics and Visualization with Python** | 6 |
| | 6.1 | Essential Data Libraries for data analytics: Pandas, NumPy, SciPy. Plotting and visualization with python: Introduction to Matplotlib, Basic Plotting with Matplotlib, Create Histogram, Bar Chart, Pie Chart, Box Plot, violin plot using Matplotlib, Matrix charts and heat maps. | |
| | 6.2 | Introduction to seaborne Library, Multiple Plots, Regression plot, replot. Discover and visualize the data to gain insights, Feature scaling and Transformation pipelines | |
| | | **Total** | 39 |

| **Textbooks:** | |
|---|---|
| 1 | Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data,EMC Education services Wiley Publication |
| 2 | Data Analytics using Python: Bharati Motwani, Wiley Publications. |

| | |
|---|---|
| 3 | Forecasting : methods and applications- Spyros G Makridakis, Steven C wheelwright, Rob J Hyndman, 3rd edition Wiley publications |
| 4 | Practical Text Mining and statistical Analysis for non-structured text data applications,1st edition,Grey Miner,Thomas Hill. |
| 5 | Ritchie S. King, Visual story telling with D3' Pearson |
| **References:** | |
| 1 | Data Mining, Concepts and Techniques: 3rd edition, Jiawei Han, Micheline Kamber and Jian Pei |
| 2 | Python for Data Analysis: 3rd Edition, Wes McKinney ,Publisher(s): O'Reilly Media, Inc. |
| 3 | Ben Fry, 'Visualizing data: Exploring and explaining data with the processing environment', O'Reilly, 2008. |

**Internal Assessment:**
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

**Continuous Assessment:-**
Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:-

| Sr.no | Rubrics | Marks |
|---|---|---|
| 1. | *Certificate course for 4 weeks or more:- NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2. | Content beyond syllabus presentation | 10 marks |
| 3. | Creating Proof of concept | 10 marks |
| 4. | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5. | Multiple Choice Questions (Quiz) | 5 marks |
| 6. | GATE Based Assignment /Tutorials etc | 10 marks |

For sr.no.1, the date of certification exam should be within the term and in case a student is unable to complete the certification, the grading has to be done accordingly.

**End Semester Theory Examination:**

| | |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| **Useful Links** | |
|---|---|
| 1 | http://varianceexplained.org/RData/ |
| 2 | https://www.kaggle.com/code/iamleonie/time-series-interpreting-acf-and-pacf |
| 3 | https://www.geeksforgeeks.org/data-visualization-using-matplotlib/ |

| Course Code | Course Name | Credit |
|---|---|---|
| ADC602 | Cryptography and System Security | 03 |

| | |
|---|---|
| **Pre-requisite: Basic concepts of OSI Layer** | |
| **Course Objectives:** The course aims: | |
| 1 | The concepts of classical encryption techniques and concepts of finite fields and number theory. |
| 2 | To explore the working principles and utilities of various cryptographic algorithms including secret key cryptography, hashes and message digests, and public key algorithms |
| 3 | To explore the design issues and working principles of various authentication protocols, PKI standards. |
| 4 | To explore various secure communication standards including Kerberos, IPsec, and SSL/TLS and email. |
| 5 | The ability to use existing cryptographic utilities to build programs for secure communication. |
| 6 | The concepts of cryptographic utilities and authentication mechanisms to design secure Applications |
| **Course Outcomes:** | |
| 1 | Identify information security goals, classical encryption techniques and acquire fundamental knowledge on the concepts of finite fields and number theory. |
| 2 | Understand, compare and apply different encryption and decryption techniques to solve problems related to confidentiality and authentication |
| 3 | Apply the knowledge of cryptographic checksums and evaluate the performance of different message digest algorithms for verifying the integrity of varying message sizes |
| 4 | Apply different digital signature algorithms to achieve authentication and create secure applications . |
| 5 | Apply network security basics, analyze different attacks on networks and evaluate the performance of firewalls and security protocols like SSL, IPSec, and PGP |
| 6 | Apply the knowledge of cryptographic utilities and authentication mechanisms to design secure applications |

| Module | | Detailed Content | Hours |
|---|---|---|---|
| **1** | | **Introduction & Number Theory** | |
| | 1.1 | Services, Mechanisms and attacks-the OSI security architecture-Network security model-Classical Encryption techniques (Symmetric cipher model, mono-alphabetic and poly-alphabetic substitution techniques: Vignere cipher, playfair cipher, Hill cipher, transposition techniques: keyed and keyless transposition ciphers, steganography). | 7 |
| **2** | | **Block Ciphers & Public Key Cryptography** | 7 |
| | 2.1 | Data Encryption Standard-Block cipher principles-block cipher modes of operationAdvanced Encryption Standard (AES)-Triple DES-Blowfish-RC5 algorithm. Public key cryptography: Principles of public key cryptosystems-The RSA algorithm, The knapsack algorithm, El-Gamal Algorithm. Key management – Diffie Hellman Key exchange | |

| | | | |
|---|---|---|---|
| **3** | | **Cryptographic Hashes, Message Digests and Digital Certificates** | 7 |
| | 3.1 | Authentication requirement – Authentication function,Typesof Authentication, MAC – Hash function – Security of hash function and MAC –MD5 – SHA – HMAC – CMAC, Digital Certificate: X.509, PKI | |
| **4** | | **Digital signature schemes and authentication Protocols** | 6 |
| | 4.1 | Digital signature and authentication protocols : Needham Schroeder Authentication protocol, Digital Signature Schemes – RSA . | |
| **5** | | **System Security** | 6 |
| | | Operating System Security: Memory and Address Protection, File Protection Mechanism, User Authentication. Linux and Windows: Vulnerabilities, File System Security<br>Database Security: Database Security Requirements, Reliability and Integrity, Sensitive Data, Inference Attacks, Multilevel Database Security | |
| **6** | | **Web security** | **6** |
| | 6.1 | Web Security Considerations, User Authentication and Session Management, Cookies, SSL, HTTPS, SSH, Web Browser Attacks, WebBugs, Clickjacking, CrossSite Request Forgery, Session Hijacking and Management, Phishing Technique, DNS Attack, Secure Electronic Transaction, Email Attacks, Firewalls, Penetration Testing | |

| **Textbooks:** | |
|---|---|
| 1 | Computer Security Principles and Practice, William Stallings, Sixth Edition, Pearson Education |
| 2 | Security in Computing, Charles P. Pfleeger, Fifth Edition, Pearson Education |
| 3 | Network Security and Cryptography, Bernard Menezes, Cengage Learning |
| 4 | Network Security Bible, Eric Cole, Second Edition, Wiley |
| 5 | Mark Stamp‘s Information Security Principles and Practice, Wiley |

**References:**

| | |
|---|---|
| 1 | Web Application Hackers Handbook by Wiley. |
| 2 | Computer Security, Dieter Gollman, Third Edition, Wiley |
| 3 | CCNA Security Study Guide, Tim Boyle, Wiley |
| 4 | Introduction to Computer Security, Matt Bishop, Pearson. 5. |
| 5 | Cloud Security and Privacy, Tim Mather, Subra Kumaraswamy, Shahed Latif , O‘Riely |
| 6 | Cryptography and Network Security, Atul Kahate, Tata Mc Graw Hill |

**Internal Assessment:**
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

**Continuous Assessment:-**
Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:-

| Sr.no | Rubrics | Marks |
|---|---|---|
| 1. | *Certificate course for 4 weeks or more:- NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2. | Content beyond syllabus presentation | 10 marks |
| 3. | Creating Proof of concept | 10 marks |
| 4. | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5. | Multiple Choice Questions (Quiz) | 5 marks |
| 6. | GATE Based Assignment /Tutorials etc | 10 marks |

For sr.no.1, the date of certification exam should be within the term and in case a student is unable to complete the certification, the grading has to be done accordingly.

| **End Semester Theory Examination:** | |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| **Useful Links** | |
|---|---|
| 1 | https://nptel.ac.in/courses/106105031 |
| 2 | https://onlinecourses.nptel.ac.in/noc22_cs03/preview |
| 3 | https://www.coursera.org/learn/basic-cryptography-and-crypto-api |

| Course Code | Course Name | Credit |
|---|---|---|
| ADC603 | Software Engineering and Project Management | 03 |

| | |
|---|---|
| **Pre-requisite: None** | |
| **Course Objectives:** The course aims: | |
| 1 | To provide the knowledge of software engineering discipline. |
| 2 | To understand Requirements and analyze it |
| 3 | To do planning and apply scheduling |
| 4 | To apply analysis, and develop software solutions |
| 5 | To demonstrate and evaluate real time projects with respect to software engineering principles and Apply testing and assure quality in software solution. |
| 6 | To understand need of project management and project management life cycle. |
| **Course Outcomes:** | |
| 1 | Understand and use basic knowledge in software engineering. |
| 2 | Identify requirements, analyze and prepare models. |
| 3 | Plan, schedule and track the progress of the projects. |
| 4 | Design & develop the software solutions for the growth of society |
| 5 | Apply testing and assure quality in software solutions |
| 6 | Generate project schedule and can construct, design and develop network diagram for different type of Projects. They can also organize different activities of project |

| Module | | Detailed Content | Hours |
|---|---|---|---|
| 1 | | **Introduction to Software Engineering** | |
| | | Nature of Software, Software Engineering, Software Process, Capability Maturity Model (CMM) Generic Process Model, Prescriptive Process Models: The Waterfall Model, V-model, Incremental Process Models, Evolutionary Process Models, Concurrent Models, Agile process, Agility Principles, Extreme Programming (XP), Scrum, Kanban model | 08 |
| 2 | | **Requirements Analysis and Cost Estimation** | 06 |
| | 2.1 | Software Requirements: Functional & non-functional – user-system requirement engineering process – feasibility studies – elicitation – validation & management – software prototyping – S/W documentation – Analysis and modelling Requirement Elicitation, Software requirement specification (SRS) 3Ps (people, product and process) Process and Project metrics Software Project Estimation: LOC, FP, Empirical Estimation Models - COCOMO II Model | |
| 3 | | **Design Engineering** | 07 |

| | | | |
|---|---|---|---|
| | 3.1 | Design Process & quality, Design Concepts, The design Model, Pattern-based Software Design. 4.2 Architectural Design :Design Decisions, Views, Patterns, Application Architectures, Modeling Component level Design: component, Designing class based components, conducting component-level design, User Interface Design: The golden rules, Interface Design steps & Analysis, Design Evaluation | |
| 4 | | **Software Risk, Configuration Management** | 05 |
| | 4.1 | Risk Identification, Risk Assessment, Risk Projection, RMMM Software Configuration management, SCM repositories, SCM process Software Quality Assurance Task and Plan, Metrics, Software Reliability, Formal Technical Review (FTR), Walkthrough. | |
| 5 | | **Software Testing and Maintenance** | 05 |
| | 5.1 | Testing: Software Quality, Testing: Strategic Approach, Strategic Issues-Testing: Strategies for Conventional Software, Object oriented software, Web AppsValidating Testing- System Testing- Art of Debugging.<br>Maintenance : Software Maintenance-Software Supportability-Reengineering- Business Process Reengineering- Software Reengineering-Reverse Engineering- Restructuring- Forward Engineering. | |
| 6 | | **IT Project Management and Project Scheduling** | 08 |
| | 6.1 | Introduction, 4 P‘s, W5HH Principle, Need for Project Management, Project Life cycle and ITPM, Project Feasibility, RFP, PMBOK Knowledge areas, Business Case, Project Planning, Project Charter and Project Scope. | |
| | 6.2 | Project Scheduling:Defining a Task Set for the Software Project, Timeline chartsWBS, Developing the Project Schedule, Network Diagrams (AON, AOA), CPM and PERT, Gantt Chart , Tracking the Schedule, Earned Value Analysis | |


| **Textbooks:** | |
|---|---|
| 1 | Roger S. Pressman, Software Engineering: A practitioner's approach, McGraw Hill |
| 2 | Rajib Mall, Fundamentals of Software Engineering, Prentice Hall India |
| 3 | John M. Nicholas, Project Management for Business and Technology, 3rd edition, Pearson Education. |
| **References:** | |
| 1 | -Software Engineering : A Precise Approach Pankaj Jalote , Wiley India |
| 2 | Ian Sommerville — Software Engineering 9th edition Pearson Education SBN-13: 978-0- 13-703515-1, ISBN-10: 0-13-703515-2 |
| 3 | PankajJalote, An integrated approach to Software Engineering, Springer/Narosa. |

**Internal Assessment:**
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approx. 50% syllabus is completed Duration of the midterm test shall be one hour.

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Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:-

| Sr.no | Rubrics | Marks |
|---|---|---|
| 1. | *Certificate course for 4 weeks or more:- NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2. | Content beyond syllabus presentation | 10 marks |
| 3. | Creating Proof of concept | 10 marks |
| 4. | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5. | Multiple Choice Questions (Quiz) | 5 marks |
| 6. | GATE Based Assignment /Tutorials etc | 10 marks |

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| **Useful Links** | |
|---|---|
| 1 | https://onlinecourses.swayam2.ac.in/cec21_cs21/preview |
| 2 | https://nptel.ac.in/courses/106101061 |
| 3 | http://www.nptelvideos.com/video.php?id=911&c=9 4 |

| Course Code | Course Name | Credit |
|---|---|---|
| ADC604 | Machine Learning | 03 |

| | |
|---|---|
| **Pre-requisite:** Data Structures, Basic Probability and Statistics, Algorithms | |
| **Course Objectives:** The course aims: | |
| 1 | To introduce Machine learning concepts |
| 2 | To develop mathematical concepts required for Machine learning algorithms |
| 3 | To understand various Regression techniques |
| 4 | To understand Clustering techniques |
| 5 | To develop Neural Network based learning models |
| **Course Outcomes:**<br>**After successful completion of the course students will be able to:** | |
| 1 | Comprehend basics of Machine Learning |
| 2 | Build Mathematical foundation for machine learning |
| 3 | Understand various Machine learning models |
| 4 | Select suitable Machine learning models for a given problem |
| 5 | Build Neural Network based models |
| 6 | Apply Dimensionality Reduction techniques |

| Module | | Detailed Content | Hours |
|---|---|---|---|
| **1** | | **Introduction to Machine Learning** | 6 |
| | 1.1 | Introduction to Machine Learning, Issues in Machine Learning, Application of Machine Learning, Steps of developing a Machine Learning Application. | |
| | | Supervised and Unsupervised Learning: Concepts of Classification, Clustering and prediction, Training, Testing and validation dataset, cross validation, overfitting and underfitting of model | |
| | | Performance Measures: Measuring Quality of model- Confusion Matrix, Accuracy, Recall, Precision, Specificity, F1 Score, RMSE | |
| **2** | | **Mathematical Foundation for ML** | 5 |
| | 2.1 | System of Linear equations, Norms, Inner products, Length of Vector, Distance between vectors, Orthogonal vectors | |
| | 2.2 | Symmetric Positive Definite Matrices, Determinant, Trace, Eigenvalues and vectors, Orthogonal Projections, Diagonalization, SVD and its applications | |
| **3** | | **Linear Models** | 7 |
| | 3.1 | The least-squares method, Multivariate Linear Regression, Regularized Regression, Using Least-Squares Regression for classification | |
| | 3.2 | Support Vector Machines | |
| **4** | | **Clustering** | 4 |
| | 4.1 | Hebbian Learning rule | |

| | | | |
|---|---|---|---|
| | 4.2 | Expectation -Maximization algorithm for clustering | |
| **5** | | **Classification models** | 10 |
| | 5.1 | Introduction, Fundamental concept, Evolution of Neural Networks, Biological Neuron, Artificial Neural Networks, NN architecture, McCulloch-Pitts Model. Designing a simple network, Non-separable patterns, Perceptron model with Bias. Activation functions, Binary, Bipolar, continuous, Ramp. Limitations of Perceptron. | |
| | 5.2 | Perceptron Learning Rule. Delta Learning Rule (LMS-Widrow Hoff), Multi-layer perceptron network. Adjusting weights of hidden layers. Errorback propagation algorithm. | |
| | 5.3 | Logistic regression | |
| **6** | | **Dimensionality Reduction** | 07 |
| | 6.1 | Curse of Dimensionality. | |
| | 6.2 | Feature Selection and Feature Extraction | |
| | 6.3 | Dimensionality Reduction Techniques, Principal Component Analysis. | |


| **Textbooks:** | |
|---|---|
| 1 | Nathalie Japkowicz & Mohak Shah, –Evaluating Learning Algorithms: A Classification Perspective, Cambridge. |
| 2 | Marc Peter Deisenroth, Aldo Faisal, Cheng Soon Ong, –Mathematics for machine learning, |
| 3 | Samir Roy and Chakraborty, –Introduction to soft computing, Pearson Edition. |
| 4 | Ethem Alpaydın, –Introduction to Machine Learning, MIT Press McGraw-Hill Higher Education |
| 5 | Peter Flach, –Machine Learning, Cambridge University Press |
| **References:** | |
| 1 | Tom M. Mitchell, –Machine Learning, McGraw Hill |
| 2 | Kevin P. Murphy, –Machine Learning — A Probabilistic Perspective, MIT Press |
| 3 | Stephen Marsland, –Machine Learning an Algorithmic Perspective, CRC Press |
| 4 | Shai Shalev-Shwartz, Shai Ben-David, –Understanding Machine Learning, Cambridge University Press |
| 5 | Peter Harrington, –Machine Learning in Action, DreamTech Press |

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| 3. | Creating Proof of concept | 10 marks |
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| 5. | Multiple Choice Questions (Quiz) | 5 marks |
| 6. | GATE Based Assignment /Tutorials etc | 10 marks |

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| **Useful links:** | |
|---|---|
| 1 | NPTEL |
| 2 | AI and ML Certification - Enroll in PGP AI ML Courses with Purdue (simplilearn.com) |
| 3 | https://www.learndatasci.com/out/coursera-machine-learning/ |
| 4 | https://www.learndatasci.com/out/google-machine-learning-crash-course/ |

| CourseCode | Course Name | Credit |
|---|---|---|
| ADLO6011 | High Performance Computing | 03 |

**Pre-requisite:** Computer Organization, C Programming, Data structures and Algorithm Analysis.

**Course Objectives:** The course aims:

| | |
|---|---|
| 1 | Learn the concepts of high-performancecomputing. |
| 2 | Gain knowledge of platforms for high performance computing. |
| 3 | Design and implement algorithms for parallel programming applications. |
| 4 | Analyze the performance metrics of High Performance Computing. |
| 5 | Understand the parallel programming paradigm, algorithms and applications. |
| 6 | Demonstrate the understanding of different High Performance Computing tools |

**Course Outcomes:**
**After successful completion of the course students will be able to:**

| | |
|---|---|
| 1 | Understand the fundamentals of parallel Computing. |
| 2 | Describe different parallel processing platforms involved in achieving High PerformanceComputing. |
| 3 | Demonstrate the principles of Parallel Algorithms and their execution. |
| 4 | Evaluate the performance of HPC systems. |
| 5 | Apply HPC programming paradigm to parallel applications |
| 6 | Discuss different current HPCPlatforms. |

| Module | | Detailed Content | Hours |
|---|---|---|---|
| 1 | | **Introduction to Parallel Computing:** | **05** |
| | 1.1 | Motivating Parallelism, Scope of Parallel Computing, Levels of parallelism (instruction,transaction, task, thread, memory, function), Models (SIMD, MIMD, SIMT, SPMD, Dataflow Models, Demand- drivenComputation). | |

| | | | |
|---|---|---|---|
| 2 | | Parallel Programming Platforms | **04** |
| | 2.1 | Implicit Parallelism: Dichotomy of Parallel Computing Platforms, Physical Organization of Parallel Platforms, Communication Costs in Parallel Machines. | |
| 3 | | Parallel Algorithm And Concurrency | **09** |
| | 3.1 | Preliminaries, Decomposition Techniques, Characteristics of Tasks and Interactions, Mapping Techniques for Load Balancing. Basic Communication Operation. | |
| 4 | | Performance Measures for HPC | **05** |
| | 4.1 | **Performance Measures :** Speedup, execution time, efficiency,cost, scalability, Effect of granularity on performance, Scalability of Parallel Systems, Amdahl‘s Law, Gustavson‘s Law. | |
| 5 | | Programming Paradigms for HPC | **09** |
| | 5.1 | Principles of Message Passing Programming, The BuildingBlocks: Send and Receive Operations, MPI: the Message Passing Interface, Topology and Embedding. One-Dimensional Matrix-Vector Multiplication, Graph Algorithms, Sample Sort, Two-Dimensional Matrix Vector Multiplication | |
| 6 | | GPU Architecture and Programming | **05** |
| | 6.1 | OpenCL Device Architectures, Introduction to OpenCL Programming. | |

| | |
|---|---|
| **Textbooks:** | |
| 1 | AnanthGrama, Anshul Gupta, George Karypis, Vipin Kumar , –Introduction to Parallel Computing, Pearson Education, Second Edition, 2007. |
| 2 | Kai Hwang, Naresh Jotwani, –Advanced Computer Architecture: Parallelism, Scalability, Programmability, McGraw Hill, Second Edition, 2010 |
| 3 | Edward Kandrot and Jason Sanders, –CUDA by Example – An Introduction to General Purpose GPU Programming, Addison-Wesley Professional ©, 2010. |
| 4 | Georg Hager, Gerhard Wellein, –Introduction to High Performance Computing for Scientists and Engineers', Chapman & Hall / CRC Computational Science series, 2011. |
| 5 | Benedict Gaster, Lee Howes, David Kaeli, Perhaad Mistry, Dana Schaa ,–Heterogeneous Computing with OpenCL , 2nd Edition, Elsevier, 2012. |
| **References:** | |
| 1 | Michael J. Quinn, –Parallel Programming in C with MPI and OpenMP, McGraw-Hill International Editions, Computer Science Series, 2008. |
| 2 | Kai Hwang, Zhiwei Xu, –Scalable Parallel Computing: Technology, Architecture, Programming, McGraw Hill, 1998. |
| 3 | Stephen Marsland, –Machine Learning an Algorithmic Perspective, CRC Press |
| 4 | Laurence T. Yang, MinyiGuo, –High- Performance Computing: Paradigm and Infrastructure Wiley, 2006. |
| 5 | Fayez Gebali, –Algorithms and Parallel Computing, John Wiley & Sons, Inc., 2011. |

**Internal Assessment:**
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| 5. | Multiple Choice Questions (Quiz) | 5 marks |
| 6. | GATE Based Assignment /Tutorials etc | 10 marks |

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**End Semester Theory Examination:**

| | |
|---|---|
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**Useful links:**

| | |
|---|---|
| 1 | https://onlinecourses.nptel.ac.in/noc21_cs46/preview |
| 2 | https://onlinecourses.nptel.ac.in/noc22_cs21/preview |

| Course Code | Course Name | Credit |
|---|---|---|
| ADLO6012 | Distributed Computing | 03 |

| | |
|---|---|
| **Pre-requisite: C Programming** | |
| **Course Objectives:** The course aims: | |
| 1 | To provide students with contemporary knowledge in distributed systems |
| 2 | To equip students with skills to analyze and design distributed applications. |
| 3 | To provide master skills to measure the performance of distributed synchronization algorithms |
| 4 | To equip students with skills to availability of resources |
| 5 | To provide master skills to distributed file system |
| **Course Outcomes:** | |
| 1 | Demonstrate knowledge of the basic elements and concepts related to distributed system technologies. |
| 2 | Illustrate the middleware technologies that support distributed applications such as RPC, RMI and Object based middleware. |
| 3 | Analyze the various techniques used for clock synchronization and mutual exclusion |
| 4 | Demonstrate the concepts of Resource and Process management and synchronization algorithms |
| 5 | Demonstrate the concepts of Consistency and Replication Management |
| 6 | Apply the knowledge of Distributed File System to analyze various file systems like NFS, AFS and the experience in building large-scale distributed applications |

| Module | | Detailed Content | Hours |
|---|---|---|---|
| **1** | | **Introduction to Distributed Systems** | |
| | 1.1 | Characterization of Distributed Systems: Issues, Goals, and Types of distributed systems, Distributed System Models, Hardware concepts, Software Concept. | 06 |
| | 1.2 | Middleware: Models of Middleware, Services offered by middleware, Client Server model. | |
| **2** | | **Communication** | 06 |
| | 2.1 | Layered Protocols, Interprocess communication (IPC): MPI, Remote Procedure Call (RPC), Remote Object Invocation, Remote Method Invocation (RMI**)** | |
| | 2.2 | Message Oriented Communication, Stream Oriented Communication, Group Communication | |
| **3** | | **Synchronization** | 09 |
| | 3.1 | Clock Synchronization, Physical Clock, Logical Clocks, Election Algorithms, Mutual Exclusion, Distributed Mutual Exclusion-Classification of Mutual Exclusion Algorithm, Requirements of Mutual Exclusion Algorithms, Performance measure. | |

| | | | |
|---|---|---|---|
| | 3.2 | Non Token based Algorithms: Lamport Algorithm, Ricart–Agrawala‘s Algorithm, Maekawa‘s Algorithm | |
| | 3.3 | Token Based Algorithms: Suzuki-Kasami‘s Broadcast Algorithms, Singhal‘s Heuristic Algorithm, Raymond‘s Tree.based Algorithm, Comparative Performance Analysis. | |
| **4** | | **Resource and Process Management** | 06 |
| | 4.1 | Desirable Features of global Scheduling algorithm, Task assignment approach, Load balancing approach, load sharing approach | |
| | 4.2 | Introduction to process management, process migration, Threads, Virtualization, Clients, Servers, Code Migration . | |
| **5** | | **Consistency, Replication and Fault Tolerance** | 06 |
| | 5.1 | Introduction to replication and consistency, Data-Centric and Client-Centric Consistency Models, Replica Management | |
| | 5.2 | Fault Tolerance: Introduction, Process resilience, Reliable client-server and group communication, Recovery | |
| **6** | | **Distributed File Systems and Name Services** | 06 |
| | 6.1 | Introduction and features of DFS, File models, File Accessing models, File-Caching ,Schemes, File Replication, Case Study: Distributed File Systems (DSF), Network File System (NFS), Andrew File System (AFS), HDFS | |

| **Textbooks:** | |
|---|---|
| 1 | Andrew S. Tanenbaum and Maarten Van Steen, –Distributed Systems: Principles and Paradigms, 2nd edition, Pearson Education. |
| 2 | George Coulouris, Jean Dollimore, Tim Kindberg, , ‘Distributed Systems: Concepts and Design’, 4th Edition, Pearson Education, 2005. |
| **References:** | |
| 1 | A. S. Tanenbaum and M. V. Steen, ‘Distributed Systems: Principles and Paradigms’, Second Edition, Prentice Hall, 2006. |
| 2 | M. L. Liu, –Distributed Computing Principles and Applications, Pearson Addison Wesley, 2004. |
| 3 | Learn to Master Distributed Computing by ScriptDemics, StarEdu Solutions |

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| | |
|---|---|
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| **Useful Links** | |
|---|---|
| 1 | https://onlinecourses.nptel.ac.in/noc21_cs87/ |
| 2 | https://nptel.ac.in/courses/106106168 |

| Course Code: | Course Title | Credit |
|---|---|---|
| ADLO6013 | Image Processing and computer vision | 3 |

| | |
|---|---|
| **Prerequisite:** Engineering Mathematics, Algorithms | |
| **Course Objectives:** | |
| 1 | To introduce students to the basic concepts of image processing, file formats. |
| 2 | To acquire an in-depth understanding of image enhancement technqiues. |
| 3 | To gain knowledge of image segmentation and compression techniques. |
| 4 | To acquire fundamentals of image transform techniques. |
| | |
| **Course Outcomes** | |
| 1 | To gain fundamental knowledge of Image processing. |
| 2 | To apply image enhancement techniques. |
| 3 | To apply image segmentation and compression techniques. |
| 4 | To gain an in-depth understanding of image transforms. |
| 5 | To gain fundamental understanding of video processing. |
| | |

| Module | | Content | Hrs |
|---|---|---|---|
| **1** | | **Digital Image Fundamentals** | **04** |
| | 1.1 | Introduction to Digital Image, Digital Image Processing System, Sampling and Quantization, | |
| | 1.2 | Representation of Digital Image, Connectivity, Image File Formats : BMP, TIFF and JPEG. | |
| **2** | | **Image Enhancement in Spatial Domain** | **08** |
| | 2.1 | **Image Enhancement** (point processing): Image Negative, Thresholding, Gray-level slicing with and without background, power law and log transform, Contrast Stretching, Histogram equalization and Histogram Specification | |
| | 2.2 | **Image Enhancement in Spatial Domain** (Neighbourhood processing): Low Pass and High Pass filtering for image enhancement, Basics of Spatial Filtering, Generating Spatial Filter Masks–Smoothing and Sharpening Spatial Filtering | |
| | 2.3 | **Image Transforms:** 1-D DFT, 2-D Discrete Fourier Transform and Its Inverse, Some Properties of 2D DFT, Walsh -Hadamard, Discrete Cosine Transform, Haar Transform, Slant Transform | |
| **3** | | **Image Compression** | **06** |
| | 3.1 | Introduction, Redundancy, Fidelity Criteria | |
| | 3.2 | Lossless Compression Techniques : Run length Coding, ArithmeticCoding, Huffman Coding | |

| | | | |
|---|---|---|---|
| | 3.3 | Lossy Compression Techniques: Improved Gray Scale Quantization,Vector Quantization | |
| **4** | 4.1 | **Morphology:** Erosion and Dilation, Opening and Closing, The Hit or-Miss Transformation. Restoration: Noise models – Mean Filters – Order Statistics – Adaptive filters –wiener filter. | **08** |
| | 4.2 | **Corner and Interest Point detection:** The Harris Interest Point Operator: Corner Signals and shifts for various geometric configuration, Performance with crossing point and Junctions, Different forms of Harris Operator, Local Invariant Feature Detectors and Descriptors: Harris scale and Affine-Invariant Detectors and Descriptors, The SIFT operators, The SURF operators. | |
| **5** | 5.1 | **Point, Line, and Edge Detection:** Detection of Isolated Points, Line detection, edge models, basic and advance edge detection, Edge linking and boundary detection, Canny's edge detection algorithm **Thresholding:** Foundation, Role of illumination, Basic Global thresholding, Otsu's method Region Based segmentation: Region Growing, Region Splitting and merging, Relationships between pixels, Hough transform | **08** |
| | 5.2 | **Region Identification:** Chain code, simple geometric border representation, Fourier Transform of boundaries, Boundary description using segment sequences | |
| **6** | 6.1 | **Motion:** Optical Flow, Interpretation of Optical Fields, Using focus of expansion to avoid collision, Time to adjacency analysis, Basic difficulties with optical flow models, Stero from Motion | **05** |
| | | **Total** | **39** |


| **Textbooks:** | |
|---|---|
| 1 | Rafael C. Gonzalez and Richard E. Woods, _Digital Image Processing‘, Pearson Education Asia, Third Edition, 2009 |
| 2 | S. Jayaraman, E. Esakkirajan and T. Veerkumar, –Digital Image Processing TataMcGraw Hill Education Private Ltd, 2009 |
| 3 | Anil K. Jain, —Fundamentals and Digital Image Processing, Prentice Hall of India Private Ltd, Third Edition |
| 4 | S. Sridhar, –Digital Image Processing, Oxford University Press, Second Edition, 2012. |
| 5. | Alan C. Bovik, –The Essential Guide To Video Processing Academic Press, |
| 6 | Yao Wang, Jorn Ostermann, Ya-Qin Zang, –Video Processing and Communications, Prentice Hall, Signal Processing series. |
| | **References Books** |
| 1. | S. Salivahanan, A. Vallavaraj, C. Gnanapriya, ‘Digital Signal Processing’, Tata McGraw Hill Publication 4th Edition, 2019. |
| 2. | E. R. Davies, ‘Computer and Machine Vision: Theory, Algorithms’, Academic Press, 4th Edition, 2012. |
| 3 | David A. Forsyth, Jean Ponce, –Computer Vision: A Modern Approach, Pearson Education, Limited, 2011 |

| | |
|---|---|
| 4 | Malay K. Pakhira, –Digital Image Processing and Pattern Recognition, Prentice Hall of India Private Ltd, Third Edition |

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| 5. | Multiple Choice Questions (Quiz) | 5 marks |
| 6. | GATE Based Assignment /Tutorials etc | 10 marks |

For sr.no.1, the date of certification exam should be within the term and in case a student is unable to complete the certification , the grading has to be done accordingly.

**End Semester Theory Examination:**

| | |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| **Useful Links** | |
|---|---|
| 1 | https://swayam.gov.in |
| 2 | https://nptel.ac.in/courses |
| 3 | https://www.coursera.org |

| Lab Code | Lab Name | Credit |
|---|---|---|
| ADL601 | Data Analytics and Visualization Lab | 1 |

| | |
|---|---|
| **Prerequisite: Basic Python** | |
| **Lab Objectives:** | |
| 1 | To effectively use libraries for data analytics. |
| 2 | To understand the use of regression Techniques in data analytics applications. |
| 3 | To use time series models for prediction. |
| 4 | To introduce the concept of text analytics and its applications. |
| 5 | To apply suitable visualization techniques using R and Python. |
| **Lab Outcomes:**<br>**At the end of the course, students will be able to —-** | |
| 1 | Explore various data analytics Libraries in R and Python. |
| 2 | Implement various Regression techniques for prediction. |
| 3 | Build various time series models on a given data set. |
| 4 | Design Text Analytics Application on a given data set. |
| 5 | Implement visualization techniques to given data sets using R . |
| 6 | Implement visualization techniques to given data sets using Python. |

**Suggested Experiments:** Students are required to complete at least 08 experiments Preferably using **R Programming Language/Python**

| Sr. No. | Name of the Experiment |
|---|---|
| 1 | Getting introduced to data analytics libraries in Python and R. |
| 2 | Simple Linear Regression in Python. |
| 3 | Multiple Linear Regression in Python |
| 4 | Time Series Analysis in Python |
| 5 | Implementation of ARIMA model in python |
| 6 | Implementation of Time series Decomposition and ACF and PACF |
| 7,8 | Set Up a D3.js Environment, Select Elements in D3, Modify Elements in D3,Data Loading in D3,Create a World Map with d3.js, Event Handling with D3.js |
| 9,10 | Two visualization experiments in python using different Libraries. |

| | |
|---|---|
| **Useful Links:** | |
| 1 | https://www.geeksforgeeks.org/data-visualization-with-python |
| 2 | https://www.coursera.org/specializations/data-science-python |
| 3 | https://www.geeksforgeeks.org/data-visualization-in-r/ |
| 5 | https://towardsdatascience.com/introduction-to-arima-for-time-series-forecasting- |

| | |
|---|---|
| **References:** | |
| 1 | Data Analytics using R, Bharati Motwani, Wiley Publications |
| 2 | Python for Data Analysis: 3rd Edition, WesMcKinney, Publisher(s): O'Reilly Media, Inc. |

| | |
|---|---|
| 3 | Better Data Visualizations A Guide for Scholars, Researchers, and Wonks, Jonathan Schwabish, Columbia University Press |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks based on evaluation of Experiments |
| **Evaluation Exam** | |
| | Practical Exam based on lab syllabus of ADL601 |

| Lab Code | Lab Name | Credit |
|---|---|---|
| ADL602 | Cryptographic and system security Lab | 1 |

| Prerequisite: Operating System, Basics of Java and Python Programming. | |
|---|---|
| **Lab Objectives:** | |
| 1 | To be able to apply the knowledge of symmetric cryptography to implement simple ciphers |
| 2 | To be able to analyze and implement public key algorithms like RSA and El Gamal |
| 3 | To analyze and evaluate performance of hashing algorithms |
| 4 | To explore the different network reconnaissance tools to gather information about networks . |
| **Lab Outcomes:** | |
| 1 | Apply the knowledge of symmetric cryptography to implement simple ciphers |
| 2 | Analyze and implement public key algorithms like RSA and El Gamal |
| 3 | Analyze and evaluate performance of hashing algorithms |
| 4 | Explore the different network reconnaissance tools to gather information about networks |
| 5 | Use tools like sniffers, port scanners and other related tools for analyzing packets in a network. |
| 6 | Apply and set up firewalls and intrusion detection systems using open source technologies and to explore email security. |

| **Suggested Experiments:** Students are required to complete at least 10 experiments. | |
|---|---|
| Star (*) marked experiments are compulsory. | |
| **Sr. No.** | **Name of the Experiment** |
| 1* | Design and Implementation of a product cipher using Substitution and Transposition ciphers. |
| 2* | Implementation and analysis of RSA cryptosystem and Digital signature scheme using RSA/El Gamal. |
| 3* | Implementation of Diffie Hellman Key exchange algorithm |
| 4 | For varying message sizes, test integrity of message using MD-5, SHA-1, and analyse the performance of the two protocols. Use crypt APIs. |
| 5* | Exploring wireless security tools like Kismet, NetStumbler etc. |
| 6* | Study the use of network reconnaissance tools like WHOIS, dig,traceroute, nslookup to gather information about networks and domain registrars. |
| 7 | Study of packet sniffer tools wireshark, :- 1. Observer performance in promiscuous as well as non-promiscuous mode. 2. Show the packets can be traced based on different filters. |
| 8* | Download and install nmap. Use it with different options to scan open ports, perform OS fingerprinting, do a ping scan, tcp port scan, udp port scan, etc. . |
| 9* | Detect ARP spoofing using nmap and/or open source tool ARPWATCH and wireshark |
| 10 | Use the NESSUS/ISO Kaali Linux tool to scan the network for vulnerabilities |

| | |
|---|---|
| 11 | Set up IPSEC under LINUX. b) Set up Snort and study the logs. c) Explore the GPG tool of linux to implement email security. |

| **Useful Links:** | |
|---|---|
| 1 | www.leetcode.com |
| 2 | www.hackerrank.com |
| 3 | www.cs.usfca.edu/ |
| 4 | www.codechef.com |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks based on evaluation of Experiments |

| Lab Code | Lab Name | Credit |
|---|---|---|
| ADL603 | Software Engineering and Project Management Lab | 1 |

| | |
|---|---|
| **Prerequisite: Knowledge of Linux Operating system, installation and configuration of services and command line basics, Basics of Computer Networks and Software Development Life cycle.** | |
| **Lab Objectives:** | |
| 1 | To understand DevOps practices which aims to simplify Software Development Life Cycle. |
| 2 | To be aware of different Version Control tools like GIT, CVS or Mercurial |
| 3 | To Integrate and deploy tools like Jenkins and Maven, which is used to build, test and deploy applications in DevOps environment |
| 4 | To understand the importance of Jenkins to Build and deploy Software Applications on server environment |
| 5 | To use Docker to Build, ship and manage applications using containerization |
| 6 | To understand the concept of Infrastructure as a code and install and configure Ansible tool |
| **Lab Outcomes:** | |
| 1 | To understand the fundamentals of DevOps engineering and be fully proficient with DevOps terminologies, concepts, benefits, and deployment options to meet your business requirements |
| 2 | To obtain complete knowledge of the –version control system to effectively track changes augmented with Git and GitHub |
| 3 | Understand the importance of Selenium and Jenkins to test Software Applications |
| 4 | To understand the importance of Jenkins to Build and deploy Software Applications on server environment |
| 5 | To understand concept of containerization and Analyze the Containerization of OS images and deployment of applications over Dockerk. |
| 6 | To Synthesize software configuration and provisioning using Ansible. |

**Suggested Experiments:** Students are required to complete at least 10 experiments from the list given below.

Star (*) marked experiments are compulsory.

| Sr. No. | Name of the Experiment |
|---|---|
| 1 | To understand DevOps: Principles, Practices, and DevOps Engineer Role and Responsibilities |
| 2 | To understand Version Control System / Source Code Management, install git and create a GitHub account |
| 3 | To Perform various GIT operations on local and Remote repositories using GIT Cheat-Sheet |
| 4 | To understand Continuous Integration, install and configure Jenkins with |

| | |
|---|---|
| | Maven/Ant/Gradle to setup a build Job |
| 5 | To Build the pipeline of jobs using Maven / Gradle / Ant in Jenkins, create a pipeline script to Test and deploy an application over the tomcat server. |
| 6 | To understand Jenkins Master-Slave Architecture and scale your Jenkins standalone implementation by implementing slave nodes. |
| 7 | To Setup and Run Selenium Tests in Jenkins Using Maven. |
| 8 | To understand Docker Architecture and Container Life Cycle, install Docker and execute docker commands to manage images and interact with containers |
| 9 | To learn Docker file instructions, build an image for a sample web application using Docker file. |
| 10 | To install and Configure Pull based Software Configuration Management and provisioning tools using Puppet |
| 11 | To learn Software Configuration Management and provisioning using Puppet Blocks(Manifest, Modules, Classes, Function) |
| 12 | To provision a LAMP/MEAN Stack using Puppet Manifest. |

| **Useful Links:** | |
|---|---|
| 1 | https://nptel.ac.in/courses/128106012 |
| 2 | https://www.edureka.co/devops-certification-training |
| 3 | https://www.coursera.org/professional-certificates/devops-and-software-engineering |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks based on evaluation of Experiments |
| **Evaluation Exam** | |
| | Practical Exam based on lab syllabus of ADL603 |

| Lab Code | Lab Name | Credit |
|---|---|---|
| ADL604 | Machine Learning Lab | 1 |

| Prerequisite: C Programming Language. | |
|---|---|
| **Lab Objectives:** | |
| 1 | To introduce platforms such as Anaconda, COLAB suitable to Machine learning |
| 2 | To implement various Regression techniques |
| 3 | To develop Neural Network based learning models |
| 4 | To implement Clustering techniques |
| **Lab Outcomes:**<br>**After successful completion of the course students will be able to:** | |
| 1 | Implement various Machine learning models |
| 2 | Apply suitable Machine learning models for a given problem |
| 3 | Implement Neural Network based models |
| 4 | Apply Dimensionality Reduction techniques |

| **Suggested Experiments:** Students are required to complete at least 10 experiments. | |
|---|---|
| **Sr. No.** | **Name of the Experiment** |
| 1 | Introduction to platforms such as Anaconda, COLAB |
| 2 | Study of Machine Learning Libraries and tools (Python library, tensorflow, keras,...) |
| | **Implementation of following algorithms for a given example data set-** |
| 3 | Linear Regression. |
| 4 | Logistic Regression. |
| 5 | Support Vector Machines |
| 6 | Hebbian Learning |
| 7 | Expectation -Maximization algorithm |
| 8 | McCulloch Pitts Model. |
| 9 | Single Layer Perceptron Learning algorithm |
| 10 | Error Backpropagation Perceptron Training Algorithm |
| 11 | Principal Component Analysis |
| 12 | Applications of above algorithms as a case study (E.g. Hand Writing Recognition using MNIST data set, classification using IRIS data set, etc) |

| **Useful Links:** | |
|---|---|
| 1 | https://www.learndatasci.com/out/edx-columbia-machine-learning/ |
| 2 | https://www.learndatasci.com/out/oreilly-hands-machine-learning-scikit-learn-keras-and-tensorflow-2nd-edition/ |
| 3 | https://www.learndatasci.com/out/google-machine-learning-crash-course/ |

| | |
|---|---|
| 4 | https://www.learndatasci.com/out/edx-columbia-machine-learning/ |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks based on evaluation of Experiments |
| **Evaluation Exam** | |
| | Practical Exam based on lab syllabus of ADL604 |

| Course Code | Course Name | Credits |
|---|---|---|
| ADL601 | Skill based Lab: R Programming / Tableau | 02 |

| | |
|---|---|
| **Prerequisite:** | |
| **Lab Objectives:** | |
| 1 | To understand and identify the problem |
| 2 | To apply basic engineering fundamentals and attempt to find solutions to the problems. |
| 3 | Identify, analyze, formulate and handle programming projects with a comprehensive and systematic approach |
| **Lab Outcomes:**<br>**At the end of the course, students will be able to —-** | |
| 1 | Identify Methodology for solving above problem and apply engineering knowledge and skills to solve it |
| 2 | Analyze and evaluate the impact of solution/product/research/innovation /entrepreneurship towards societal/environmental/sustainable development |
| 3 | Identify Methodology for solving above problem and apply engineering knowledge and skills to solve it |

| **R Programming** | |
|---|---|
| **1** | Introduction: Installing R on personal machines. installing R and RStudio. • The basic functionality of R will be demonstrated, Variable types in R. Numeric variables, strings and factors. • Accessing the help system. Retrieving R packages. • Basic data types and operations: numbers, characters and composites. • Data entry and exporting data |
| **2** | Data structures: vectors, matrices, lists and<br>data frames. |
| **3** | R as a programming language:Grouping, loops and conditional<br>execution, Functions<br>Exploratory data analysis Range, summary, mean, variance,<br>median, standard deviation, histogram, box plot, scatterplot |
| **4** | Graphics in R<br>• Graphics and tables<br>• Working with larger datasets<br>• Building tables with aggregate<br>• Introduction to ggplot2 graphics |
| **5** | Regression and correlation<br>• Simple regression and correlation<br>Multiple regression<br>• Tabular data and analysis of Categorical Data |
| **6** | R for Data Science (Mini Project)<br>Implementing a mini project using any data<br>mining or big data analytics algorithm in R<br>• Extracting data from a large Dataset<br>• Exploratory analysis<br>• Using Mining algorithm<br>• Visualizations and interpretation of Results |

| Tableau | |
|---|---|
| **1** | **Tableau Basic** :Connecting to Excel Files Connecting to Text Files , Connect to Microsoft SQL Server , Connecting to Microsoft Analysis Services ,Creating and Removing Hierarchies , Bins , Joining Tables , Data Blending |
| **2** | **Learn Tableau Basic Reports** : Parameters , Grouping Example 1 , Grouping Example 2 ,Edit Groups , Set , Combined Sets • Creating a First Report , Data Labels • Create Folders , Sorting Data , Add Totals, Sub Totals and Grand Totals to Report |
| **3** | **Learn Tableau Charts** : Area Chart ,Bar Chart , Box Plot , Bubble Chart , Bump Chart , Bullet Graph , Circle Views , Dual Combination Chart , Dual Lines Chart , Funnel Chart , Traditional Funnel Charts , Gantt Chart , Grouped Bar or Side by Side Bars Chart , Heat map , Highlight Table , Histogram , Cumulative Histogram • Line Chart |
| **4** | **Learn Tableau Calculations & Filters** : Calculated Fields ,Basic Approach to Calculate Rank , Advanced Approach to Calculate Rank , Calculating Running Total, Filters Introduction , Quick Filters , Filters on Dimensions , Conditional Filters ,Top and Bottom Filters , Filters on Measures , Context Filters , Slicing Filters , Data Source Filters , Extract Filters |
| **5** | **Learn Tableau Dashboards** : Create a Dashboard , Format Dashboard Layout , Create a Device preview of dashboard. Create Filters on Dashboard , Dashboard Objects , Create a Story |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 5 Experiment. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 50 Marks<br>(Experiments: 50 Marks) |

| Course Code | Course Name | Credits |
|---|---|---|
| ADS602 | Skill based Lab: AWS Essentials / Azure for data engineering | 02 |

| Prerequisite: | |
|---|---|
| **Lab Objectives:** | |
| 1 | To understand and identify the problem |
| 2 | To apply basic engineering fundamentals and attempt to find solutions to the problems. |
| 3 | Identify, analyze, formulate and handle programming projects with a comprehensive and systematic approach |
| **Lab Outcomes:**<br>**At the end of the course, students will be able to —-** | |
| 1 | Identify Methodology for solving above problem and apply engineering knowledge and skills t solve it |
| 2 | Analyze and evaluate the impact of solution/product/research/innovation /entrepreneurship towards societal/environmental/sustainable development |
| 3 | Identify Methodology for solving above problem and apply engineering knowledge and skills to solve it |

| AWS Essentials | |
|---|---|
| 1 | Introduction to Amazon Web Services |
| 2 | Compute in the Cloud |
| 3 | Global Infrastructure and Reliability |
| 4 | Networking storage and database |
| 5 | Monitoring and Analytics |

| Data Engineering on Microsoft Azure | |
|---|---|
| **1** | Introduction to data engineering on Azure |
| **2** | Introduction to Azure Data Lake Storage Gen2 |
| **3** | Introduction to Azure Synapse Analytics |
| **4** | Use Azure Synapse serverless SQL pool to query files in a data lake |
| **5** | Use Azure Synapse serverless SQL pools to transform data in a data lake |

| Term Work: | |
|---|---|
| 1 | Term work should consist of 5 Experiment. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 50 Marks<br>(Experiments: 50 Marks) |

**Program Structure for Fourth Year AI&DS**

**(With Effect** from 2023-2024)

## Semester VII

| Course Code | Course Name | Teaching Scheme (Contact Hours) | | Credits Assigned | | |
|---|---|---|---|---|---|---|
| | | Theory | Pract. Tut. | Theory | Pract. | Total |
| ADC701 | Deep Learning | 3 | -- | 3 | -- | 3 |
| ADC 702 | Big Data Analytics | 3 | -- | 3 | | 3 |
| ADDO 701X | Department Level Optional Course-3 | 3 | -- | 3 | -- | 3 |
| ADDO 702X | Department Level Optional Course-4 | 3 | -- | 3 | -- | 3 |
| ILO701X | Institute Level Optional Course-1 | 3 | -- | 3 | -- | 3 |
| ADL701 | Deep Leaning Lab | -- | 2 | -- | 1 | 1 |
| ADL 702 | Big Data Analytics Lab | -- | 2 | -- | 1 | 1 |
| ADDOL 701X | Department Level Optional Course-3 Lab | -- | 2 | -- | 1 | 1 |
| ADDOL 702X | Department Level OptionalCourse-4 Lab | -- | 2 | -- | 1 | 1 |
| AD CP701 | Major Project1 | -- | 6# | -- | 3 | 3 |
| **Total** | | **15** | **14** | **15** | **7** | **22** |

| Course Code | Course Name | Examination Scheme | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | Term Work | Prac. | Total |
| | | Internal Assessment | | End Sem Exam | Exam. Duration (in Hrs) | | | |
| | | Mid Test | CA* | | | | | |
| ADC701 | Deep Learning | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADC 702 | Big Data Analytics | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADDO 701X | Department Level Optional Course-3 | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADDO 702X | Department Level Optional Course-4 | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ILO 701X | Institute Level Optional Course-1 | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADL701 | Deep Leaning Lab | -- | -- | -- | -- | 25 | 25 | 50 |
| ADL 702 | Big Data Analytics Lab | -- | -- | -- | -- | 25 | 25 | 50 |
| ADLDOL 701X | Department Level Optional Course-3 Lab | | | | | 25 | - | 25 |
| ADLDOL 702X | Department Level OptionalCourse-4 Lab | -- | -- | -- | -- | 25 | - | 25 |
| AD CP701 | Major Project1 | -- | -- | -- | -- | 50 | 25 | 75 |
| **Total** | | **--** | **--** | **400** | **--** | **150** | **75** | **725** |

**Program Structure for Fourth Year AI&DS**

**(With Effect** from 2023-2024)

## Semester VIII

| Course Code | Course Name | Teaching Scheme (Contact Hours) | | Credits Assigned | | |
|---|---|---|---|---|---|---|
| | | Theory | Pract. Tut. | Theory | Pract. | Total |
| ADC801 | Advanced Artificial Intelligence | 3 | -- | 3 | -- | 3 |
| ADDO 801X | Department Level Optional Course-5 | 3 | -- | 3 | -- | 3 |
| ADDO 802X | Department Level OptionalCourse-6 | 3 | -- | 3 | -- | 3 |
| ILO 801X | Institute Level OptionalCourse-2 | 3 | -- | 3 | -- | 3 |
| ADL801 | Advanced Artificial Intelligence Lab | -- | 2 | -- | 1 | 1 |
| ADDOL 801X | Department Level Optional Course-5 Lab | -- | 2 | -- | 1 | 1 |
| ADDOL 802X | Department Level Optional Course-6 Lab | -- | 2 | -- | 1 | 1 |
| ADP801 | Major Project-2 | -- | 12# | -- | 6 | 6 |
| **Total** | | **12** | **18** | **12** | **9** | **21** |

| Course Code | Course Name | Examination Scheme | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | | | | Term Work | Pract. | Total |
| | | Internal Assessment | | End Sem Exam | Exam Duration (in Hrs) | | | |
| | | Mid Test | CA* | | | | | |
| ADC801 | Advanced Artificial Intelligence | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADDO 801X | Department Level Optional Course -5 | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADDO 802X | Department Level Optional Course -6 | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ILO 801X | Institute Level Optional Course-2 | 20 | 20 | 60 | 2 | -- | -- | 100 |
| ADL801 | Advanced Artificial Intelligence Lab | -- | -- | -- | -- | 25 | 25 | 50 |
| ADDOL 801X | Department Level Optional Course -5 Lab | -- | -- | -- | -- | 25 | 25 | 50 |
| ADDOL 802X | Department Level Optional Course -6 Lab | | | | | 25 | 25 | 50 |
| ADP801 | Major Project 2 | -- | -- | -- | -- | 75 | 75 | 150 |
| **Total** | | **--** | **--** | **400** | **--** | **150** | **150** | **700** |

**Major Project 1 and 2 :**

- Students can form groups with minimum 2 (Two) and not more than 4 (Four)
- Faculty Load : In Semester VII – ½ hour per week per project group In Semester VIII – 1 hour per week per project group

**Program Structure for Fourth Year CSE (AIML), CSE (DS) AI&DS, DE, AI&ML**

**UNIVERSITY OF MUMBAI (With Effect** from 2023-2024)

**Department and Institute Optional Courses and Labs**

| **Semester** | **Department/ Institute Optional Courses and Labs** | **Subject and Labs** |
|---|---|---|
| VII | Department Optional Course -3 | ADDO7011: Natural Language Processing<br>ADDO7012: AI for Healthcare<br>ADDO7013: Neural Network & Fuzzy System |
| | Department Optional Lab -3 | ADDOL7011: Natural Language Processing Lab<br>ADDOL7012.: AI for Healthcare Lab<br>ADDOL7013: Neural Network & Fuzzy System |
| | Department Optional Course -4 | ADDO7021: User Experience Design with VR<br>ADDO7022: Blockchain Technologies<br>ADDO7023: Game Theory for Data Science |
| | Department Optional Lab -4 | ADDOL7021: User Experience Design with VR Lab<br>ADDOL7022: Blockchain Technologies<br>ADDOL7023: Game Theory for Data Science |
| | Institute level Optional Courses- I | ILO7011:Product Lifecycle Management<br>ILO7012: Reliability Engineering ILO7013.: Management Information System ILO7014: Design of Experiments<br>ILO7015: Operation Research<br>ILO7016: Cyber Security and Laws<br>ILO7017: Disaster Management & Mitigation Measures<br>ILO7018: Energy Audit and Management<br>ILO7019: Development Engineering |

**Program Structure for Fourth Year CSE (AIML), CSE (DS) AI&DS, DE, AI&ML**

**UNIVERSITY OF MUMBAI (With Effect** from 2023-2024)

**Department and Institute Optional Courses and Labs**

| **Semester** | **Department/ Institute Optional Courses and Labs** | **Subject and Labs** |
|---|---|---|
| VIII | Department Optional Course -5 | ADDO8011: AI for financial & Banking application ADDO8012: Quantum Computing ADDO8013: Reinforcement Learning |
| | Department Optional Lab -5 | ADDOL8011: AI for financial & Banking application Lab ADDOL8012: Quantum Computing Lab ADDOL8013: Reinforcement Learning Lab |
| | Department Optional Course -6 | ADDO8021: Graph Data Science ADDO8022: Recommendation Systems ADDO8023: Social Media Analytics |
| | Department Optional Lab -6 | ADDOL8021: Graph Data Science Lab ADDOL8022: Recommendation Systems Lab ADDOL8023: Social Media Analytics Lab |
| | Institute level Optional Courses-II | ILO8021: Project Management ILO8022: Finance Management ILO8023: Entrepreneurship Development and Management ILO8024: Human Resource Management ILO8025: Professional Ethics and CSR ILO8026: Research Methodology ILO8027: IPR and Patenting ILO8028: Digital Business Management ILO8029: Environmental Management |

| Course Code: | Course Title | Credit |
|---|---|---|
| ADC701 | Deep Learning | 3 |

| Prerequisite: Basic mathematics and Statistical concepts, Linear algebra, Machine Learning | |
|---|---|
| **Course Objectives:** | |
| 1 | To learn the fundamentals of Neural Network. |
| 2 | To gain an in-depth understanding of training Deep Neural Networks. |
| 3 | To acquire knowledge of advanced concepts of Convolution Neural Networks, Autoencoders and Recurrent Neural Networks. |
| 4 | Students should be familiar with the recent trends in Deep Learning. |
| **Course Outcomes:** | |
| 1 | Gain basic knowledge of Neural Networks. |
| 2 | Acquire in depth understanding of training Deep Neural Networks. |
| 3 | Design appropriate DNN model for supervised, unsupervised and sequence learning applications. |
| 4 | Gain familiarity with recent trends and applications of Deep Learning. |

| Module | | Content | Hrs |
|---|---|---|---|
| **1** | | **Fundamentals of Neural Network** | **4** |
| | **1.1** | History of Deep Learning, Deep Learning Success Stories, Multilayer Perceptrons (MLPs), Representation Power of MLPs, Sigmoid Neurons Gradient Descent, Feedforward Neural Networks, Representation Power of Feedforward Neural Networks | |
| | **1.2** | Deep Networks: Three Classes of Deep Learning Basic Terminologies of Deep Learning | |
| **2** | | **Training, Optimization and Regularization of Deep Neural Network** | **10** |
| | **2.1** | **Training Feedforward DNN**<br>Multi Layered Feed Forward Neural Network, Learning Factors, Activation functions: Tanh, Logistic, Linear, Softmax, ReLU, Leaky ReLU, Loss functions: Squared Error loss, Cross Entropy, Choosing output function and loss function | |
| | **2.2** | **Optimization**<br>Learning with backpropagation, Learning Parameters: Gradient Descent (GD), Stochastic and Mini Batch GD, Momentum Based GD, Nesterov Accelerated GD, AdaGrad, Adam, RMSProp | |
| | **2.3** | **Regularization**<br>Overview of Overfitting, Types of biases, Bias Variance Tradeoff Regularization Methods: L1, L2 regularization, Parameter sharing, Dropout, Weight Decay, Batch normalization, Early stopping, Data Augmentation, Adding noise to input and output | |

| | | | |
|---|---|---|---|
| **3** | | **Autoencoders: Unsupervised Learning** | **6** |
| | **3.1** | Introduction, Linear Autoencoder, Undercomplete Autoencoder, Overcomplete Autoencoders, Regularization in Autoencoders | |
| | **3.2** | Denoising Autoencoders, Sparse Autoencoders, Contractive Autoencoders | |
| | **3.3** | Application of Autoencoders: Image Compression | |
| **4** | | **Convolutional Neural Networks (CNN): Supervised Learning** | **7** |
| | **4.1** | Convolution operation, Padding, Stride, Relation between input, output and filter size, CNN architecture: Convolution layer, Pooling Layer, Weight Sharing in CNN, Fully Connected NN vs CNN, Variants of basic Convolution function, Multichannel convolution operation,2D convolution. | |
| | **4.2** | Modern Deep Learning Architectures:<br>LeNET: Architecture, AlexNET: Architecture, ResNet : Architecture | |
| **5** | | **Recurrent Neural Networks (RNN)** | **8** |
| | **5.1** | Sequence Learning Problem, Unfolding Computational graphs, Recurrent Neural Network, Bidirectional RNN, Backpropagation Through Time (BTT), Limitation of " vanilla RNN" Vanishing and Exploding Gradients, Truncated BTT | |
| | **5.2** | Long Short Term Memory(LSTM): Selective Read, Selective write, Selective Forget, Gated Recurrent Unit (GRU) | |
| **6** | | **Recent Trends and Applications** | **4** |
| | **6.1** | Generative Adversarial Network (GAN): Architecture | |
| | **6.2** | Applications: Image Generation, DeepFake | |

| **Textbooks:** | |
|---|---|
| 1 | Ian Goodfellow, Yoshua Bengio, Aaron Courville. ―Deep Learning‖, MIT Press Ltd, 2016 |
| 2 | Li Deng and Dong Yu, ―Deep Learning Methods and Applications‖, Publishers Inc. |
| 3 | Satish Kumar "Neural Networks A Classroom Approach" Tata McGraw-Hill. |
| 4 | JM Zurada ―Introduction to Artificial Neural Systems‖, Jaico Publishing House |
| 5 | M. J. Kochenderfer, Tim A. Wheeler. ―Algorithms for Optimization‖, MIT Press. |
| **References:** | |
| 1 | Deep Learning from Scratch: Building with Python from First Principles- Seth Weidman by O`Reilley |
| 2 | François Chollet. ―Deep learning with Python ―(Vol. 361). 2018 New York: Manning. |
| 3 | Douwe Osinga. ―Deep Learning Cookbook‖, O'REILLY, SPD Publishers, Delhi. |
| 4 | Simon Haykin, Neural Network- A Comprehensive Foundation- Prentice Hall International, Inc |
| 5 | S.N.Sivanandam and S.N.Deepa, Principles of soft computing-Wiley India |

| Useful Links | |
|---|---|
| 1 | http://www.cse.iitm.ac.in/~miteshk/CS6910.html |
| 2 | https://nptel.ac.in/courses/106/106/106106184/ |
| 3 | https://www.deeplearningbook.org/ |

**Internal Assessment:**
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| 3. | Creating Proof of concept | 10 marks |
| 4. | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5. | Multiple Choice Questions (Quiz) | 5 marks |
| 6. | GATE Based Assignment /Tutorials etc | 10 marks |

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| End Semester Theory Examination: | |
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| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| Course Code | Course/Subject Name | Credits |
|---|---|---|
| ADC702 | **Big Data Analytics** | **3** |

| | |
|---|---|
| **Prerequisite:** Some prior knowledge about Java programming, Basics of SQL, Data mining and machine learning methods would be beneficial. | |
| **Course Objectives:** | |
| 1 | To provide an overview of an exciting growing field of big data analytics. |
| 2 | To introduce programming skills to build simple solutions using big data technologies such as MapReduce and scripting for NoSQL, and the ability to write parallel algorithms for multiprocessor execution |
| 3 | To teach the fundamental techniques and principles in achieving big data analytics with scalability and streaming capability. |
| 4 | To enable students to have skills that will help them to solve complex real-world problems in decision support. |
| 5 | To provide an indication of the current research approaches that is likely to provide a basis for tomorrow's solutions. |
| **Course Outcomes:** | |
| 1 | Understand the key issues in big data management and its associated applications for business decisions and strategy. |
| 2 | Develop problem solving and critical thinking skills in fundamental enabling techniques like Hadoop, Map reduce and NoSQL in big data analytics. |
| 3 | Collect, manage, store, query and analyze various forms of Big Data. |
| 4 | Interpret business models and scientific computing paradigms, and apply software tools for big data analytics. |
| 5 | Adapt adequate perspectives of big data analytics in various applications like recommender systems, social media applications etc. |
| 6 | Solve Complex real world problems in various applications like recommender systems, social media applications, health and medical systems, etc. |

**Prerequisites:** Database Management System.

| Module | | Content | Hrs. |
|---|---|---|---|
| 0 | | **Prerequisites:** Data Mining, database Systems, Algorithms | |
| 1 | | **Introduction to Big Data** | 4 |
| | 1.1 | Introduction to Big Data, Big Data characteristics, types of Big Data, Traditional vs. Big Data business approach, Big Data Challenges, Examples of Big Data in Real Life, Big Data Applications | |
| 2 | | **Introduction to Big Data Frameworks: Hadoop, NOSQL** | 7 |
| | 2.1 | What is Hadoop? Core Hadoop Components; Hadoop Ecosystem;<br>**Overview of** : Apache Spark, Pig, Hive, Hbase, Sqoop<br>**Introduction to NoSQL,**CAP Theorem, BASE characteristics for Databases; NoSQL data architecture patterns: Key-value stores, Graph stores, Column family (Bigtable) stores, Document stores, | |
| 3 | | **MapReduce Paradigm** | 5 |
| | 3.1 | **Introduction to Map Reduce:** The Map Tasks, Grouping by Key, The Reduce Tasks, Combiners, Partitioners, Details of MapReduce Execution, Coping With Node Failures.<br>**Algorithms Using MapReduce:**<br>● Matrix-Vector Multiplication<br>● Relational-Algebra Operations - Computing Selections, Projections, Union, Intersection, and Difference<br>● Database operations - Computing Natural Join, Group By and Aggregation<br>● Matrix Multiplication with two and One MapReduce Steps.<br>**Illustrating benefits of MapReduce**<br>Real life examples of databases and applications | |
| 4 | | **Mining Big Data** | 9 |
| | 4.1 | The Stream Data Model: A Data Stream Management System, Examples of Stream Sources, Stream Queries, Issues in Stream Processing. Sampling Data in a Stream : Sampling Techniques. Filtering Streams: The Bloom Filter; Counting Distinct Elements in a Stream : The Count-Distinct Problem, The Flajolet-Martin Algorithm, Combining Estimates, Space Requirements . Counting Ones in a Window: The Cost of Exact Counts, The Datar-Gionis-Indyk- Motwani Algorithm, Query Answering in the DGIM Algorithm | |
| 5 | | **Streams** | 6 |
| | 5.1 | **Frequent Itemset Mining** : Overview of Market basket analysis, using main memory to count frequent itemsets, Cost of counting pairs. Apriori. Handling Larger Datasets in Main Memory Basic Algorithm of Park, Chen, and Yu. The SON Algorithm and MapReduce.<br>**Finding Similar items:** Distance Measures: Euclidean Distances, Jaccard Distance, Cosine Distance, Edit Distance, Hamming Distance. Jaccard Similarity of Sets, Similarity of Documents, Shingling of documents- K Shingles, Matrix Representation of Sets, Minhashing, Minhashing and Jaccard Similarity<br>**Clustering Algorithms:** CURE Algorithm. GRGPF Algorithm | |
| 6 | | **Big Data Analytics Applications** | 8 |

| | | | |
|---|---|---|---|
| | **6.1** | **Link Analysis :** Early Search Engines, Spam PageRank, Definition, Structure of the web, dead ends, Spider traps, Using Page rank in a search engine, Efficient computation of Page Rank using matrices. MapReduce and PageRank, link Spam and spam Farm, HITS Algorithm.<br>**Mining Social- Network Graphs** : Social Networks as Graphs, Types , Clustering of Social Network Graphs, Girvan newman method, Direct Discovery of Communities CPM method<br>**Recommendation Engine**s: A Model for Recommendation Systems, Content-Based Recommendations, Collaborative Filtering. | |

| **Textbooks:** | |
|---|---|
| 1 | Anand Rajaraman and Jeff Ullman ―Mining of Massive Datasets‖, Cambridge University Press, |
| 2 | Alex Holmes ―Hadoop in Practice‖, Manning Press, Dreamtech Press. |
| 3 | Dan Mcary and Ann Kelly ―Making Sense of NoSQL‖ – A guide for managers and the rest of us, Manning Press. |
| **References:** | |
| 1 | Bill Franks , ―Taming The Big Data Tidal Wave: Finding Opportunities In Huge Data Streams With Advanced Analytics‖, Wiley |
| 2 | Chuck Lam, ―Hadoop in Action‖, Dreamtech Press |
| 3 | Jared Dean, ―Big Data, Data Mining, and Machine Learning: Value Creation for Business Leaders and Practitioners‖, Wiley India Private Limited, 2014. |
| 4 | Jiawei Han and Micheline Kamber, ―Data Mining: Concepts and Techniques‖, Morgan Kaufmann Publishers, 3rd ed, 2010. |
| 5 | Lior Rokach and Oded Maimon, ―Data Mining and Knowledge Discovery Handbook‖, Springer, 2nd edition, 2010. |
| 6 | Ronen Feldman and James Sanger, ―The Text Mining Handbook: Advanced Approaches in Analyzing Unstructured Data‖, Cambridge University Press, 2006. |
| 7 | Vojislav Kecman, ―Learning and Soft Computing‖, MIT Press, 2010 |

**Internal Assessment:**
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| Course Code: | Course Title | Credit |
|---|---|---|
| ADDO7011 | Natural Language Processing | 3 |

| Prerequisite: Artificial Intelligence and Machine Learning, Basic knowledge of Python | |
|---|---|
| **Course Objectives:** | |
| 1 | To understand natural language processing and to learn how to apply basic algorithms in this field |
| 2 | To get acquainted with the basic concepts and algorithmic description of the main language levels:<br>morphology, syntax, semantics, and pragmatics |
| 3 | To design and implement various language models and POS tagging techniques |
| 4 | To design and learn NLP applications such as Information Extraction, Question answering |
| 5 | To design and implement applications based on natural language processing |
| **Course Outcomes:** | |
| 1 | To have a broad understanding of the field of natural language processing |
| 2 | To design language model for word level analysis for text processing |
| 3 | To design various POS tagging techniques |
| 4 | To design, implement and test algorithms for semantic analysis |
| 5 | To develop basic understanding of Pragmatics and to formulate the discourse segmentation and anaphora resolution |
| 6 | To apply NLP techniques to design real world NLP applications |

| Module | | Content | Hrs |
|---|---|---|---|
| **1** | | **Introduction** | **4** |
| | **1.1** | Origin & History of NLP, The need of NLP, Generic NLP System, Levels of NLP, Knowledge in Language Processing, Ambiguity in Natural Language, Challenges of NLP, Applications of NLP. | |
| **2** | | **Word Level Analysis** | **8** |
| | **2.1** | Tokenization, Stemming, Segmentation, Lemmatization, Edit Distance, Collocations, Finite Automata, Finite State Transducers (FST), Porter Stemmer, MorphologicalAnalysis, Derivational and Reflectional Morphology, Regular expression with types. | |

| | | | |
|---|---|---|---|
| | **2.2** | N –Grams, Unigrams/Bigrams Language Models, Corpora, Computing the Probability of Word Sequence, Training and Testing. | |
| **3** | | **Syntax analysis** | **8** |
| | **3.1** | Part-Of-Speech Tagging (POS) - Open and Closed Words. Tag Set for English (Penn Treebank), Rule Based POS Tagging, Transformation Based Tagging, Stochastic POS Tagging and Issues –Multiple Tags & Words, Unknown Words. | |
| | **3.2** | Introduction to CFG, Hidden Markov Model (HMM), Maximum Entropy, And Conditional Random Field (CRF). | |
| **4** | | **Semantic Analysis** | **8** |
| | **4.1** | Introduction, meaning representation; Lexical Semantics; Corpus study; Study of Various language dictionaries like WordNet, Babelnet; Relations among lexemes & their senses –Homonymy, Polysemy, Synonymy, Hyponymy; Semantic Ambiguity | |
| | **4.2** | Word Sense Disambiguation (WSD); Knowledge based approach (Lesk‘s Algorithm), Supervised (Naïve Bayes, Decision List), Introduction to Semi-supervised method (Yarowsky), Unsupervised (Hyperlex) | |
| **5** | | **Pragmatic & Discourse Processing** | **6** |
| | **5.1** | Discourse: Reference Resolution, Reference Phenomena, Syntactic & Semantic constraint on coherence; Anaphora Resolution using Hobbs and Cantering Algorithm | |
| **6** | | **Applications (preferably for Indian regional languages)** | **5** |
| | **6.1** | Machine Translation, Information Retrieval, Question Answers System, Categorization, Summarization, Sentiment Analysis, Named Entity Recognition. | |
| | **6.2** | Linguistic Modeling – Neurolinguistics Models- Psycholinguistic Models – Functional Models of Language – Research Linguistic Models- Common Features of Modern Models of Language. | |

| | |
|---|---|
| **Textbooks:** | |
| 1 | Daniel Jurafsky, James H. and Martin, Speech and Language Processing, Second Edition, Prentice Hall, 2008. |
| 2 | Christopher D.Manning and HinrichSchutze, Foundations of Statistical Natural Language Processing, MIT Press, 1999. |
| **References:** | |
| 1 | Siddiqui and Tiwary U.S., Natural Language Processing and Information Retrieval, Oxford University Press, 2008. |
| 2 | Daniel M Bikel and ImedZitouni ― Multilingual natural language processing applications: from theory to practice, IBM Press, 2013. |
| 3 | Nitin Indurkhya and Fred J. Damerau, ―Handbook of Natural Language Processing, Second Edition, Chapman and Hall/CRC Press, 2010. |
| **Useful Links** | |
| 1 | https://onlinecourses.nptel.ac.in/noc21_cs102/preview |
| 2 | https://onlinecourses.nptel.ac.in/noc20_cs87/preview |
| 3 | https://nptel.ac.in/courses/106105158 |

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| Course Code | Course/Subject Name | Credits |
|---|---|---|
| ADDO7012 | AI for Healthcare | 3 |

| | |
|---|---|
| **Prerequisites:** Artificial Intelligence, Machine Learning | |
| **Course Objectives:** | |
| 1 | To understand the need and significance of AI and ML for Healthcare. |
| 2 | To study advanced AI algorithms for Healthcare. |
| 3 | To learn Computational Intelligence techniques . |
| 4 | To understand evaluation metrics and ethics in intelligence for Healthcare systems, |
| 5 | To learn various NLP algorithms and their application in Healthcare, |
| 6 | To investigate the current scope, implications of AI and ML for developing futuristic Healthcare Applications. |
| **Course Outcomes:** | |
| After successful completion of the course, the student will be able to: | |
| 1 | Understand the role of AI and ML for handling Healthcare data. |
| 2 | Apply Advanced AI algorithms for Healthcare Problems. |
| 3 | Learn and Apply various Computational Intelligence techniques for Healthcare Application. |
| 4 | Use evaluation metrics for evaluating healthcare systems. |
| 5 | Develop NLP applications for healthcare using various NLP Techniques.. |
| 6 | Apply AI and ML algorithms for building Healthcare Applications |

| Module | | Content | Hrs. |
|---|---|---|---|
| **1** | | **Introduction** | **6** |
| | **1.1** | Overview of AI , ML and DL ,A Multifaceted Discipline, Applications of AI in Healthcare - Prediction, Diagnosis, personalized treatment and behavior modification, drug discovery, followup care etc, | |
| | **1.2** | Realizing potential of AI in healthcare, Healthcare Data - Use Cases. | |
| **2** | | **AI, ML, Deep Learning and Data Mining Methods for Healthcare** | **8** |
| | **2.1** | Knowledge discovery and Data Mining, ML, Multi classifier Decision Fusion, Ensemble Learning, Meta-Learning and other Abstract Methods. | |
| | **2.2** | Evolutionary Algorithms, Illustrative Medical Application-Multiagent Infectious Disease Propagation and Outbreak Prediction, Automated Amblyopia Screening System etc. | |
| | **2.3** | Computational Intelligence Techniques, Deep Learning, Unsupervised learning, dimensionality reduction algorithms. | |
| **3** | | **Evaluating learning for Intelligence** | **4** |
| | **3.1** | Model development and workflow, evaluation metrics, Parameters and Hyperparameters, Hyperparameter tuning algorithms, multivariate testing, Ethics of Intelligence. | |

| | | | |
|---|---|---|---|
| **4** | | **Natural Language Processing in Healthcare** | **8** |
| | **4.1** | NLP tasks in Medicine, Low-level NLP components, High level NLP components, NLP Methods. | |
| | **4.2** | Clinical NLP resources and Tools, NLP Applications in Healthcare. Model Interpretability using Explainable AI for NLP applications. | |
| **5** | | **Intelligent personal Health Record** | **5** |
| | **5.1** | Introduction, Guided Search for Disease Information, Recommending SCA's. | |
| | | Recommending HHP's , Continuous User Monitoring. | |
| **6** | | **Future of Healthcare using AI** | **08** |
| | **6.1** | Evidence based medicine, Personalized Medicine, Connected Medicine, Digital Health and Therapeutics, Conversational AI, Virtual and Augmented Reality, Blockchain for verifying supply chain, patient record access, Robot - Assisted Surgery, Smart Hospitals, Case Studies on use of AI and ML for Disease Risk Diagnosis from patient data, Augmented reality applications for Junior doctors. | |
| | **6.2** | Blockchain for verifying supply chain, patient record access, Robot - Assisted Surgery, Smart Hospitals, Case Studies on use of AI and ML for Disease Risk Diagnosis from patient data, Augmented reality applications for Junior doctors. | |
| | | **Total** | **39** |

| **Textbooks:** | |
|---|---|
| 1 | Arjun Panesar, "Machine Learning and AI for Healthcare", A Press. |
| 2 | Arvin Agah, "Medical applications of Artificial Systems ", CRC Press |

| **References:** | |
|---|---|
| 1 | Erik R. Ranschaert Sergey Morozov Paul R. Algra, "Artificial Intelligence in medical Imaging Opportunities, Applications and Risks", Springer |
| 2 | Sergio Consoli Diego Reforgiato Recupero Milan Petković,"Data Science for Healthcare- Methodologies and Applications", Springer |
| 3 | Dac-Nhuong Le, Chung Van Le, Jolanda G. Tromp, Gia Nhu Nguyen, "Emerging technologies for health and medicine", Wiley. |
| 4 | Ton J. Cleophas • Aeilko H. Zwinderman, "Machine Learning in Medicine- Complete Overview", Springer |

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| 3. | Creating Proof of concept | 10 marks |
| 4. | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5. | Multiple Choice Questions (Quiz) | 5 marks |
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| Course Code: | Course Title | Credit |
|---|---|---|
| ADDO7013 | Neural Networks and Fuzzy Systems | 3 |

| | |
|---|---|
| **Prerequisite:** Engineering Mathematics, Data Structures and Algorithm, Python Programming | |
| **Course Objectives:** | |
| 1 | To relate to the basic terminologies with respect to Fuzzy set theory. |
| 2 | To analyze and interpret fuzzy logic principles, relations and operations. |
| 3 | To recognize various components of Associative Memory Networks. |
| 4 | To have basic understanding of Unsupervised learning through Networks. |
| 5 | To understand Special networks and its applications in soft computing. |
| 6 | To infer the significance of Hybrid computing. |
| **Course Outcomes:** After successful completion of the course student will be able to | |
| 1 | Acquire basic knowledge of fuzzy set theory properties and relations. |
| 2 | Implement Fuzzy operations towards Fuzzy-rule creations. |
| 3 | Gain familiarity with the training and implementation of Associative Memory Network. |
| 4 | Understand the architecture and basics components of Unsupervised learning networks. |
| 5 | Analyze the significance and working of the Special Networks. |
| 6 | Interpret Hybrid System to analyze the Principles of Soft computing in Neuro-Fuzzy applications. |

| Module | | Content | Hrs |
|---|---|---|---|
| **1** | | **Fuzzy Set Theory** | **07** |
| | **1.1** | **Introduction to soft and hard computing Fuzzy Sets:** Basic definition and terminology of fuzzy sets, Classic set operations; Fuzzy set operations- Union, Intersection, complement Difference; Properties of fuzzy sets. | |
| | **1.2** | **Fuzzy relations:** Cartesian product of relation, Classica Relation, Cardinality of fuzzy relations, Operations on Fuzzy relations, Properties of Fuzzy ,Fuzzy relations composition, Tolerance and Equivalence Relationship. | |
| | **1.3** | **Membership Functions:** Features of Membership Functions, Fuzzification, Methods of membership value assignments. | |
| **2** | | **Fuzzy Rules, Reasoning, and Inference System** | **08** |
| | **2.1** | **Defuzzification:** Lambda-Cuts for Fuzzy Sets; Lambda-Cuts for Fuzzy Relations; Defuzzification methods: Max-Membership Principles, Centroid, Method, Weighted Average Method, Mean-Max Membership, Center of Sums, Center of Largest Area, First of Maxima. | |
| | **2.2** | **Fuzzy Arithmetic and Rules:** Fuzzy arithmetic, Fuzzy measures, Measures of Fuzziness, Truth Value and Tables in Fuzzy Logic, Fuzzy Propositions, Formation of rules, Decomposition of rules, Fuzzy Reasoning. | |

| | | | |
|---|---|---|---|
| | **2.3** | **Fuzzy Inference System (FIS):**<br>Mamdani FIS, Sugeno FIS, Comparison between Mamdani and Sugeno FIS. | |
| **3** | | **Associative Memory Networks** | **6** |
| | **3.1** | **Introduction:**<br>Basics of associative memory networks, Training algorithms for Pattern Association. | |
| | **3.2** | **Types of Networks:**<br>Radial basis function network : architecture training algorithm**,** Auto-associative Memory Network – Architecture, Flowchart of training process, Training algorithm, Testing algorithm, Hetero- associative Memory Network- Architecture and Testing algorithm, Bidirectional Associative Memory(BAM) Network- Architecture, Discrete BAM, Continuous BAM. | |
| **4** | | **Unsupervised Learning Networks** | **8** |
| | **4.1** | **Introduction :** Fixed weight competitive nets**,** Maxnet, Maxican net, Hamming Network | |
| | **4.2** | **Kohonen Self- Organizing Feature Maps:** Basic concepts, Architecture, Flowchart, Algorithms, Kohonen, Self-Organizing Motor map, Training algorithm. | |
| | **4.3** | **Adaptive resonance Theory:**<br>Architecture, Fundamental Operating principles, a Algorithms, Adaptive Resonance Theory I – Architecture, Flowchart of Training process, Training algorithm, Adaptive Resonance Theory 2 - Architecture, Algorithm, Flowchart, Training algorithm, Sample Values of Parameter. | |
| **5** | | **Special Network** | **5** |
| | **5.1** | **Introduction:**<br>Boltzmann Machine, Gaussian Machine, Probabilistic neural nets Spatio-Temporal connection network model, Ensemble neural model Extreme learning machine models, Online, Pruned, Improved Application of ELM | |

| | | | |
|---|---|---|---|
| 6 | | **Hybrid Computing** | **5** |
| | **6.1** | **Neuro-Fuzzy Hybrid Systems:**<br>Introduction to Neuro-Fuzzy systems, Comparison of Fuzzy systems and Neural networks, Characteristics of Neuro-Fuzzy systems, Classification of Neuro-Fuzzy systems. Introduction to Adaptive Neuro-Fuzzy Inference System (ANIFS), ANFS Architecture, Constraints of ANFIS, ANFIS as a Universal Approximator. | |

| **Textbooks:** | |
|---|---|
| 1 | S.N. Sivanandan and S.N. Deepa, Principles of Soft Computing, Wiley India, 2007, ISBN: 10: 81- 265-1075-7. |
| 2 | J.-S. R. Jang, C. –T. Sun, E. Mizutani, Neuro-Fuzzy and Soft Computing, A Computational Approach to Learning and Machine Intelligence, PHI Learning Private Limited-2014 |
| 3 | Neural Networks: A Classroom Approach, Satish Kumar, Tata McGraw-Hill Education, 2004/2007 |
| 4 | Simon Haykin, Neural Networks A Comprehensive Foundation, Second Edition, Pearson Education-2004 |
| 5 | David E. Goldberg, Genetic Algorithms, in search, optimization and Machine Learning, Pearson |

| **References:** | |
|---|---|
| 1 | Anupam Shukla, Ritu Tiwari, Rahul Kala, Real Life Applications of Soft Computing, CRC Press, Taylor & Francis Group, 2010. |
| 2 | Genetic Algorithms and Genetic Programming Modern Concepts and Practical Applications © 2009 Michael Affenzeller, Stephan Winkler, Stefan Wagner, and Andreas Beham, CRC Press |
| 3 | Laurene V. Fausett, Fundamentals of Neural Networks: Architectures, Algorithms And Applications, Pearson |
| **Digital References:** | |
| 1 | https://onlinecourses.nptel.ac.in/noc22_ee21/preview |
| 2 | https://onlinecourses.nptel.ac.in/noc23_ge15/preview |

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| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| Course Code: | Course Title | Credit |
|---|---|---|
| ADDO7021 | User Experience Design with VR | 3 |

| | |
|---|---|
| **Prerequisite:** Web Technologies; Software Engineering | |
| **Course Objectives:** | |
| 1 | To study and understand importance of user experience design principles |
| 2 | To understand elements of user experience design |
| 3 | To encourage students to participate in designing futuristic applications |
| 4 | To understand the need and significance of Virtual Reality |
| 5 | To understand the technical and engineering aspects of virtual reality systems |
| **Course Outcomes:** | |
| 1 | To Apply principles of user experience |
| 2 | To apply emerging and established technologies to enhance User Experience design |
| 3 | To create interface for international standards with ethics |
| 4 | To evaluate user experience. |
| 5 | Describe how VR systems work and list the applications of VR |
| 6 | Design and implementation of the hardware that enables VR systems to be built |

| Module | | Content | Hrs |
|---|---|---|---|
| **1** | | **Introduction** | **4** |
| | **1.1** | Introduction to interface design, Understanding and conceptualizing Interface, understanding user's conceptual cognition, Core Elements of User Experience, Working of UX elements | |
| **2** | | **The UX Design - life cycle** | **7** |
| | **2.1** | What is UX, Ubiquitous interaction, Emerging desire for usability, From usability to user experience, Emotional impact as part of the user experience, User experience needs a business case, Roots of usability. | |
| | **2.2** | Introduction, A UX process lifecycle template, Choosing a process instance for your project, The system complexity space, Meet the user interface team, Scope of UX presence within the team, More about UX lifecycles. | |

| | | | |
|---|---|---|---|
| **3** | | **The UX Design Process** | **10** |
| | **3.1** | Introduction, The system concept statement, User work activity gathering, Look for emotional aspects of work practice, Abridged contextual inquiry process, Data-driven vs. model driven inquiry, Contextual Analysis, Extracting Interaction Design Requirements, Constructing Design Information Models. | |
| | **3.2** | Information ,Architecture and Interaction Design and Prototyping<br>Introduction, Design paradigms, Design thinking, Design perspectives, User personas, Ideation, Sketching, More about phenomenology, Mental Models and Conceptual Design, Wireframe, Prototyping | |
| **4** | | **The UX Design Process** | **6** |
| | **4.1** | UX Evaluation and Improve UX Goals, Metrics and Targets, UX Evaluation Techniques.- Formative vs summative ,types of formative and informal summative evaluation methods, types of evaluation data, some data collection techniques | |
| | **4.2** | Rapid Evaluation Methods: Design walkthroughs and reviews UX Inspection, Heuristic evaluation, a UX inspection method, practical approach to UX Inspection, Do UX Evaluation rite, Quasi-empirical UX evaluation Questionnaires, Specialized rapid UX evaluation methods | |
| **5** | | **Introduction to Virtual Reality** | **6** |
| | **5.1** | Defining Virtual Reality, The three I's of Virtual Reality, History, The five classic components of a VR system, Input Devices: Trackers, Navigation and Gesture Interfaces, | |
| | **5.2** | Output Devices: Graphics, Three dimensional sound and Haptic displays | |
| **6** | | **Virtual Reality** | **6** |
| | **6.1** | Modeling: Geometric modeling, Kinematics modeling, Physical Modeling, Behaviour modeling, Model management. Human factor in VR: Methodology and terminology, User performance studies. Traditional VR Applications, Emerging Applications of VR. | |

| Textbooks: | |
|---|---|
| 1 | The UX Book Process and Guidelines for Ensuring a Quality User Experience by Rex Hartson, Pardha payla |
| 2 | Interaction Design, Beyond Human Computer Interaction, Rogers, Sharp, Preece Wiley India Pvt Ltd. |
| 3 | The UX Book by Rex Hartson and PardhaPyla, MK Publication |
| 4 | Smashing UX Design by Jesmond Allen and James Chudley, John Wiley & Sons |

| References: | |
|---|---|
| 1 | The Elements of User Experience by Jesse James Garrett |
| 2 | Don’t make me think, by Steve Krug |
| 3 | Observing the User Experience: A Practitioner's Guide to User Research by Mike Kuniavsky |

| Useful Links | |
|---|---|
| 1 | https://archive.nptel.ac.in/courses/124/107/124107008/ |
| 2 | https://nptel.ac.in/courses/106106138 |
| 3 | https://www.coursera.org/specializations/virtual-reality |

**Internal Assessment:**
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of20 marks. Mid Term test is to be conducted when approximately 50% syllabus is completed. Duration of the midterm test shall be one hour.

**Continuous Assessment: -**
Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered based on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

| Sr.no | Rubrics | Marks |
|---|---|---|
| 1. | *Certificate course for 4 weeks or more:- NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2. | Content beyond syllabus presentation | 10 marks |
| 3. | Creating Proof of concept | 10 marks |
| 4. | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5. | Multiple Choice Questions (Quiz) | 5 marks |
| 6. | GATE Based Assignment /Tutorials etc | 10 marks |

*For sr.no.1, the date of certification exam should be within the term and in case a student is unable to complete the certification, the grading has to be done accordingly.

| **End Semester Theory Examination:** | |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| Course Code: | Course Title | Credit |
|---|---|---|
| ADDO7022 | Blockchain Technologies | 3 |

| | |
|---|---|
| **Prerequisite:** Cryptography and Distributes systems | |
| **Course Objectives:** | |
| 1 | To get acquainted with the concept of Distributed ledger system and Blockchain. |
| 2 | To learn the concepts of consensus and mining in Blockchain through the Bitcoin network. |
| 3 | To understand Ethereum and develop-deploy smart contracts using different tools and frameworks. |
| 4 | To understand permissioned Blockchain and explore Hyperledger Fabric. |
| 5 | To understand different types of crypto assets. |
| **Course Outcomes:** | |
| 1 | Describe the basic concept of Blockchain and Distributed Ledger Technology. |
| 2 | Interpret the knowledge of the Bitcoin network, nodes, keys, wallets and transactions |
| 3 | Implement smart contracts in Ethereum using different development frameworks. |
| 4 | Develop applications in permissioned Hyperledger Fabric network. |
| 5 | Interpret different Crypto assets and Crypto currencies |
| 6 | Analyze the use of Blockchain with AI, IoT and Cyber Security using case studies. |

| Module | | Content | Hrs |
|---|---|---|---|
| **1** | | **Introduction to Blockchain** | **5** |
| | **1.1** | **Distributed Ledger Technologies:** Introduction to blockchain: History, evolution, fundamentals concepts, components, types.<br>**Block in a Blockchain:** Structure of a Block, Block Header Hash and Block Height, The Genesis Block, Linking Blocks in the Blockchain, Merkle Tree. | |
| **2** | | **Consensus Protocol and Bitcoin blockchain** | **6** |
| | **2.1** | **Consensus**: Byzantine Generals Problem, consensus algorithms: PoW, PoS, PoET, PoA, LPoS, pBFT, Proof-of-Burn (PoB), Life of a miner, Mining difficulty, Mining pool and its methods. | |
| | **2.2** | **Bitcoin**: What is Bitcoin, history of Bitcoin, Bitcoin Common terminologies: keys, addresses and nodes, Bitcoin mining, hashcash, Block propagation and relay, bitcoin scripts, transaction in the bitcoin network. | |

| | | | |
|---|---|---|---|
| **3** | | **Ethereum and Smart Contracts** | **8** |
| | **3.1** | **Ethereum:** History, Components, Architecture of Ethereum, Consensus, Miner and mining node, Ethereum virtual machine, Ether, Gas, Transactions, Accounts, Patricia Merkle Tree, Swarm, Whisper and IPFS, complete transaction working and steps in Ethereum, Case study of Ganache for Ethereum blockchain. Exploring etherscan.io and ether block structure, Comparison between Bitcoin and Ethereum | |
| | **3.2** | **Smart Contracts:** history, characteristics, working of smart contracts, types, Oracles, Structure & Limitations.<br>**Solidity programming:** set-up tools and installation, Basics, functions, Visibility and Activity Qualifiers, Ethereum networks, solidity compiler, solidity files and structure of contracts, data types, storages, array, functions, Developing and executing smart contracts in Ethereum. Smart Contracts Use cases, Opportunities and Risk. | |
| **4** | | **Private and Consortium blockchains** | **9** |
| | **4.1** | **Introduction to Private Blockchain:** Key characteristics, need, Examples of Private and Consortium blockchains, Smart contracts in private blockchain. | |
| | **4.2** | Introduction to Hyperledger, Tools and Frameworks, Hyperledger Fabric, Comparison between Hyperledger Fabric & Other Technologies. Hyperledger Platform, Paxos and Raft consensus, Ripple and Corda blockchains, Byzantine Faults: Byzantine Fault Tolerant (BFT) and Practical BFT. | |
| **5** | | **Cryptocurrencies and digital tokens** | **6** |
| | **5.1** | Cryptocurrency basics, types, usage, ERC20 and ERC721 Tokens, comparison between ERC20 & ERC721, ICO: basics and related terms, launching an ICO, pros and cons, evolution and platforms, STO, Different Crypto currencies, Defi, Metaverse, Types of cryptocurrencies. Bitcoin, Altcoin, and Tokens (Utility and Security), Cryptocurrency wallets: Hot and cold wallets, Cryptocurrency usage, Transactions in Blockchain, UTXO and double spending problem | |

| | | | |
|---|---|---|---|
| **6** | | **Blockchain applications, Tools and case studies** | **5** |
| | 6.1 | **Applications of Blockchain**: Various domains including Education, Energy, Healthcare, real-estate, logistics, supply chain.<br>**Tools:** Corda, Ripple, Quorum and other Emerging Blockchain Platforms, Case Study on any of the Blockchain Platforms. | |

| **Textbooks:** | |
|---|---|
| 1. | Blockchain Technology, Chandramouli Subramanian, Asha A George, Abhillash K. A and Meena Karthikeyen, Universities press. |
| 2. | Solidity Programming Essentials: A beginner's Guide to Build Smart Contracts for Ethereum and Blockchain, Ritesh Modi, Packt publication |
| 3. | Hyperledger Fabric In-Depth: Learn, Build and Deploy Blockchain Applications Using Hyperledger Fabric, Ashwani Kumar, BPB publications |
| 4. | Cryptoassets: The Innovative Investor‘s Guide to Bitcoin and Beyond, Chris Burniske & Jack Tatar. |
| 5 | Mastering Ethereum, Building Smart Contract and Dapps, Andreas M. Antonopoulos Dr. Gavin Wood, O‘reilly. |
| **References:** | |
| 1. | Mastering Bitcoin, programming the open Blockchain‖, 2nd Edition by Andreas M. Antonopoulos, June 2017, Publisher(s): O'Reilly Media, Inc. ISBN: 9781491954386. |
| 2. | Mastering Ethereum, Building Smart Contract and Dapps, Andreas M. Antonopoulos Dr. Gavin Wood, O'reilly. |
| 3. | Blockchain Technology: Concepts and Applications, Kumar Saurabh and Ashutosh Saxena, Wiley Publication. |
| 4. | The Basics of Bitcoins and Blockchains: An Introduction to Cryptocurrencies and the Technology that Powers Them, Antony Lewis. for Ethereum and Blockchain, Ritesh Modi, Packt publication. University of Mumbai, B. E. (Information Technology), Rev 2016 276 |

| **Useful Links** | |
|---|---|
| 1 | NPTEL courses: Blockchain and its Applications, Blockchain Architecture Design and Use Cases |
| 2 | https://ethereum.org/en/ |
| 3 | https://www.trufflesuite.com/tutorials |
| 4 | https://hyperledger-fabric.readthedocs.io/en/release-2.2/ |
| 5 | **Blockchain demo:** https://andersbrownworth.com/blockchain/ |
| 6 | **Blockchain Demo:** Public / Private Keys & Signing: |

**Internal Assessment:**
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of20 marks. Mid Term test is to be conducted when approximately 50% syllabus is completed. Duration of the midterm test shall be one hour.

**Continuous Assessment: -**
Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered based on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

| Sr.no | Rubrics | Marks |
|---|---|---|
| 1. | *Certificate course for 4 weeks or more:- NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2. | Content beyond syllabus presentation | 10 marks |
| 3. | Creating Proof of concept | 10 marks |
| 4. | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5. | Multiple Choice Questions (Quiz) | 5 marks |
| 6. | GATE Based Assignment /Tutorials etc | 10 marks |

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| **End Semester Theory Examination:** | |
|---|---|
| 1 | Question paper will be of 60 marks |
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| Course Code: | Course Title | Credit |
|---|---|---|
| **ADDO7023** | **Game Theory for Data Science** | **3** |

| **Prerequisite: Probability Algebra** | |
|---|---|
| **Course Objectives:** | |
| 1. | To introduce the student to the notion of a game, its solutions concepts, and other basic notions and tools of game theory, and the main applications for which they are appropriate, including electronic trading markets. |
| 2. | To formalize the notion of strategic thinking and rational choice by using the tools of game theory, and to provide insights into using game theory in modeling applications. |
| 3. | To draw the connections between game theory, computer science, and economics, especially emphasizing the computational issues. |
| 4. | To introduce contemporary topics in the intersection of game theory, computer science, and economics. |
| 5. | To apply game theory in searching, auctioning and trading. |

| **Course Outcomes:** | |
|---|---|
| On successful completion, of course, learner/student will be able to: | |
| 1. | Analyze and Discuss the notion of a strategic game and equilibria and identify the characteristics of main applications of these concepts. |
| 2. | Discuss the use of Nash Equilibrium for other problems. Identify key strategic aspects and based on these be able to connect them to appropriate game theoretic concepts given a real world situation. |
| 3. | Identify some applications that need aspects of Bayesian Games. Implement a typical Virtual Business scenario using Game theory. |
| 4. | Identify and discuss working principle of Non-Cooperative Games |
| 5. | Discuss the Mechanism for Design Aggregating Preferences |
| 6. | Identify and discuss working principle : Repeated Games |

| Sr. No. | Module | Content | Hrs. |
|---|---|---|---|
| | | **Prerequisite** | |
| **0** | **0.1** | Probability , Algebra | **1** |
| **1** | | **Introduction** | |
| | **1.1** | Making rational choices: basics of Games – strategy – preferences – payoffs – Mathematical basics – Game theory – Rational Choice – Basic solution concepts-non-cooperative versus cooperative games – Basic computational issues – finding equilibria and learning in gamesTypical application areas for game theory (e.g. Google's sponsored search, eBay auctions, electricity trading markets). | **6** |
| **2** | | **Games with Perfect Information** | |
| | **2.1** | Strategic games – prisoner's dilemma, matching pennies - Nash equilibria – theory and illustrations – Cournot's and Bertrand models of oligopoly – auctions – mixed strategy equilibrium – zero-sum games – Extensive Games with Perfect Information – repeated games (prisoner's dilemma) – subgame perfect Nash equilibrium; computational issues. | **7** |
| **3** | | **Games with Imperfect Information** | |
| | **3.1** | Games with Imperfect Information – Bayesian Games – Motivational Examples – General Definitions – Information aspects – Illustrations – Extensive Games with Imperfect – Information – Strategies – Nash Equilibrium – Beliefs and sequential equilibrium – Illustrations – Repeated Games – The Prisoner's Dilemma – Bargaining. | **6** |
| **4** | | **Non-Cooperative Game Theory** | |
| | **4.1** | Non-cooperative Game Theory – Self-interested agents – Games in normal form – Analyzing games: from optimality to equilibrium – Computing Solution Concepts of Normal – Form Games – Computing Nash equilibria of two-player, zero-sum games –Computing Nash equilibria of two-player, generalsum games – Identifying dominated strategies | **7** |
| **5** | | **Mechanism Design Aggregating Preferences** | |
| | **5.1** | Social Choice – Formal Model – Voting – Existence of social functions – Ranking systems – Protocols for Strategic Agents: Mechanism Design – Mechanism design with unrestricted preferences – Efficient mechanisms – Vickrey and VCG mechanisms (shortest paths) – Combinatorial auctions – profit maximization Computational applications of mechanism design – applications in Computer Science – Google's sponsored search – eBay auctions – K-armed bandits. | **6** |

| | | | |
|---|---|---|---|
| **6** | | **Repeated Games** | |
| | **6.1** | Repeated games: The Prisoner's Dilemma , The main idea , Preferences ,Infinitely repeated games, Strategies ,Some Nash equilibria of the infinitely repeated Prisoner's Dilemma , Nash equilibrium payoffs of the infinitely repeated Prisoner's Dilemma when the players are patient , Subgame perfect equilibria and the one-deviation property | **6** |

| **Textbooks:** | |
|---|---|
| 1 | An Introduction to Game Theory by Martin J. Osborne |
| 2 | M. J. Osborne, An Introduction to Game Theory. Oxford University Press, 2004 |

| **References:** | |
|---|---|
| **1** | M. Machler, E. Solan, S. Zamir, Game Theory, Cambridge University Press, 2013. |
| **2** | N. Nisan, T. Roughgarden, E. Tardos, and V. V. Vazirani (Editors), Algorithmic Game Theory. Cambridge University Press, 2007. |
| **3** | A.Dixit and S. Skeath, Games of Strategy, Second Edition. W W Norton & Co Inc, 2004. |
| **4** | YoavShoham, Kevin Leyton-Brown, Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Cambridge University Press 2008. |
| **5** | Zhu Han, DusitNiyato, WalidSaad, TamerBasar and Are Hjorungnes, "Game Theory in Wireless and Communication Networks", Cambridge University Press, 2012. |
| **6** | Y.Narahari, "Game Theory and Mechanism Design", IISC Press, World Scientific. |
| **Digital References:** | |
| **1.** | https://nptel.ac.in/courses/110104063 |
| **2.** | https://onlinecourses.nptel.ac.in/noc19_ge32/preview |

**Internal Assessment:**
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**Continuous Assessment: -**
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| 5. | Multiple Choice Questions (Quiz) | 5 marks |
| 6. | GATE Based Assignment /Tutorials etc | 10 marks |

*For sr.no.1, the date of certification exam should be within the term and in case a student is unable to complete the certification, the grading has to be done accordingly.

| **End Semester Theory Examination:** | |
|---|---|
| 1 | Question paper will be of 60 marks |
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| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| Lab Code | Lab Name | Credit |
|---|---|---|
| **ADL701** | **Deep Learning Lab** | **1** |

| | |
|---|---|
| **Prerequisite:** Python Programming, Engineering Mathematics | |
| **Lab Objectives:** | |
| 1 | To implement basic neural network models. |
| 2 | To implement various training algorithms for feedforward neural networks. |
| 3 | To design deep learning models for supervised, unsupervised and sequence learning. |
| **Lab Outcomes:** At the end of the course, the students will be able to | |
| 1 | Implement basic neural network models. |
| 2 | Design and train feedforward neural networks using various learning algorithms and optimize model performance. |
| 3 | Build and train deep learning models such as Autoencoders, CNNs, RNN, LSTM,GRU etc. |

| **Suggested List of Experiments:** | |
|---|---|
| **Sr. No.** | **Name of the Experiment** |
| **1** | **Based on Module 1 using Virtual Lab** |
| | 1. Implement Multilayer Perceptron algorithm to simulate XOR gate.<br>2. To explore python libraries for deep learning e.g. Theano, TensorFlow etc. |
| **2** | **Module 2 (Any Two)** |
| | 3. Apply any of the following learning algorithms to learn the parameters of the supervised single layer feed forward neural network.<br>a. Stochastic Gradient Descent<br>b. Mini Batch Gradient Descent<br>c. Momentum GD<br>d. Nestorev GD<br>e. Adagrad GD<br>f. Adam Learning GD<br>4. Implement a backpropagation algorithm to train a DNN with at least 2 hidden layers.<br>5.Design and implement a fully connected deep neural network with at least 2 hidden layers for a classification application. Use appropriate Learning Algorithm, output function and loss function. |
| **3** | **Module 3 (Any One)** |
| | 6. Design the architecture and implement the autoencoder model for Image Compression.<br>7. Design the architecture and implement the autoencoder model for Image denoising |

| | |
|---|---|
| **4** | **Module 4 (Any One)** |
| | 8. Design and implement a CNN model for digit recognition application.<br>9. Design and implement a CNN model for image classification. |
| **5** | **Module 5 (Any Two)** |
| | 10. Design and implement LSTM model for handwriting recognition, speech recognition, machine translation, speech activity detection, robot control, video games, time series forecasting etc.<br>11. Design and implement GRU for any real-life applications, chat bots etc.<br>12. Design and implement RNN for classification of temporal data, sequence to sequence data modelling etc. |

| **Textbooks:** | |
|---|---|
| 1 | Ian Goodfellow, Yoshua Bengio, Aaron Courville. ―Deep Learning‖, MIT Press Ltd, 2016 |
| 2 | Li Deng and Dong Yu, ―Deep Learning Methods and Applications‖, Publishers Inc. |
| 3 | Satish Kumar "Neural Networks A Classroom Approach" Tata McGraw-Hill. |
| 4 | JM Zurada ―Introduction to Artificial Neural Systems‖, Jaico Publishing House |
| 5 | M. J. Kochenderfer, Tim A. Wheeler. ―Algorithms for Optimization‖, MIT Press. |
| **References:** | |
| 1 | Deep Learning from Scratch: Building with Python from First Principles- Seth Weidman by O`Reilley |
| 2 | François Chollet. ―Deep learning with Python ―(Vol. 361). 2018 New York: Manning. |
| 3 | Douwe Osinga. ―Deep Learning Cookbook‖, O'REILLY, SPD Publishers, Delhi. |
| 4 | Simon Haykin, Neural Network- A Comprehensive Foundation- Prentice Hall International, Inc |
| 5 | S.N.Sivanandam and S.N.Deepa, Principles of soft computing-Wiley India |
| **Web References:** | |
| 1 | https://keras.io/ |
| 2 | https://stanford.edu/~shervine/teaching/cs-230/cheatsheet-recurrent-neural-networks |
| 3 | https://keras.io/examples/vision/autoencoder/ |
| 4 | https://stanford.edu/~shervine/teaching/cs-230/cheatsheet-convolutional-neural-networks |

| | |
|---|---|
| **Term Work:** | |
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks for Experiments |
| **Evaluation Exam** | |
| 1 | Practical based on the subject and related lab of Deep Learning and Theory |

| Course Code | Course Name | Credits |
|---|---|---|
| ADL702 | Big Data Analytics Lab | 1 |

| | |
|---|---|
| **Prerequisite:** Java/Python | |
| **Lab Objectives:** | |
| 1 | To provide an overview of an exciting growing field of big data analytics. |
| 2 | To introduce programming skills to build simple solutions using big data technologies such as MapReduce and scripting for NoSQL, and the ability to write parallel algorithms for multiprocessor execution. |
| 3 | To teach the fundamental techniques and principles in achieving big data analytics with scalability and streaming capability. |
| 4 | To enable students to have skills that will help them to solve complex real-world problems in decision support. |
| **Lab Outcomes:** | |
| 1 | Understand the key issues in big data management and its associated applications for business decisions and strategy. |
| 2 | Develop problem solving and critical thinking skills in fundamental enabling techniques like Hadoop, Map reduce and NoSQL in big data analytics. |
| 3 | Collect, manage, store, query and analyze various forms of Big Data. |
| 4 | Interpret business models and scientific computing paradigms, and apply software tools for big data analytics. |
| 5 | Adapt adequate perspectives of big data analytics in various applications like recommender systems, social media applications etc. |
| 6 | Solve Complex real world problems in various applications like recommender systems, social media applications, health and medical systems, etc. |

| **Suggested List of Experiments:** | |
|---|---|
| **Sr. No.** | **Name of the Experiment** |
| **1** | Assignment on Study of Hadoop ecosystem |
| **2** | Programming exercises on Hadoop Using Hive, Pig, Hbase Sqoop NOSQL. |
| **3** | Implementing simple algorithms in Map- Reduce Matrix multiplication, Aggregates, joins, sorting, searching etc. |
| **4** | Implementing Algorithms using MapReduce (Any 2)<br>● Implementing Frequent Item set Mining<br>● Implementing Clustering algorithms<br>● Implementing Classification Algorithms |
| **5** | Big Data Applications (Any 2)<br>● Implementing Analytics on data streams<br>● Implementing Social Network Analysis Algorithms<br>● Implementing Web Graph Algorithms<br>● Implementing recommendation Engines |
| **6** | **Mini Project**: One real life large data application to be implemented (Use standard Datasets available on the web) a) Twitter data analysis b) Fraud Detection c) Text Mining d) Recommendation Engines<br>(list of datsets also given in the text book) |

| | |
|---|---|
| **Useful Links** | |
| 1 | https://nptel.ac.in/courses/117/102/117102062/ |
| 2 | https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=305 |
| 3 | https://nptel.ac.in/courses/106/106/106106167/ |
| **Term Work:** | |
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks for Experiments |
| **Evaluation Exam** | |
| 1 | Practical exam based on the subject and related lab of Big data analytics lab and theory |

| Course Code: | Course Title | Credit |
|---|---|---|
| ADDOL7011 | Natural Language Processing Lab | 1 |

| | |
|---|---|
| **Prerequisite:** Java/Python | |
| **Lab Objectives:** | |
| 1 | To understand the key concepts of NLP. |
| 2 | To learn various phases of NLP |
| 3 | To design and implement various language models and POS tagging techniques |
| 4 | To understand various NLP Algorithms |
| 5 | To learn NLP applications such as Information Extraction, Sentiment Analysis, Question answering, Machine translation etc. |
| 6 | To design and implement applications based on natural language processing |
| **Lab Outcomes:** | |
| 1 | Apply various text processing techniques |
| 2 | Design language model for word level analysis |
| 3 | Design, implement and analyze NLP algorithms |
| 4 | Realize semantics of English language for text processing |
| 5 | To apply NLP techniques to design real world NLP applications such as machine translation, sentiment analysis, text summarization, information extraction, Question Answering system etc. |
| 6 | Implement proper experimental methodology for training and evaluating empirical NLP systems |

| **Suggested List of Experiments:** | |
|---|---|
| **Sr. No.** | **Name of the Experiment** |
| **1** | Study various applications of NLP and Formulate the Problem Statement for Mini Project based on chosen real world NLP applications:<br>[Machine Translation, Text Categorization, Text summarization, Chat Bot, Plagiarism, Spelling & Grammar Checkers, Sentiment / Opinion analysis, Question answering, Personal Assistant, Tutoring Systems, etc.] |

| | |
|---|---|
| **2** | Apply various text preprocessing techniques for any given text: Tokenization and Filtration & Script Validation |
| **3** | Apply various other text preprocessing techniques for any given text: Stop Word Removal, Lemmatization / Stemming |
| **4** | Perform morphological analysis and word generation for any given text |
| **5** | Implement N-Gram model for the given text input |
| **6** | Study the different POS taggers and Perform POS tagging on the given text |
| **7** | Perform chunking by analyzing the importance of selecting proper features for training a model and size of training |
| **8** | Implement Named Entity Recognizer for the given text input |
| **9** | Implement Text Similarity Recognizer for the chosen text documents |
| **10** | Implement word sense disambiguation using LSTM/GRU |
| **11** | Exploratory data analysis of a given text (Word Cloud) |
| **12** | Mini Project Report: For any one chosen real world NLP application |
| **13** | Implementation and Presentation of Mini Project |

| **Useful Links** | |
|---|---|
| 1 | https://nlp-iiith.vlabs.ac.in/List%20of%20experiments.html |
| 2 | https://onlinecourses.nptel.ac.in/noc21_cs102/preview |
| 3 | https://onlinecourses.nptel.ac.in/noc20_cs87/preview |
| 4 | https://nptel.ac.in/courses/106105158 |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks for Experiments |

| Course Code: | Course Title | Credit |
|---|---|---|
| ADDOL7012 | AI for Healthcare Lab | 1 |

| | |
|---|---|
| **Prerequisites:** Python | |
| **Lab Objectives:** | |
| 1 | To Collect, clean, integrate, and transform healthcare data for a specific disease. |
| 2 | To Perform exploratory data analysis on healthcare data. |
| 3 | To Develop AI models for medical diagnosis using MRI/X-ray data. |
| 4 | To Build AI models for medical prognosis. |
| 5 | Extract entities from medical reports using natural language processing. |
| 6 | To Predict disease risk using patient data |
| **Lab Outcomes:** | |
| After successful completion of the course, the student will be able to: | |
| 1 | Understand computational models of AI , |
| 2 | Develop healthcare applications using appropriate computational tools. |
| 3 | Apply appropriate models to solve specific healthcare problems. |
| 4 | Analyze and justify the performance of specific models as applied to healthcare problems. |
| 5 | Design and implement AI based healthcare applications. |

| **Suggested Experiments:** | |
|---|---|
| **Sr. No.** | **Name of the Experiment** |
| 1 | Collect, Clean, Integrate and Transform Healthcare Data based on specific disease. |
| 2 | Perform Exploratory data analysis of Healthcare Data. |
| 3 | AI for medical diagnosis based on MRI/X-ray data. |
| 4 | AI for medical prognosis . |
| 5 | Natural language Entity Extraction from medical reports. |
| 6 | Predict disease risk from Patient data. |
| 7 | Medical Reviews Analysis from social media data. |
| 8 | Explainable AI in healthcare for model interpretation. |
| 9 | Mini Project-Design and implement innovative web/mobile based AI application using Healthcare Data. (this needs to be implemented in group of 3-4 students ) |
| 10 | Documentation and Presentation of Mini Project. |

| Textbooks: | |
|---|---|
| 1 | Arjun Panesar, "Machine Learning and AI for Healthcare", A Press. |
| 2 | Arvin Agah, "Medical applications of Artificial Systems ", CRC Press |

| References: | |
|---|---|
| 1 | Erik R. Ranschaert Sergey Morozov Paul R. Algra, "Artificial Intelligence in medical Imaging-Opportunities, Applications and Risks", Springer |
| 2 | Sergio Consoli Diego Reforgiato Recupero Milan Petković,"Data Science for Healthcare-Methodologies and Applications", Springer |
| 3 | Dac-Nhuong Le, Chung Van Le, Jolanda G. Tromp, Gia Nhu Nguyen, "Emerging technologies for<br>health and medicine", Wiley. |
| 4 | Ton J. Cleophas • Aeilko H. Zwinderman, "Machine Learning in Medicine- Complete Overview", Springer |
| **Useful Links** | |
| 1 | https://www.coursera.org/learn/introduction-tensorflow?specialization=tensorflow-in-practice |
| 2 | https://www.coursera.org/learn/convolutional-neural-networks-tensorflow?specialization=tensorflo w- in-practice |
| 3 | https://datarade.ai/data-categories/electronic-health-record-ehr-data |
| 4 | https://www.cms.gov/Medicare/E-Health/EHealthRecords |
| 5 | https://www.coursera.org/learn/tensorflow-sequences-time-series-and-prediction?specialization=te nsorflow-in-practice |

| Term Work: | |
|---|---|
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks for experiments |

| Course Code: | Course Title | Credit |
|---|---|---|
| ADDL7013 | Neural Networks and Fuzzy Systems Lab | 1 |

| | |
|---|---|
| **Prerequisite:** C/C++/Java/MATLAB | |
| **Lab Objectives:** | |
| 1 | Articulate basic knowledge of fuzzy set theory through programing. |
| 2 | To design Associative Memory Networks. |
| 3 | To apply Unsupervised learning towards Networks design. |
| 4 | To demonstrate Special networks and its applications in soft computing. |
| 5 | To implement Hybrid computing systems. |
| **Lab Outcomes:** At the end of the course, the students will be able to | |
| 1 | Implement Fuzzy operations and functions towards Fuzzy-rule creations. |
| 2 | Build and training Associative Memory Network. |
| 3 | Build Unsupervised learning based networks . |
| 4 | Design and implement architecture of Special Networks |
| 5 | Implement Neuro-Fuzzy hybrid computing applications. |

| **Suggested Experiments:** | |
|---|---|
| **Sr. No.** | **Name of the Experiment** |
| **1** | Demonstrate Union and intersection of two Fuzzy Sets. |
| **2** | Demonstrate difference between two Fuzzy Sets. |
| **3** | Implement Fuzzy membership functions. |
| **4** | Implement Fuzzy Inference system (FIS). |
| **5** | Implement any De-fuzzification of membership method. |
| **6** | Implement Bidirectional Associative Memory(BAM) Network |
| **7** | Implement Radial basis function network. |
| **8** | Implement Basic Neural Network learning rules. |
| **9** | Implement any Unsupervised Learning algorithm. |
| **10** | Implement Kohonen Self- Organizing Feature Maps |
| **11** | Implement a Probabilistic Neural Network. |
| **12** | Implement any Ensemble neural model. |
| **13** | Design any one Neuro-Fuzzy system. |

| Useful Links | |
|---|---|
| 1 | https://onlinecourses.nptel.ac.in/noc21_ge07/preview |
| 2 | http://www.nitttrc.edu.in/nptel/courses/video/127105006/L25.html |
| 3 | https://archive.nptel.ac.in/courses/108/104/108104157/ |

| Term Work: | |
|---|---|
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks for Experiments |

| Course Code: | Course Title | Credit |
|---|---|---|
| ADDOL7021 | User Experience Design with VR Lab | 1 |

| | |
|---|---|
| **Prerequisite:** Computer Graphics, Python | |
| **Lab Objectives:** | |
| 1 | Analyze how to design Effective and Efficient User Interfaces for intended users |
| 2 | Learn techniques for Prototyping and Evaluating User Experience |
| 3 | Apply the concept of Good UI and User Experience (UX) |
| 4 | To perform installation of Unity and explore working of VR Gadget |
| 5 | To develop scene VR application |
| **Lab Outcomes:** | |
| 1 | Demonstrate the tools and techniques for designing informing models |
| 2 | Develop a high fidelity prototype for an end end solution. |
| 3 | Apply best practices for evaluating user experience. |
| 4 | Setup VR development environment and use HTC Vive/ Google Cardboard/ Google Daydream and Samsung gear VR. |
| 5 | Develop VR scene and place object |

| **Suggested Experiments:** | |
|---|---|
| **Sr. No.** | **Name of the Experiment** |
| **1** | Project Proposal and Requirement Gathering (Choose the project). Briefly state the problem(s) that the project will seek to solve. Take the user's point of view. Consider what the user's goals are, and what obstacles lie in the way. |
| **2** | Creation of Scenario : Write a scenario that involves all three of the tasks identified for the chosen project. |
| **3** | Creating a Paper Prototype on selected problem statement. |
| **4** | High Fidelity prototype (Wire Frame) using Figma tool. |
| **5** | Usability Evaluation of the Design Testing of User Interface from Third Party(Test scripts) |
| **6** | Design an interactive design for the selected problem. |

| | |
|---|---|
| **7** | Installation of Unity and Visual Studio, setting up Unity for VR development, understanding documentation of the same. |
| **8** | Demonstration of the working of HTC Vive, Google Cardboard, Google Daydream and Samsung gear VR. |
| **9** | Develop a scene in Unity that includes:<br>i. a cube, plane and sphere, apply transformations on the 3 game objects.<br>ii. add a video and audio source |
| **10** | Develop a simple UI(User interface ) menu with images, canvas, sprites and button. Write a C# program to interact with UI menu through VR trigger button such that on each successful trigger interaction display a score on scene . |

| **Useful Links** | |
|---|---|
| 1 | https://www.coursera.org/professional-certificates/google-ux-design |
| 2 | https://nptel.ac.in/courses/124107008 |
| 3 | https://www.coursera.org/learn/develop-augmented-virtual-mixed-extended-reality-applications-webxr-unity-unreal |
| 4 | https://tih.iitr.ac.in/AR-VR.html |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks for Experiments |

| Course Code: | Course Title | Credit |
|---|---|---|
| ADDOL7022 | Blockchain Lab | 1 |

| | |
|---|---|
| **Prerequisite:** Java, Python, JavaScript. | |
| **Lab Objectives:** | |
| 1 | To develop and deploy smart contracts on local Blockchain. |
| 2 | To deploy the smart contract on test networks. |
| 3 | To deploy and publish smart contracts on Ethereum test network. |
| 4 | To design and develop crypto currency. |
| 5 | To deploy chain code on permissioned Blockchain. |
| 6 | To design and develop a Full-fledged DApp using Ethereum/Hyperledger. |
| **Lab Outcomes:** | |
| 1 | Develop and test smart contract on local Blockchain. |
| 2 | Develop and test smart contract on Ethereum test networks. |
| 3 | Write and deploy smart contract using Remix IDE and Metamask. |
| 4 | Design and develop Cryptocurrency. |
| 5 | Write and deploy chain code in Hyperledger Fabric. |
| 6 | Develop and test a Full-fledged DApp using Ethereum/Hyperledger. |

| **Suggested Experiments:** | |
|---|---|
| **Sr. No.** | **Name of the Experiment** |
| **1** | Local Blockchain: Introduction to Truffle, establishing local Blockchain using Truffle<br>**a)** Cryptography in Blockchain and Merkle root tree hash |
| **2** | **Smart contracts and Chain code:** Solidity programming language, chain code (Java/JavaScript/Go), deployment on Truffle local<br>a) Creating Smart Contract using Solidity<br>b) Embedding wallet and transaction using Solidity |

| | |
|---|---|
| **3** | **Deployment and publishing smart contracts on Ethereum test network:** Ethereum Test networks (Ropsten/Gorelli/Rinkeby), deployment on test networks, Web3.js/Web3.py for interaction with Ethereum smart contract<br>a) Blockchain platform ethereum using Geth.<br>b) Blockchain platform Ganache |
| **4** | **Remix IDE and Metamask:** Smart contract development and deployment using Metamask and Remix. Design and develop Crypto currency |
| **5** | **Chain code deployment in Hyperledger Fabric:** Chain code deployment in Hyperledger fabric Mini project: Study required front end tools |
| **6** | Case Study on Hyperledger |
| **7** | Case Study on Other Blockchain platforms. |
| **8** | Creating a blockchain Application |
| **9** | **Mini-project on Design and Development of a DApps using Ethereum/Hyperledger Fabric**: Implementation of Mini Project,<br>1. Design, configure and testing of mini project<br>2. Report submission as per guidelines<br>3. Implementation and Presentation of Mini Projects |

| **Text Books:** | |
|---|---|
| 1 | Ethereum Smart Contract Development, Mayukh Mukhopadhyay, Packt publication. |
| 2 | Solidity Programming Essentials: A Beginner's Guide to Build Smart Contracts for Ethereum and Blockchain, Ritesh Modi, Packt publication |
| 3 | Hands-on Smart Contract Development with Hyperledger Fabric V2, Matt Zand, Xun Wu and Mark Anthony Morris, O'Reilly. |

| **Reference Books:** | |
|---|---|
| 1 | Mastering Blockchain, Imran Bashir, Packt Publishing |
| 2 | Introducing Ethereum and Solidity, Chris Dannen, APress. |
| 3 | Hands-on Blockchain with Hyperledger, Nitin Gaur, Packt Publishing. |

| Useful Links | |
|---|---|
| 1 | https://trufflesuite.com/ |
| 2 | https://metamask.io/ |
| 3 | https://remix.ethereum.org/ |
| 4 | https://www.hyperledger.org/use/fabric |

| Term Work: | |
|---|---|
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks for Experiments |

**Mini project:**

Students should carry out mini-project in a group of three/four students with a subject In-charge

The group should meet with the concerned faculty during laboratory hours and the progress of work discussed must be documented.

3. Each group should perform a detailed literature survey and formulate a problem statement.
4. Each group will identify the hardware and software requirement for their defined mini project problem statement.
5. Design, develop and test their smart contract/chain code.
6. Each group may present their work in various project competitions and paper presentations

**Documentation of the Mini Project**

The Mini Project Report can be made on following lines:

1. Abstract
2. Contents
3. List of figures and tables
4. Chapter-1 (Introduction, Literature survey, Problem definition, Objectives, Proposed Solution, Technology/platform used)
5. Chapter-2 (System design/Block diagram, Flow chart, Software requirements, cost estimation)
6. Chapter-3 (Implementation snapshots/figures with explanation, code, future directions)
7. Chapter-4 (Conclusion)
8. References

| Course Code: | Course Title | Credit |
|---|---|---|
| ADDOL7023 | Game Theory for Data Science LAB | 1 |

| **Prerequisite:** Probability , Algebra | |
|---|---|
| **Lab Objectives:** | |
| 1 | To understand fundamental game theory concepts. |
| 2 | To apply game theory to real-world data science scenarios. |
| 3 | To analyze Nash equilibria in different types of games. |
| 4 | To investigate mixed strategies and their implications. |
| 5 | To learn game theory algorithms and computational tools. |
| 6 | To explore applications of game theory in data science. |

| **Lab Outcomes:** Learner will be able to | |
|---|---|
| 1 | Gain a solid understanding of fundamental game theory concepts. |
| 2 | Develop the ability to apply game theory principles to real-world data science problems. |
| 3 | Analyze and identify Nash equilibria in various game scenarios. |
| 4 | Comprehend the implications and applications of mixed strategies in game theory. |
| 5 | Acquire practical skills in utilizing game theory algorithms and computational tools. |
| 6 | Explore and appreciate the wide range of applications of game theory in data science. |

| Suggested List of Experiments: | |
|---|---|
| **Sr. No.** | **Name of the Experiment** |
| **1.** | Prisoners dilemma |
| **2.** | Pure Strategy Nash Equilibrium |
| **3.** | Extensive Form – Graphs and Trees, Game Trees |
| **4.** | Strategic Form – Elimination of dominant strategy |
| **5.** | Minimax theorem, minimax strategies |
| **6.** | Perfect information games: trees, players assigned to nodes, payoffs, backward Induction, subgame perfect equilibrium, |
| **7.** | Imperfect-information games – Mixed Strategy Nash Equilibrium – Finding mixed-strategy Nash equilibria for zero sum games, mixed versus behavioral strategies. |
| **8.** | Repeated Games |
| **9.** | Bayesian Nash equilibrium |
| **10** | Implementation of any game for example Tic Tac To , coloring triangle , water jug , 8 queen , 8 puzzle etc (this should be done in group of 3-4 ) |

| **Textbooks:** | |
|---|---|
| 1 | An Introduction to Game Theory by Martin J. Osborne |
| 2 | M. J. Osborne, An Introduction to Game Theory. Oxford University Press, 2004. |

| **References:** | |
|---|---|
| 1 | M. Machler, E. Solan, S. Zamir, Game Theory, Cambridge University Press, 2013. |
| 2 | N. Nisan, T. Roughgarden, E. Tardos, and V. V. Vazirani (Editors), Algorithmic Game Theory. Cambridge University Press, 2007. |
| 3 | A.Dixit and S. Skeath, Games of Strategy, Second Edition. W W Norton & Co Inc, 2004. |
| 4 | YoavShoham, Kevin Leyton-Brown, Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations, Cambridge University Press 2008. |
| 5 | Zhu Han, DusitNiyato, WalidSaad, TamerBasar and Are Hjorungnes, “Game Theory in Wireless and Communication Networks”, Cambridge University Press, 2012. |
| 6 | Y.Narahari, “Game Theory and Mechanism Design”, IISC Press, World Scientific. |

| Digital References: | |
|---|---|
| 1 | https://nptel.ac.in/courses/110104063 |
| 2 | https://onlinecourses.nptel.ac.in/noc19_ge32/preview |

| Term Work: | |
|---|---|
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks for Experiments |

| Course Code: | Course Title | Credit |
|---|---|---|
| ADP701 | Major Project 1 | 3 |

| Course Objectives: | |
|---|---|
| 1 | To acquaint with the process of identifying the needs and converting it into the problem. |
| 2 | To familiarize the process of solving the problem in a group. |
| 3 | To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems. |
| 4 | To inculcate the process of self-learning and research. |
| **Course Outcomes:** | |
| 1 | Identify problems based on societal /research needs. |
| 2 | Apply Knowledge and skill to solve societal problems in a group |
| 3 | Draw the proper inferences from available results through theoretical/ experimental/simulations |
| 4 | Analyse the impact of solutions in societal and environmental context for sustainable development. |
| 5 | Demonstrate capabilities of self-learning in a group, which leads to life long learning. |
| 6 | Demonstrate project management principles during project work. |

**Guidelines:**

**1. Project Topic Selection and Allocation:**

- Project topic selection Process to be defined and followed:
  - Project orientation can be given at the end of sixth semester.
  - Students should be informed about the domain and domain experts whose guidance can be taken before selecting projects.
  - Student‘s should be recommended to refer papers from reputed conferences/journals like IEEE, Elsevier, ACM etc. which are not more than 3 years old for review of literature.
  - Dataset selected for the project should be large and realtime
  - Students can certainly take ideas from anywhere, but be sure that they should evolve them in the unique way to suit their project requirements. Students can be informed to refer Digital India portal, SIH portal or any other hackathon portal forproblem selection.

- Topics can be finalized with respect to following criterion:
  - **Topic Selection**: The topics selected should be novel in nature (Product based, Application based or Research based) or should work towards removing the lacuna in currently existing systems.

- **Technology Used:** Use of latest technology or modern tools can be encouraged. AI, ML, DL, NNFS, NLP based algorithms can be implemented
- Students should not repeat work done previously (work done in the last three years).
- Project work must be carried out by the group of at least 3 students and maximum
- The project work can be undertaken in a research institute or organization/Industry/any business establishment. (out-house projects)
- The project proposal presentations can be scheduled according to the domains and should be judged by faculty who are expert in the domain.
- Head of department and senior staff along with project coordinators will take decision regarding final selection of projects.
- Guide allocation should be done and students have to submit weekly progress report to the internal guide.
- Internal guide has to keep track of the progress of the project and also has to maintain attendance report. This progress report can be used for awarding term work marks.
- In case of industry/ out-house projects, visit by internal guide will be preferred and external members can be called during the presentation at various levels

**2. Project Report Format:**

At the end of semester, each group needs to prepare a project report as per the guidelines issued by the University of Mumbai.

A project report should preferably contain following details:

- Abstract
- Introduction
- Literature Survey/ Existing system
- Limitation Existing system or research gap
- Problem Statement and Objective
- Proposed System
- Analysis/Framework/ Algorithm
- Design details
- Methodology (your approach to solve the problem) Proposed System
- Experimental Set up
- Details of Database or details about input to systems or selected data
- Performance Evaluation Parameters (for Validation)
- Software and Hardware Setup
- Implementation Plan for Next Semester
- Timeline Chart for Term1 and Term-II (Project Management tools can be used.)
- References

**Desirable**

Students can be asked to undergo some Certification course (for the technical skill set that will be useful and applicable for projects.)

**3. Term Work:**

Distribution of marks for term work shall be done based on following:

- Weekly Log Report
- Project Work Contribution
- Project Report (Spiral Bound) (both side print)
- Term End Presentation (Internal)

The final certification and acceptance of TW ensures the satisfactory performance on then above aspects.

**4. Oral and Practical:**

Oral and Practical examination (Final Project Evaluation) of Project 1 should be conducted by Internal and External examiners approved by University of Mumbai at the end of the semester.

**Suggested quality evaluation parameters are as follows:**

- Quality of problem selected
- Clarity of problem definition and feasibility of problem solution
- Relevance to the specialization / industrial trends
- Originality
- Clarity of objective and scope
- Quality of analysis and design
- Quality of written and oral presentation
- Individual as well as teamwork

| Course Code | Course Title | Credit |
|---|---|---|
| ADSC801 | Advanced Artificial Intelligence | 3 |

| | |
|---|---|
| **Prerequisite:** Engineering Mathematics, Data Structures and Algorithm, Python Programming | |
| **Course Objectives:** | |
| 1 | To relate with the basic concepts of Probabilistic Models. |
| 2 | To understand the scope of Generative Networks in the field of AI. |
| 3 | To recognize various components of Autoencoder Architecture and Training process. |
| 4 | To learn the fundamentals of Transfer Learning. |
| 5 | Provide students with a comprehensive understanding of ensemble methods and their applications. |
| 6 | To explore the nascent applications of AI |
| **Course Outcomes:** After successful completion of the course student will be able to | |
| 1 | Acquire basic knowledge of Probabilistic Models. |
| 2 | Analyze the working and architecture for Generative Networks. |
| 3 | Interpret various components and various types of Autoencoders |
| 4 | Understand various aspects of Transfer Learning. |
| 5 | Apply ensemble learning techniques to real-world problems and demonstrate improved predictive performance. |
| 6 | Relate to the nascent technologies in the field of artificial intelligence. |

| Module | | Content | Hrs |
|---|---|---|---|
| **1** | | **Generative and Probabilistic Models** | **08** |
| | **1.1** | **Introduction:** Overview of generative models and their importance in AI, Fundamentals of Probability theory and generative modeling, Introduction to GANs, VAEs and other generative models. Significance of generative models, Challenges with generative models. | |
| | **1.2** | **Probabilistic Models:** Gaussian Mixture Models (GMMs), Hidden Markov Models (HMMs), Bayesian Networks, Markov Random Field (MRFs), Probabilistic Graphical Model. | |
| **2** | | **Generative Adversarial Network** | **07** |
| | **2.1** | **Basics of GAN :** Generative Adversarial Networks (GANs) architecture, The discriminator model and generator model, Architecture and Training GANs, Vanilla GAN Architecture. GAN variants and improvements (DCGAN, WGAN, Conditional GAN, CycleGAN), Challenges- Training instability and model collapse, GAN applications in image synthesis and style transfer. | |

| | | | |
|---|---|---|---|
| **3** | | **Variational Autoencoders** | **07** |
| | **3.1**<br><br><br><br>**3.2** | **Introduction:**<br>Basic components of Variational Autoencoders(VAEs), Architecture and training of VAEs the loss function, Latent space representation and inference, Applications of VAEs in image generation.<br><br>**Types of Autoencoders:**<br>Undercomplete autoencoders, Sparse autoencoders, Contractive autoencoders, Denoising autoencoders, Variational Autoencoders (for generative modelling) | |
| **4** | | **Transfer Learning** | **05** |
| | **4.1** | **Introduction to transfer learning**<br>Basic terminologies, Pre-trained model and data sets, Feature extraction and fine tune transfer learning , Recent advancement in transfer learning : self- supervised learning and meta learning. | |
| **5** | | **Ensemble learning** | **06** |
| | **5.1** | **Ensemble Classifiers**:<br>Introduction to Ensemble Methods. Bagging and random forests, Boosting algorithms : AdaBoost Stacking and blending models, Extreme Gradient Boosting (XGBoost): XGBoost Regression and classification. | |
| **6** | | **Nascent Technologies in AI** | **06** |
| | **6.1** | **Convergence of AI with Augmented / virtual reality techniques for product and process development** Limitations of 2D Learning Environments, Evolution of virtual worlds and immersive technologies, Definition and concepts of Augmented Reality, Definition and concept of the Metaverse, Characteristics and components of the Metaverse, Challenges and opportunities in the Metaverse ecosystem, AI in the realm of emerging quantum computing | |

| **Textbooks:** | |
|---|---|
| 1 | Foster, D., 2022. *Generative deep learning*. " O'Reilly Media, Inc.". |
| 2 | Koller, D. and Friedman, N., 2009. *Probabilistic graphical models: principles and techniques*. MIT press |
| 3 | Goodfellow, I., 2016. Deep Learning-Ian Goodfellow, Yoshua Bengio, Aaron Courville- Google Books |
| 4 | Murphy, K.P., 2012. *Machine learning: a probabilistic perspective*. MIT press |
| 5 | Zhou, Z.H., 2012. *Ensemble methods: foundations and algorithms*. CRC press. |

| References: | |
|---|---|
| 1 | Xiong, J., Hsiang, E.L., He, Z., Zhan, T. and Wu, S.T., 2021. Augmented reality and virtual reality displays: emerging technologies and future perspectives. *Light: Science & Applications*, *10*(1), p.216. |
| 2 | Mystakidis, S., 2022. Metaverse. *Encyclopedia*, *2*(1), pp.486-497 |
| 3 | Gill, S.S., Xu, M., Ottaviani, C., Patros, P., Bahsoon, R., Shaghaghi, A., Golec, M., Stankovski, V., Wu, H., Abraham, A. and Singh, M., 2022. AI for next generation computing: Emerging trends and future directions. *Internet of Things*, *19*, p.100514 |
| 4 | Mangini, S., Tacchino, F., Gerace, D., Bajoni, D. and Macchiavello, C., 2021. Quantum computing models for artificial neural networks. *Europhysics Letters*, *134*(1), p.10002. |

| Digital References: | |
|---|---|
| 1 | https://nptel.ac.in/courses/106106201 |
| 2 | https://onlinecourses.nptel.ac.in/noc20_cs62/preview |
| 3 | https://machinelearningmastery.com/what-are-generative-adversarial-networks-gans/ |

**Internal Assessment:**

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approximately 50% syllabus is completed. Duration of the midterm test shall be one hour.

**Continuous Assessment:-**

Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered based on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

| Sr.no | Rubrics | Marks |
|---|---|---|
| 1. | *Certificate course for 4 weeks or more:- NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2. | Content beyond syllabus presentation | 10 marks |
| 3. | Creating Proof of concept | 10 marks |
| 4. | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5. | Multiple Choice Questions (Quiz) | 5 marks |
| 6. | GATE Based Assignment /Tutorials etc | 10 marks |

*For sr.no.1, the date of certification exam should be within the term and in case a student is unable to complete the certification , the grading has to be done accordingly.

| **End Semester Theory Examination:** | |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| Course Code | Course Name | Total |
|---|---|---|
| ADDO8011 | AI for financial & Banking application | 03 |

| Course Objectives | |
|---|---|
| 1 | To understand the impact of technology and digitization on financial and banking enterprises. |
| 2 | To explore blockchain technologies in the financial sector. |
| 3 | To examine digital money transfer mechanisms and GIFT cities. |
| 4 | To evaluate the benefits of digitization and cloud services in banking. |
| 5 | To analyze enterprise software solutions for financial operations. |
| 6 | To study the integration of AI in banking processes |

| Course Outcomes | |
|---|---|
| On successful completion, of course, learner/student will be able to: | |
| 1 | Gain knowledge of technology's influence on financial and banking enterprises. |
| 2 | Understand the applications of blockchain in the financial sector. |
| 3 | Recognize digital money transfer mechanisms and its role in digitization |
| 4 | Evaluate the advantages of digitization and cloud services in banking. |
| 5 | Analyze enterprise software solutions for financial operations. |
| 6 | Explore the integration of AI in banking processes. |

| Sr. No. | Content | Hrs. |
|---|---|---|
| 1 | **Information Technology Infrastructureand Digitization of Financial Banking Enterprises** Digital Technology driven processes, Blockchain technologies for Financial – Banking sector, GIFT cities Digital Money transfer Mechanisms. Digitization/ cloud services and solutions in banking and financial services Profiling enterprise software's in financial and banking enterprises.Building Efficiencies, productivity, and infallibility in financial & Banking operations. Detailed study of various processes which shall be transformed by AI integration in banking and financial services.<br><br>Self-learning : Introduction to business efficiencies, industrial productivity and high degree reliability systems for competitive advantage and carbon neutral enterprises. | 04 |

| | | |
|---|---|---|
| **2** | **Financial Statistics and The Sharpe Ratio** Probability, Combinatorics, Mathematical Expectation ,Sample Mean, Standard Deviation, and Variance ,Sample Skewness and Kurtosis ,Sample Covariance and Correlation ,Financial Returns ,Capital Asset Pricing Model ,Sharpe Ratio Formula, Time Periods and Annualizing, Ranking Investment Candidates, The Quantmod Package, Measuring Income Statement Growth, Sharpe Ratios for Income Statement Growth | **07** |
| **3** | **Cluster Analysis** K-Means Clustering, Dissecting the K-Means Algorithm Sparsity and Connectedness of Undirected Graph Covariance and Precision Matrices, Visualizing Covariance, The Wishart distribution Glasso Penalization for Undirected Graphs, Running the Glasso Algorithm, Tracking a Value Stock through the Years Regression on Yearly Sparsity , Regression on Quarterly Sparsity , Regression on Monthly Sparsity | **07** |
| **4** | **Gauging the Market Sentiment** Markov Regime Switching Model, Reading the Market Data, Bayesian Reasoning, The Beta Distribution , Prior and Posterior Distributions , Examining Log Returns for Correlation ,Momentum Graphs ,Simulating Trading Strategies , Foreign Exchange Markets , Chart Analytics Initialization and Finalization , Momentum Indicators , Bayesian Reasoning within Positions , Entries , Exils ,Profitability,, Short-Term Volatility, The State Machine | **07** |
| **5** | **Trading algorithms** Vectorized Backtesting, Backtesting an SMA-Based Strategy, Backtesting a Daily DNN-Based Strategy Backtesting an Intraday DNN-Based Strategy , Risk Management : Trading Bot , Vectorized Backtesting Event-Based Backtesting ,Assessing Risk , Backtesting Risk Measures , Stop Loss , Trailing Stop Loss , Take Profit | **07** |
| **6** | **Fraud Analytics** Introduction , The Analytical Fraud Model Life Cycle , Model Representation , Traffic Light Indicator Approach ,Decision Tables , Selecting the Sample to Investigate ,Fraud Alert and Case Management ,Visual Analytics ,Backtesting Analytical Fraud Models : Backtesting Data Stability ,Backtesting Model Stability ,Backtesting Model Calibration , Model Design and Documentation | **07** |

| **Textbooks:** | |
|---|---|
| 1 | Financial Analytics with R Building a Laptop Laboratory for Data Science MARK J. BENNETT University of Chicago DIRK L. HUGEN University of Iowa |
| 2 | Artificial Intelligence in Finance A Python-Based Guide, Yves Hilpisch A |
| 3 | Fraud Analytics Using Descriptive, Predictive, and Social Network Techniques: A Guide to Data Science for Fraud Detection, Bart Baesens, Veronique Van Vlasselaer, Wouter Verbeke |

| **References:** | |
|---|---|
| 1 | " Machine Learning for Asset Managers" by Marcos López de Prado |
| 2 | "Advances in Financial Machine Learning" by Marcos López de Prado. |

| Digital References: | |
|---|---|
| 1. | https://www.eastnets.com/newsroom/digital-transformation-in-the-banking-and-financial-services-sector |
| 2. | https://www.techopedia.com/definition/34633/generative-ai |

**Internal Assessment:**

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approximately 50% syllabus is completed. Duration of the midterm test shall be one hour.

**Continuous Assessment:-**

Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered based on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

| Sr.no | Rubrics | Marks |
|---|---|---|
| 1. | *Certificate course for 4 weeks or more:- NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2. | Content beyond syllabus presentation | 10 marks |
| 3. | Creating Proof of concept | 10 marks |
| 4. | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5. | Multiple Choice Questions (Quiz) | 5 marks |
| 6. | GATE Based Assignment /Tutorials etc | 10 marks |

*For sr.no.1, the date of certification exam should be within the term and in case a student is unable to complete the certification , the grading has to be done accordingly.

| End Semester Theory Examination: | |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| Course Code | Course Title | Credit |
|---|---|---|
| ADDO8012 | Quantum Computing | 3 |

| | | | |
|---|---|---|---|
| **Prerequisite:** Engineering Mathematics, Data Structures and Algorithm, Python Programming | | | |
| **Course Objectives:** | | | |
| 1 | To understand basics of quantum computing | | |
| 2 | To understand mathematics required for quantum computing | | |
| 3 | To understand building blocks of quantum computing and design algorithms | | |
| 4 | To understand quantum hardware principles and tools for quantum computing. | | |
| **Course Outcomes:** After successful completion of the course student will be able to | | | |
| 1 | Understand basic concepts of quantum computing | | |
| 2 | Illustrate building blocks of quantum computing through architecture and programming models. | | |
| 3 | Appraise various mathematical models required for quantum computing | | |
| 4 | Discuss various quantum hardware building principles. | | |
| 5 | Identify the various quantum algorithms | | |
| 6 | Describe usage of tools for quantum computing. | | |
| **Module** | | **Content** | **Hrs** |
| **1.0** | | **Introduction to Quantum Computing** | **7** |
| | **1.1** | Motivation for studying Quantum Computing<br>Origin of Quantum Computing<br>Quantum Computer vs. Classical Computer<br>Introduction to Quantum mechanics<br>Overview of major concepts in Quantum Computing | |
| | **1.2** | Qubits and multi-qubits states<br>Bloch Sphere representation<br>Quantum Superposition<br>Quantum Entanglement<br>Major players in the industry (IBM, Microsoft, Rigetti, D-Wave etc.) | |
| **2.0** | | **Mathematical Foundations for Quantum Computing** | **05** |
| | **2.1** | Matrix Algebra: basis vectors and orthogonality, inner product and Hilbert spaces, matrices and tensors, unitary operators and projectors, Dirac notation, Eigen values and Eigen vectors. | |
| **3.0** | | **Building Blocks for Quantum Program** | **08** |

| | | | |
|---|---|---|---|
| | **3.1** | Architecture of a Quantum Computing platform Details of q-bit system of information representation: Block Sphere<br><br>Multi-qubits States Quantum superposition of qubits (valid and invalid superposition)<br>Quantum Entanglement<br>Useful states from quantum algorithmic perceptive e.g. Bell State<br>Operation on qubits: Measuring and transforming using gates.<br>Quantum Logic gates and Circuit<br>No Cloning Theorem and Teleportation | |
| | **3.2** | Programming model for a Quantum Computing<br>Program Steps performed on classical computer<br>Steps performed on Quantum<br>Computer Moving data between bits<br>and qubits. | |
| **4.0** | | **Quantum Algorithms and Error correction** | **06** |
| | **4.1** | Quantum Algorithms, Shor‘s Algorithm, Grover‘s Algorithm.<br>Deutsch‘s Algorithm, Deutsch -Jozsa Algorithm | |
| | **4.2** | Quantum error correction using repetition codes<br>3 qubit codes, Shor‘s 9 qubit error correction Code | |
| **5.0** | | **Quantum Hardware** | **10** |
| | **5.1** | Ion Trap Qubits ,The DiVincenzo Criteria , Lagrangian and Hamiltonian Dynamics in a Nutshell: Dynamics of a Translating | |
| | **5.2** | Rotor<br>Quantum Mechanics of a Free Rotor: A Poor Person‘s Atomic | |
| | **5.3** | Model: Rotor Dynamics and the Hadamard Gate, Two-Qubit Gates The Cirac-Zoller Mechanism: Quantum Theory of Simple Harmonic Motion, A Phonon-Qubit Pair Hamiltonian, Light-Induced Rotor-Phonon Interactions, Trapped Ion Qubits, Mølmer-Sørenson Coupling .. | |
| | **5.4** | Cavity Quantum Electrodynamics (cQED): Eigenstates of the Jaynes-Cummings Hamiltonian<br>Circuit QED (cirQED): Quantum LC Circuits, Artificial Atoms, Superconducting Qubits<br>Quantum computing with spins:<br>Quantum inverter realized with two exchange coupled spins in quantum dots, A 2-qubit spintronic universal quantum gate. | |
| **6.0** | | **OSS Toolkits for implementing Quantum program** | **03** |
| | **6.1** | IBM quantum experience<br>Microsoft Q<br>Rigetti PyQuil (QPU/QVM) | |

| Textbooks: | |
|---|---|
| 1 | Michael A. Nielsen, ―Quantum Computation and Quantum Information‖, Cambridge University Press. |
| 2 | David McMahon, ―Quantum Computing Explained‖, Wiley ,2008 |
| 3 | Qiskit textbook https://qiskit.org/textbook-beta/ |
| 4 | Vladimir Silva, Practical Quantum Computing for Developers,2018 |

| References: | |
|---|---|
| 1 | Bernard Zygelman, A First Introduction to Quantum Computing and Information,2018 |
| 2 | Supriyo Bandopadhyay and Marc Cahy, ―Introduction to Spintronics‖, CRC Press, 2008 |
| 3 | The Second Quantum Revolution: From Entanglement to Quantum Computing and Other Super-Technologies, Lars Jaeger |
| 4 | La Guardia, Giuliano Gladioli ―Quantum Error correction codes‖Springer,2021 |
| **Digital References:** | |
| 1 | https://onlinecourses.nptel.ac.in/noc21_cs103/preview |
| 2 | https://www.coursera.org/courses?query=quantum%20computing |
| 3 | https://www.cl.cam.ac.uk/teaching/1617/QuantComp/ |

**Internal Assessment:**
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approximately 50% syllabus is completed. Duration of the midterm test shall be one hour.

**Continuous Assessment:-**
Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered based on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

| Sr.no | Rubrics | Marks |
|---|---|---|
| 1. | *Certificate course for 4 weeks or more:- NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2. | Content beyond syllabus presentation | 10 marks |
| 3. | Creating Proof of concept | 10 marks |
| 4. | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5. | Multiple Choice Questions (Quiz) | 5 marks |
| 6. | GATE Based Assignment /Tutorials etc | 10 marks |

*For sr.no.1, the date of certification exam should be within the term and in case a student is unable to complete the certification , the grading has to be done accordingly.

| **End Semester Theory Examination:** | |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| Course Code: | Course Title | Credit |
|---|---|---|
| ADDO8013 | Reinforcement Learning | 3 |

| Module | Content | Hours |
|---|---|---|
| 0 | **Prerequisite** | 02 |
| | Probability distributions and expected values, and basic linear algebra (e.g., inner products). | |
| 1 | **Introduction to Reinforcement Learning:** | 04 |
| | Reinforcement Learning: Key features and Elements of RL, Types of RL, rewards. Reinforcement Learning Algorithms: Q-Learning, State Action Reward State action (SARSA), | |
| 2 | Bandit problems and online learning: | 07 |
| | An n-Armed Bandit Problem, Action-Value Methods Tracking a Nonstationary Problem, Optimistic Initial Values Upper-Confidence-Bound Action Selection Gradient Bandits | |
| 3 | Markov Decision Processes: | 07 |
| | The Agent–Environment Interface, The Agent–Environment Interface, Goals and Rewards, Returns, Markov properties, Markov Decision Process, Value Functions and Optimal Value Functions, | |
| 4 | Dynamic Programming: | 07 |
| | Policy Evaluation (Prediction), Policy Improvement, Policy Iteration, Value Iteration, Asynchronous Dynamic Programming, Generalized Policy Iteration | |
| 5 | Monte Carlo Methods and Temporal-Difference Learning | 07 |
| | Monte Carlo Prediction, Monte Carlo Estimation of Action Values, Monte Carlo Control, TD Prediction, TD control using Q-Learning | |
| 6 | Applications and Case Studies | 05 |
| | Elevator Dispatching, Dynamic Channel Allocation, Job-Shop Scheduling | |

| **Text Books:** | |
|---|---|
| 1 | Reinforcement Learning: An Introduction, by Richard S. Sutton and Andrew G. Barto |
| 2 | Alessandro Palmas, Dr. Alexandra Galina Petre, Emanuele Ghelfi, The Reinforcement Learning Workshop: Learn how to Apply Cutting-edge Reinforcement Learning Algorithms to a Wide Range of Control Problems, 2020 Packt publishing. |
| 3 | Phil Winder, Reinforcement Learning Industrial Applications with Intelligent Agents, O'Reilly |
| 4 | Dr Engr S M Farrukh Akhtar, Practical Reinforcement Learning, Packt Publishing, 2017. |

| References Books: | |
|---|---|
| 1 | Maxim Lapan, Deep Reinforcement Learning Hands-On: Apply modern RL methods, with deep Q-networks, value iteration, policy gradients, TRPO, AlphaGo Zero. |
| 2 | Csaba Szepesv´ari, Algorithms for Reinforcement Learning, Morgan & Claypool Publishers |
| 3 | Alberto Leon-Garcia, Probability, Statistics and Random Processes for Electrical Engineering, Third Edition, Pearson Education, Inc. |

**Internal Assessment:**

Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approximately 50% syllabus is completed. Duration of the midterm test shall be one hour.

**Continuous Assessment:-**

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| Sr.no | Rubrics | Marks |
|---|---|---|
| 1. | *Certificate course for 4 weeks or more:- NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2. | Content beyond syllabus presentation | 10 marks |
| 3. | Creating Proof of concept | 10 marks |
| 4. | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5. | Multiple Choice Questions (Quiz) | 5 marks |
| 6. | GATE Based Assignment/Tutorials etc | 10 marks |

*For sr.no.1, the date of certification exam should be within the term and in case a student is unable to complete the certification , the grading has to be done accordingly.

| End Semester Theory Examination: | |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| Course Code | Course Name | Credit |
|---|---|---|
| ADDO8021 | Graph Data Science | 03 |

| Course Objectives: | |
|---|---|
| 1 | To Understand the basics of graphs, including definitions, connectivity, and properties. |
| 2 | To Explore the use of graphs in solving puzzles and optimization problems. |
| 3 | To Learn about the advantages of graph databases over relational and NoSQL databases. |
| 4 | To Gain knowledge of data modeling with graphs, including the labeled property graph model. |
| 5 | To Develop skills in building graph database applications, including data modeling and testing. |
| 6 | To Explore real-world use cases and understand non-functional characteristics of graph databases. |

| Course Outcomes: | |
|---|---|
| On successful completion, of course, learner/student will be able to: | |
| 1 | Demonstrate a solid understanding of graph concepts and properties. |
| 2 | Apply graph algorithms to solve puzzles and optimization problems. |
| 3 | Compare graph databases with relational and NoSQL databases. |
| 4 | Model data using the labeled property graph model and avoid common pitfalls. |
| 5 | Build graph database applications with proper data modeling and testing. |
| 6 | Analyze and implement graph database solutions for real-world use cases, considering non-functional characteristics |

| Module | Content | Hours |
|---|---|---|
| 1 | **Introduction to Graph** | 04 |
| | Definitions and examples, Three puzzles, Paths and cycles, Connectivity, Eulerian graphs, Hamiltonian graphs, shortest path, Chinese postman problem, traveling salesman problem, trees, properties of trees | |
| 2 | **Introduction Graph databases** | 07 |
| | A High-Level View of the Graph Space, Graph Databases, Graph Compute Engines, The Power of Graph Databases, Performance, Flexibility, Agility, Options for Storing Connected Data, Relational Databases Lack<br>Relationships, NOSQL Databases Also Lack Relationships, Graph databases embraces relationship | |
| 3 | **Data Modelling with Graphs** | 07 |
| | Models and Goals, The Labelled Property Graph Mode Querying Graphs, A Comparison of Relational and Graph Modelling, Cross-Domain Models, Common Modelling Pitfalls, Identifying Nodes and Relationships, Avoiding Anti-Patterns | |
| 4 | **Building a Graph Database Application** | 07 |
| | Data Modelling, Application Architecture, Testing , Capacity Planning, Importing and Bulk Loading Data, | |
| 5 | **Graphs in the Real-World** | 07 |

| | | |
|---|---|---|
| | Organizations Choose Graph Databases, Common Use Cases, Real-World Examples, Authorization and Access Control, Geospatial and Logistics, Graph Database Internals, Native Graph Processing, Native Graph Storage Programmatic APIs, Kernel API, Core API, Traversa Framework, Non-functional Characteristics | |
| **6** | **Case Study** | **07** |
| | Neo4j – About, Neo4j – Installation, Neo4j – Browser Neo4j - Query Language (Cypher), Neo4j - Create a Node Neo4j - Create Relationship, Neo4j - Create an Index Neo4j - Create a Constraint, Neo4j - Select Data with MATCH, Neo4j - Import Data from CSV, Neo4j - Drop an Index, Neo4j - Drop a Constraint, Neo4j - Delete a Node, Neo4j - Delete a Relationship | |

| **Textbooks:** | |
|---|---|
| 1 | Introduction to Graph Theory Fourth edition, Robin J. Wilson |
| 2 | Daphne Koller and Nir Friedman, "Probabilistic Graphical Models: Principles and Techniques", Cambridge, MA: The MIT Press, 2009 (ISBN 978-0-262-0139- 2). |
| 3 | Graph databases, Ian Robinson, Jim Webber & Emil Eifrem |

| **References:** | |
|---|---|
| 1 | "Graph Databases: New Opportunities for Connected Data" by Ian Robinson, Jim Webber, and Emil Eifrém. |
| 2 | "Neo4j in Action" by Aleksa Vukotic, Nicki Watt, and Tareq Abedrabbo. |
| 3 | "Graph Databases for Beginners" by Mark Needham and Amy E. Hodler. |
| 4 | "Practical Neo4j" by Gregory Jordan. |
| 5 | "Learning Neo4j" by Rik Van Bruggen. |
| 6 | "Graph Database Applications and Concepts with Neo4j" by Dionysios Synodinos. |

**Digital References:**

1. https://web4.ensiie.fr/~stefania.dumbrava/OReilly_Graph_Databases.pdf
2. https://www.quackit.com/neo4j/tutorial/

**Internal Assessment:**
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approximately 50% syllabus is completed. Duration of the midterm test shall be one hour.

**Continuous Assessment: -**
Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered based on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

| Sr.no | Rubrics | Marks |
|---|---|---|
| 1. | *Certificate course for 4 weeks or more:- NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2. | Content beyond syllabus presentation | 10 marks |
| 3. | Creating Proof of concept | 10 marks |
| 4. | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5. | Multiple Choice Questions (Quiz) | 5 marks |
| 6. | GATE Based Assignment /Tutorials etc | 10 marks |

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## End Semester Theory Examination:

| | |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
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| 4 | Any three questions out of five needs to be solved. |

| Course Code: | Course Title | Credit |
|---|---|---|
| ADDO8022 | Recommendation Systems | 3 |

| | |
|---|---|
| **Prerequisite:** Artificial Intelligence and Machine Learning, Basic knowledge of Python | |
| **Course Objectives:** | |
| 1 | To introduce Recommendation systems and it's basic concepts. |
| 2 | To understand design and working of Collaborative Filtering based recommendation. |
| 3 | To analyze design and working of Content-based recommendation. |
| 4 | To understand design and working of Knowledge based recommendation. |
| 5 | To understand design and working of Ensembled- Based and Hybrid Recommendation Systems. |
| 6 | To identify the methods for evaluation of recommendation systems. |
| **Course Outcomes:** After successful completion of the course student will be able to | |
| 1 | To have a broad understanding of the field of Recommendation Systems. |
| 2 | In-depth Knowledge of the architecture and models for Collaborative Filtering. |
| 3 | Understanding the architecture and working of Content based recommendation systems. |
| 4 | Understanding the architecture and basics of Knowledge based recommendation systems. |
| 5 | Analyzing hybrid and ensembles recommendation systems. |
| 6 | Evaluation of recommendation systems by selecting right evaluation parameter. |

| Module | | Content | Hrs |
|---|---|---|---|
| **1.0** | | **Introduction to Recommendation System** | **06** |
| | **1.1** | History of recommendation system, Eliciting Ratings and other Feedback Contributions, Implicit and Implicit Ratings, Recommender system functions. | |
| | **1.2** | Linear Algebra notation: Matrix addition, Multiplication, transposition, and inverses; covariance matrices, Understanding ratings, Applications of recommendation systems, Issues with recommender system. | |
| **2.0** | | **Collaborative Filtering** | **06** |
| | **2.1** | Architecture of Collaborative Filtering, User-based nearest neighbour recommendation, Item-based nearest neighbour recommendation, Model based and pre-processing based approaches, Clustering for recommendation system, Attacks on collaborative recommender systems, Advantages and drawbacks of Collaborative Filtering. | |

| | | | |
|---|---|---|---|
| **3.0** | | **Content-based recommendation** | **07** |
| | **3.1** | Architecture of content-based systems, Content representation and content similarity, Item profiles, Discovering features of documents, Obtaining item features from tags, Representing item profiles, Methods for learning user profiles, Similarity based retrieval, The Role of User Generated Content in the Recommendation Process. | |
| | **3.2** | Bayes classifier for recommendation, Regression based recommendation system. Advantages and drawbacks of content-based filtering | |
| **4.0** | | **Knowledge based recommendation** | **06** |
| | **4.1** | Knowledge representation and reasoning, Constraint based recommenders, Case based recommenders, Persistent Personalization in Knowledge-Based Systems, Conversational Recommendation. Search based recommendation, Navigation-based recommendation. | |
| **5.0** | | **Ensembled- Based and Hybrid Recommendation System** | **06** |
| | **5.1** | 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. | |
| **6.0** | | **Evaluating Recommendation System** | **08** |
| | **6.1** | Characteristics and properties of evaluation research, Evaluation design goals- Accuracy, Coverage, Confidence and Trust, Novelty, Serendipity, Diversity, Robustness, Stability and Scalability. | |
| | **6.2** | Comparison between evaluation design of classification model and recommendation system, Error metrics, Decision-Support metrics, User-Centered metrics. Comparative analysis between different types of recommendation systems. | |

| **Textbooks:** | |
|---|---|
| 1 | Jannach, D., Zanker, M., Felfernig, A., & Friedrich, G. (2010). *Recommender systems: an introduction*. Cambridge University Press. |
| 2 | Ricci, F., Rokach, L., & Shapira, B. (2011). Introduction to Recommender Systems Handbook. Springer, Boston, MA. |
| **References:** | |
| 1 | Aggarwal, C. C. (2016). *Recommender systems* (Vol. 1). Cham: Springer International Publishing. |

| Useful Links: | |
|---|---|
| 1 | http://www.iem.iitkgp.ac.in/eco/Recommender_Systems/ |
| 2 | https://www.coursera.org/specializations/recommender-systems |
| 3 | https://www.udemy.com/course/recommender-systems/ |
| 4 | https://www.analyticsvidhya.com/blog/2021/08/developing-a-course-recommender-system- using-python/ |

**Internal Assessment:**
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approximately 50% syllabus is completed. Duration of the midterm test shall be one hour.

**Continuous Assessment: -**
Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered based on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

| Sr.no | Rubrics | Marks |
|---|---|---|
| 1 | *Certificate course for 4 weeks or more: - NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 2 | Content beyond syllabus presentation | 10 marks |
| 3 | Creating Proof of concept | 10 marks |
| 4 | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 5 | Multiple Choice Questions (Quiz) | 5 marks |
| 6 | GATE Based Assignment/Tutorials etc | 10 marks |

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| End Semester Theory Examination: | |
|---|---|
| 1 | Question paper will be of 60 marks |
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| 4 | Any three questions out of five needs to be solved. |

| Course Code | Course Name | Credit |
|---|---|---|
| ADDO8023 | Social Media Analytics | 03 |

| | |
|---|---|
| **Prerequisite:** Graph Theory, Data Mining, Python/R programming | |
| **Course Objectives:** The course aims: | |
| 1 | Familiarize the learners with the concept of social media. |
| 2 | Familiarize the learners with the concept of social media analytics and understand its significance. |
| 3 | Enable the learners to develop skills required for analyzing the effectiveness of social media. |
| 4 | Familiarize the learners with different tools of social media analytics. |
| 5 | Familiarize the learner with different visualization techniques for Social media analytics. |
| 6 | Examine the ethical and legal implications of leveraging social media data. |
| **Course Outcomes:** | |
| 1 | Understand the concept of Social media |
| 2 | Understand the concept of social media Analytics and its significance. |
| 3 | Learners will be able to analyze the effectiveness of social media |
| 4 | Learners will be able to use different Social media analytics tools effectively and efficiently. |
| 5 | Learners will be able to use different effective Visualization techniques to represent social media analytics. |
| 6 | Acquire the fundamental perspectives and hands-on skills needed to work with social media data. |

| Module | Detailed Content | Hrs. |
|---|---|---|
| **1.** | **Social Media Analytics: An Overview** | |
| | Core Characteristics of Social Media, Types of Social Media, Social media landscape, Need for Social Media Analytics (SMA), SMA in small & large organizations. Purpose of Social Media Analytics, Social Media vs. Traditional Business Analytics, Seven Layers of Social Media Analytics, Types of Social Media Analytics, Social Media Analytics Cycle, Challenges to Social Media Analytics, Social Media Analytics Tools | 6 |
| **2.** | **Social Network Structure, Measures & Visualization** | |
| | Basics of Social Network Structure - Nodes, Edges & Tie Describing the Networks Measures - Degree Distribution, Density, Connectivity, Centralization, Tie Strength & Trust Network Visualization - Graph Layout, Visualizing Network features, Scale Issues. Social Media Network Analytics - Common Network Terms, Common Social Media Network Types, Types of Networks, Common Network Terminologies, Network Analytics Tools. | 6 |

| | | |
|---|---|---|
| **3.** | **Social Media Text, Action & Hyperlink Analytics** | **8** |
| | Social Media Text Analytics - Types of Social Media Text, Purpose of Text Analytics, Steps in Text Analytics, Social Media Text Analysis Tools Social Media Action Analytics - What Is Actions Analytics? Common Social Media Actions, Actions Analytics Tools Social Media Hyperlink Analytics - Types of Hyperlinks, Types of Hyperlink Analytics, Hyperlink Analytics Tools | |
| **4.** | **Social Media Location & Search Engine Analytics** | **6** |
| | Location Analytics - Sources of Location Data, Categories of Location Analytics, Location Analytics and Privacy Concerns, Location Analytics Tools Search Engine Analytics - Types of Search Engines, Search Engine Analytics, Search Engine Analytics Tools | |
| **5.** | **Social Information Filtering** | **6** |
| | Social Information Filtering - Social Sharing and filtering , Automated Recommendation systems, Traditional Vs social Recommendation Systems<br>Understanding Social Media and Business Alignment, Social Media KPI, Formulating a Social Media Strategy, Managing Social Media Risks | |
| **6.** | **Social Media Analytics Applications and Privacy** | **7** |
| | Social media in public sector - Analyzing public sector social media, analyzing individual users, case study. Business use of Social Media - Measuring success, Interaction and monitoring, case study. Privacy - Privacy policies, data ownership and maintaining privacy online. | |

| **Textbooks:** | |
|---|---|
| 1. | Seven Layers of Social Media Analytics_ Mining Business Insights from Social Media Text, Actions, Networks, Hyperlinks, Apps, Search Engine, and Location Data, Gohar F. Khan,(ISBN-10: 1507823207). |
| 2. | Analyzing the Social Web 1st Edition by Jennifer Golbeck |
| 3. | Mining the Social Web_ Analyzing Data from Facebook, Twitter, LinkedIn, and Other Social Media Sites, Matthew A Russell, O'Reilly |
| 4 | Charu Aggarwal (ed.), Social Network Data Analytics, Springer, 2011 |
| **References:** | |
| 1. | Social Media Analytics [2015], Techniques and Insights for Extracting Business Value Out of Social Media, Matthew Ganis, AvinashKohirkar, IBM Press |
| 2. | Social Media Analytics Strategy_ Using Data to Optimize Business Performance, Alex Gonçalves, APress Business Team |
| 3. | Social Media Data Mining and Analytics, Szabo, G., G. Polatkan, O. Boykin & A. Chalkiopoulus (2019), Wiley, ISBN 978-1-118-82485-6 |

| Useful Links | |
|---|---|
| 1 | https://cse.iitkgp.ac.in/~pawang/courses/SC16.html |
| 2 | https://onlinecourses.nptel.ac.in/noc20_cs78/preview |
| 3 | https://nptel.ac.in/courses/106106146 |
| 4 | https://7layersanalytics.com/ |

**Internal Assessment:**
Assessment consists of one Mid Term Test of 20 marks and Continuous Assessment of 20 marks. Mid Term test is to be conducted when approximately 50% syllabus is completed. Duration of the midterm test shall be one hour.

**Continuous Assessment:-**
Continuous Assessment **is of 20 marks.** The rubrics for assessment will be considered based on approval by the subject teachers. The rubrics can be any 2 or max 4 of the following:

| Sr.no | Rubrics | Marks |
|---|---|---|
| | *Certificate course for 4 weeks or more:-<br>NPTEL/ Coursera/ Udemy/any MOOC | 10 marks |
| 1. | Content beyond syllabus presentation | 10 marks |
| 2. | Creating Proof of concept | 10 marks |
| 3. | Mini Project / Extra Experiments/ Virtual Lab / Competitive programming-based event / Group Discussion | 10 marks |
| 4. | Multiple Choice Questions (Quiz) | 5 marks |
| 5. | GATE Based Assignment/Tutorials etc | 10 marks |

*For sr.no.1, the date of certification exam should be within the term and in case a student is unable to complete the certification , the grading has to be done accordingly.

| End Semester Theory Examination: | |
|---|---|
| 1 | Question paper will be of 60 marks |
| 2 | Question paper will have a total of five questions |
| 3 | All questions have equal weightage and carry 20 marks each |
| 4 | Any three questions out of five needs to be solved. |

| Course Code: | Course Title | Credit |
|---|---|---|
| ADL801 | Advanced AI Lab | 01 |

| | |
|---|---|
| **Prerequisite:** C/C++/Java/MATLAB | |
| **Lab Objectives:** | |
| 1 | Articulate basic knowledge of fuzzy set theory through programing. |
| 2 | To design Associative Memory Networks. |
| 3 | To apply Unsupervised learning towards Networks design. |
| 4 | To demonstrate Special networks and its applications in soft computing. |
| 5 | To implement Hybrid computing systems. |
| **Lab Outcomes:** At the end of the course, the students will be able to | |
| 1 | Implement Fuzzy operations and functions towards Fuzzy-rule creations. |
| 2 | Build and training Associative Memory Network. |
| 3 | Build Unsupervised learning-based networks. |
| 4 | Design and implement architecture of Special Networks |
| 5 | Implement Neuro-Fuzzy hybrid computing applications. |

| **Suggested Experiments:** | |
|---|---|
| **Sr. No.** | **Name of the Experiment** |
| **1** | Design and implement a Hidden Markov Models for outcome prediction. |
| **2** | Design and implement a Bayesian Network for outcome prediction. |
| **3** | Design and implement a Gaussian Mixture Models for outcome prediction. |
| **4** | Build and Train a Generative Multi-Layer Network Model using appropriate dataset. |
| **5** | Build and Train a Deep Convolution Generative Multi-Layer (DCGAN) Network Model for an image-based dataset. |
| **6** | Develop a Conditional GAN (CGAN) Network to direct the image generation process of the generator model. |
| **7** | Train a variational autoencoder using Tensorflow on Fashion MNIST |

| | |
|---|---|
| **8** | Explore the working of any pre-trained model towards outcome generation. |
| **9** | Implement and analyze the working of Local Interpretable Model-agnostic Explanations (LIME) supervised model. |
| **10** | Case-study on the emerging technologies in AI like Metaverse, Augmented reality etc. |
| **11** | Mini Project Report: For any one chosen real world application as per the syllabus of CSC801: Advanced AI. |
| **12** | Implementation and Presentation of Mini Project |

| **Useful Links** | |
|---|---|
| 1 | https://nptel.ac.in/courses/106106224 |
| 2 | https://www.tensorflow.org/tutorials/generative/cvae |
| 3 | https://www.analyticsvidhya.com/blog/2022/07/everything-you-need-to-know-about-lime/ |
| 4 | https://onlinecourses.nptel.ac.in/noc20_cs62/preview |
| 5 | https://machinelearningmastery.com/what-are-generative-adversarial-networks-gans/ |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks for Experiments |
| **Evaluation Exam** | |
| Based on the subject and related lab of Adv AI and Theory | |

| Lab Code | Lab Name | Credit |
|---|---|---|
| **ADDOL8011** | **AI for financial & banking application lab** | **1** |

| | |
|---|---|
| Prerequisite: Python Programming, Deep Learning, Machine Learning. | |
| **Lab Objectives:** Students will try | |
| 1 | To implement digital money transfer systems in the banking sector. |
| 2 | To calculate risk-adjusted performance measures for investment portfolios. |
| 3 | To apply cluster analysis to identify patterns in financial data. |
| 4 | To analyze market sentiment using the Markov regime switching model. |
| 5 | To design and back test trading algorithms for financial markets |
| 6 | To detect and prevent fraudulent activities using fraud analytics techniques |
| **Lab Outcomes:** At the end of the course, the students will be able to | |
| 1 | Proficiency in implementing secure and efficient digital money transfer systems. |
| 2 | Ability to assess investment performance using risk-adjusted measures. |
| 3 | Competence in identifying meaningful patterns and segments in financial data. |
| 4 | Understanding of market sentiment and its impact on trading decisions. |
| 5 | Practical skills in developing and evaluating trading algorithms. |
| 6 | Knowledge of fraud detection methods for financial systems. |

**Suggested Experiments:**

| Sr. No. | Suggested List of Experiments |
|---|---|
| **1.** | Setting up a Digital Money Transfer System |
| **2.** | Calculating Sharpe Ratios for Investment Portfolios |
| **3.** | Cluster Analysis of Financial Data for Market Segmentation |
| **4.** | Analyzing Market Sentiment using the Markov Regime Switching Model |
| **5.** | Developing and Backtesting a Simple Trading Algorithm |
| **6.** | Implementing Advanced Risk Management Techniques in Trading Algorithms |
| **7.** | Fraud Detection using Machine Learning Algorithms |
| **8.** | Visualizing Fraud Patterns and Analytics |
| **9.** | Designing and Backtesting Complex Trading Strategies |
| **10.** | Evaluating and Enhancing the Performance of Trading Algorithms |
| **11.** | Applying Machine Learning for Predictive Fraud Analytics |

| Textbooks: | |
|---|---|
| 1 | Financial Analytics with R Building a Laptop Laboratory for Data Science MARK J. BENNETT University of Chicago DIRK L. HUGEN University of Iowa |
| 2 | Artificial Intelligence in Finance A Python-Based Guide, Yves Hilpisch A |
| 3 | Fraud Analytics Using Descriptive, Predictive, and Social Network Techniques: A Guide to Data Science for Fraud Detection , Bart Baesens, Veronique Van Vlasselaer, Wouter Verbeke |

| References: | |
|---|---|
| 1 | " Machine Learning for Asset Managers" by Marcos López de Prado |
| 2 | "Advances in Financial Machine Learning" by Marcos López de Prado. |
| **Digital References:** | |
| 1. | https://www.eastnets.com/newsroom/digital-transformation-in-the-banking-and-financial-services-sector |
| 2. | https://www.techopedia.com/definition/34633/generative-ai |

| Term Work: | |
|---|---|
| 1. | Term work should consist of 8(min) to 12(max) experiments. |
| 2. | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3. | Total 25 Marks for Experiments |
| **Evaluation Exam** | |
| Based on the subject and related lab of AI for financial & banking application Lab and theory | |

| Lab Code | Lab Name | Credit |
|---|---|---|
| ADDOL8012 | Quantum Computing Lab | 1 |

| **Prerequisite: Python Programming Language.** | |
|---|---|
| **Lab Objectives:** | |
| 1 | To implement fundamental quantum computing concepts |
| 2 | To learn quantum computation and quantum information |
| 3 | To understand quantum entanglement, quantum algorithms |
| 4 | To understand quantum information theory and channels |
| **Lab Outcomes:** Students will be able to | |
| 1 | Implement basic quantum computing logic by building dice and random numbers using open source simulation tools. |
| 2 | Understand quantum logic gates using open-source simulation tools. |
| 3 | Implement quantum circuits using open-source simulation tools. |
| 4 | I implement quantum algorithms using open-source simulation tools. |

**Suggested Experiments:** Students are required to complete at least 10 experiments. Faculty may develop their own set of experiments for students. List below is only suggestive.

| Sr. No. | Name of the Experiment |
|---|---|
| **1** | Building Quantum dice |
| **2** | Building Quantum Random No. Generation |
| **3** | Composing simple quantum circuits with q-gates and measuring the output into classical bits. |
| **4** | Implementation of Shor ‘s Algorithms |
| **5** | Implementation of Grover ‘s Algorithm |
| **6** | Implementation of Deutsch ‘s Algorithm |
| **7** | Implementation of Deutsch-Jozsa‘s Algorithm |
| **8** | Quantum Circuits |
| **9** | Qubit Gates |
| **10** | Bell Circuit & GHZ Circuit |
| **11** | Accuracy of Quantum Phase Estimation |
| **12** | Mini Project such as implementing an API for efficient search using Grover ‘s Algorithms or Integer factorization using Shor‘s Algorithm. |

| **Useful Links:** | |
|---|---|
| 1 | IBM Experience: https://quantum-computing.ibm.com/ |
| 2 | Microsoft Quantum Development Kit https://azure.microsoft.com/en-us/resources/development-kit/quantum-computing/#overview |
| 3 | Forest SDK PyQuil: https://pyquil-docs.rigetti.com/en/stable/ |
| 4 | Google Quantum CIRQ https://quantumai.google/cirq |
| 5 | Qiskit Labs IBM https://learn.qiskit.org/course/ch-labs/lab-1-quantum-circuits |

| | |
|---|---|
| **Term Work:** | |
| 1. | Term work should consist of 8(min) to 12(max) experiments. |
| 2. | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3. | Total 25 Marks for Experiments |
| **Evaluation Exam** | |
| Based on the subject and related lab of Quantum Computing and theory | |

| Course Code: | Course Title | Credit |
|---|---|---|
| ADDOL8013 | Reinforcement Learning Lab | 1 |

| | |
|---|---|
| Prerequisite: Python Programming, Deep Learning, Machine Learning. | |
| **Lab Objectives:** Students will try | |
| 1 | Introduce the fundamentals of reinforcement learning and problem formulation using MDPs and Bandit problems |
| 2 | Explode different exploration strategies and their impact on online leaning scenarios. |
| 3 | Understand dynamic programming algorithms for solving Markov Decision Processes. |
| 4 | Apply dynamic programming techniques to solve small-scale MDP problems |
| 5 | Implement and compare Monte Carlo methods and Temporal-Difference learning algorithms. |
| 6 | Explore real-world applications of reinforcement learning in domains such as autonomous driving or robotics |
| **Lab Outcomes:** At the end of the course, the students will be able to | |
| 1 | Gain a solid understanding of reinforcement learning concepts and problem formulation. |
| 2 | Evaluate and compare exploration strategies in online learning scenarios. |
| 3 | Solve Markov Decision Processes using dynamic programming algorithms |
| 4 | Apply dynamic programming techniques to solve small-scale MDP problems. |
| 5 | Implement and analyze Monte Carlo methods and Temporal-Difference learning algorithms |
| 6 | Explore practical applications of reinforcement learning in real-world domains. |

| Sr. No. | Suggested List of Experiments |
|---|---|
| **1.** | Implementing a simple grid-world environment and training an agent using basic Q-learning |
| **2.** | Implementing a multi-armed bandit problem and comparing different exploration strategies like epsilon-greedy and UCB. |
| **3,** | Implementing a basic grid-world environment as an MDP and applying policy iteration and value iteration algorithms to find optimal policies. |
| **4.** | Applying dynamic programming algorithms, such as policy evaluation and policy improvement, to solve a small-scale MDP problem. |
| **5.** | Implementing Monte Carlo control and Temporal Difference (TD) learning algorithms to train an agent in a grid-world environment. |
| **6.** | Exploration vs. Exploitation Trade-off: Experimenting with different exploration strategies and analyzing their impact on the learning performance of an agent in a bandit problem. |
| **7.** | Function Approximation in Reinforcement Learning: Using function approximation techniques, such as linear regression or neural networks, to approximate value functions in reinforcement learning problems. |

| | |
|---|---|
| 8. | Deep Reinforcement Learning: Implementing a deep Q-network (DQN) to train an agent to play a popular Atari game, such as Pong or Space Invaders. |
| 9. | Transfer Learning and Multi-Task Reinforcement Learning: Investigating transfer learning in reinforcement learning by training an agent in one environment and transferring its knowledge to a different but related environment |
| 10. | Policy Gradient Methods:<br>Implementing policy gradient methods, such as REINFORCE or Proximal Policy Optimization (PPO), to train an agent in a continuous control environment. |
| *11. | Applications and Case Studies:<br>Applying reinforcement learning techniques to solve a real-world problem, such as training a self-driving car to navigate a simulated road environment. |

| **Textbooks** | |
|---|---|
| 1 | Reinforcement Learning: An Introduction, by Richard S. Sutton and Andrew G. Barto |
| 2 | Alessandro Palmas, Dr. Alexandra Galina Petre, Emanuele Ghelfi, The Reinforcement Learning Workshop: Learn how to Apply Cutting-edge Reinforcement Learning Algorithms to a Wide Range of Control Problems, 2020 Packt publishing. |
| 3 | Phil Winder, Reinforcement Learning Industrial Applications with Intelligent Agents, O'Reilly |
| 4 | Dr Engr S M Farrukh Akhtar, Practical Reinforcement Learning, Packt Publishing, 2017. |
| **References Books** | |
| 1 | Maxim Lapan, Deep Reinforcement Learning Hands-On: Apply modern RL methods, with deep Q-networks, value iteration, policy gradients, TRPO, AlphaGo Zero. |
| 2 | Csaba Szepesv´ari, Algorithms for Reinforcement Learning, Morgan & Claypool Publishers |
| 3 | Alberto Leon-Garcia, Probability, Statistics and Random Processes for Electrical Engineering, Third Edition, Pearson Education, Inc. |

| **Useful Links** | |
|---|---|
| 1 | Machine Learning and Friends at Carnegie Mellon University |
| 2 | Reinforcement Learning: A Survey |
| 3 | Bibliography on Reinforcement Learning |
| 4 | David J. Finton's Reinforcement Learning Page |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks for Experiments |
| **Evaluation Exam** | |
| Based on the subject and related lab of **Reinforcement Learning and theory** | |

| Lab Code | Lab Name | Credit |
|---|---|---|
| **ADDOL8021** | **Graph Data Science Lab** | **1** |

| | |
|---|---|
| **Lab Objectives:** Students will try | |
| 1 | To understand graph database fundamentals and their advantages. |
| 2 | To design and implement effective data models using the labeled property graph model. |
| 3 | To develop proficiency in querying and analyzing graph data using Cypher. |
| 4 | To gain knowledge of graph database administration tasks and data management. |
| 5 | To apply graph database techniques to real-world use cases. |
| 6 | To develop practical skills in graph database application development. |
| **Lab Outcomes:** At the end of the course, the students will be able to | |
| 1 | Comprehensive understanding of graph databases and their benefits. |
| 2 | Proficiency in creating data models for representing complex relationships. |
| 3 | Ability to write efficient queries and analyze graph data effectively. |
| 4 | Competence in administering and managing graph databases. |
| 5 | Application of graph database techniques to solve real-world problems. |
| 6 | Understand developing graph database applications. |

**Prerequisite:** Python Programming, Deep Learning, Machine Learning.

| Sr. No. | Suggested List of Experiments |
|---|---|
| **1.** | Graph Database Fundamentals:<br>○ Install and set up a graph database system (e.g., Neo4j) on a local machine.<br>○ Familiarize yourself with the graph database environment, including the query language (Cypher) and browser interface. |

| | |
|---|---|
| **2.** | Data Modeling with Graphs:<br>○ Design a data model using the labeled property graph model for a specific domain (e.g., social network, e-commerce).<br>○ Implement the data model in the graph database and populate it with sample data. |
| **3.** | Basic Graph Queries:<br>○ Perform basic graph queries using Cypher to retrieve nodes, relationships, and their properties.<br>○ Explore different query patterns, such as finding paths, filtering nodes, and ordering results. |
| **4.** | Advanced Graph Queries:<br>○ Extend your query knowledge by performing more complex graph queries, including subgraph matching, aggregation, and conditional filtering.<br>○ Optimize query performance by understanding and utilizing indexes. |
| **5.** | Graph Database Administration:<br>○ Learn and practice essential administrative tasks, such as managing users, roles, and access control.<br>○ Perform backup and restore operations to ensure data integrity. |
| **6.** | Importing and Exporting Data:<br>○ Import data from external sources (e.g., CSV files) into the graph database.<br>○ Export graph data to different formats for analysis or sharing. |
| **7.** | Graph Algorithms and Analytics:<br>○ Explore the built-in graph algorithms provided by the graph database system (e.g., centrality, community detection).<br>○ Apply graph algorithms to analyze and extract insights from your graph data |
| **8.** | Graph Visualization and Exploration:<br>○ Utilize visualization tools and libraries to visualize your graph data.<br>○ Explore and navigate the graph visually to gain a better understanding of its structure and relationships. |
| **9.** | Performance Optimization:<br>○ Identify and address performance bottlenecks in your graph database application.<br>○ Optimize queries, indexes, and data modeling to improve overall system |

| | |
|---|---|
| | performance. |
| **10.** | Scaling and Replication:<br>○ Learn techniques for scaling and replicating a graph database to handle larger datasets and higher workloads.<br>○ Implement and test replication strategies to ensure data availability and fault tolerance. |
| ***11.** | Real-World Use Cases:<br>○ Choose a specific real-world use case (e.g., recommendation systems, fraud detection) and apply graph database techniques to solve the problem.<br>○ Design and implement a graph database application that addresses the unique requirements of the chosen use case. |

| **Textbooks:** | |
|---|---|
| 1 | Introduction to Graph Theory Fourth edition, Robin J. Wilson |
| 2 | Daphne Koller and Nir Friedman, "Probabilistic Graphical Models: Principles and Techniques", Cambridge, MA: The MIT Press, 2009 (ISBN 978-0-262-0139- 2). |
| 3 | Graph databases, Ian Robinson, Jim Webber & Emil Eifrem |

| **References:** | |
|---|---|
| 1 | "Graph Databases: New Opportunities for Connected Data" by Ian Robinson, Jim Webber, and Emil Eifrém. |
| 2 | "Neo4j in Action" by Aleksa Vukotic, Nicki Watt, and Tareq Abedrabbo. |
| 3 | "Graph Databases for Beginners" by Mark Needham and Amy E. Hodler. |
| 4 | "Practical Neo4j" by Gregory Jordan. |
| 5 | "Learning Neo4j" by Rik Van Bruggen. |
| 6 | "Graph Database Applications and Concepts with Neo4j" by Dionysios Synodinos. |
| **Useful Links:** | |
| 1. | https://web4.ensiie.fr/~stefania.dumbrava/OReilly_Graph_Databases.pdf |
| 2. | https://www.quackit.com/neo4j/tutorial/ |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks for Experiments |
| **Evaluation Exam** | |
| Based on the subject and related lab of Graph Data Science and Theory | |

| Course Code: | Course Title | Credit |
|---|---|---|
| ADDOL8022 | Recommendation Systems Lab | 1 |

| | |
|---|---|
| **Prerequisite:** Java/Python | |
| **Lab Objectives:** | |
| 1 | To understand the key concepts of Recommendation systems. |
| 2 | Design and implement cluster-based approaches for recommendation systems. |
| 3 | Design, implement and analyze classification algorithms for recommendation systems. |
| 4 | To understand various Recommendation system Algorithms. |
| 5 | To understand data processing for Recommendation system Algorithms |
| **Lab Outcomes:** At the end of the course, the students will be able to | |
| 1 | Understand mathematics and representation of data for recommendation systems. |
| 2 | Design, implement and analyze Collaborative filtering based for recommendation systems. |
| 3 | Design, implement and analyze Content-based recommendation systems. |
| 4 | Design, implement and analyze Knowledge-based recommendation systems. |
| 5 | Understanding feature engineering and pre-processing for recommendation systems. |
| 6 | To solve real world problems using recommendation systems. |

| **Suggested Experiments:** | |
|---|---|
| **Sr. No.** | **Name of the Experiment** |
| **1** | Implementation of Matrix operations and data representation towards understanding mathematics for recommendation system |
| **2** | Experiment on the role of clustering methods with respect to recommendation systems |
| **3** | Feature engineering and pre-processing of data for recommendation systems. |
| **4** | Implementation of Bayes classifier for recommendation. |
| **5** | Implement User-based Nearest neighbor recommendation. |
| **6** | Implement Item-based Nearest neighbor recommendation |
| **7** | Implement Content-based recommendation system. |
| **8** | Implement Knowledge-based recommendation system. |
| **9** | Implementation of a recommendation system using Hybrid approach. |
| **10** | Implementation of a recommendation system using Ensembled approach. |
| **11** | Implementation of a Regression based recommendation system. |

| | |
|---|---|
| **12** | Analyze results on the basis of different evaluation parameters and graphical representations for recommendation systems. |
| **13** | Mini Project Report: For any one chosen real world Recommendation systems application. |
| **14** | Implementation and Presentation of Mini Project |

| **Useful Links** | |
|---|---|
| **1** | https://towardsdatascience.com/recommendation-systems-explained-a42fc60591ed |
| **2** | https://www.coursera.org/specializations/recommender-systems |

| **Term Work:** | |
|---|---|
| 1. | Term work should consist of 8(min) to 12(max) experiments. |
| 2. | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3. | Total 25 Marks for Experiments |
| **Evaluation Exam** | |
| Based on the subject and related lab of **Recommendation Systems and Theory** | |

| Lab Code | Lab Name | Credit |
|---|---|---|
| **ADDOL8023** | **Social Media Analytics Lab** | **1** |

| | |
|---|---|
| **Prerequisite**: Types of Graphs, Data Mining, Data Analytics | |
| **Lab Objectives:** | |
| 1 | To understand the fundamental concepts of social media networks. |
| 2 | To learn various social media analytics tools and evaluation matrices. |
| 3 | To collect and store social media data. |
| 4 | To analyze and visualize social media data |
| 5 | To design and develop social media analytics models. |
| 6 | To design and build a social media analytics application. |
| **Lab Outcomes: The students will be able to** | |
| 1 | Understand characteristics and types of social media networks. |
| 2 | Use social media analytics tools for business |
| 3 | Collect, monitor , store and track social media data |
| 4 | Analyze and visualize social media data from multiple platforms |
| 5 | Design and develop content and structure based social media analytics models. |
| 6. | Design and implement social media analytics applications for business. |

| **Suggested Experiments:** | |
|---|---|
| **Sr. No.** | **Name of the Experiment** |
| **1** | Study various -<br>1. Social Media platforms (Facebook, twitter, YouTube etc)<br>2. Social Media analytics tools (Facebook insights, google analytics net lytic etc)<br>3. Social Media Analytics techniques and engagement metrics (page level, post level, member level)<br>4. Applications of Social media analytics for business.<br>e.g. Google Analytics https://marketingplatform.google.com/about/analytics/<br>https://netlytic.org/ |
| **2** | Data Collection-Select the social media platforms of your choice (Twitter, Facebook, LinkedIn, YouTube, Web blogs etc), connect to and capture social media data for business (scraping, crawling, parsing). |
| **3** | Data Cleaning and Storage- Preprocess, filter and store social media data for business (Using Python, MongoDB, R, etc). |
| **4** | Exploratory Data Analysis and visualization of Social Media Data for business. |

| | |
|---|---|
| **5** | Develop Content (text, emoticons, image, audio, video) based social media analytics model for business.<br>(e.g. Content Based Analysis: Topic , Issue ,Trend, sentiment/opinion analysis, audio, video, image analytics) |
| **6** | Develop Structure based social media analytics model for any business.<br>( e.g. Structure Based Models -community detection, influence analysis) |
| **7** | Develop a dashboard and reporting tool based on real time social media data. |
| **8** | Design the creative content for promotion of your business on social media |
| | |
| | platform. |
| **9** | Analyze competitor activities using social media data. |
| **10** | Develop social media text analytics models for improving existing product/ service by analyzing customer ‘s reviews/comments. |

| **Reference Books:** | |
|---|---|
| **1** | Python Social Media Analytics: Analyze and visualize data from Twitter, YouTube, GitHub, and more Kindle Edition by Siddhartha Chatterjee , Michal Krystyanczuk |
| 2 | Learning Social Media Analytics with R,byRaghav Bali, Dipanjan Sarkar, Tushar Sharma. |
| 3 | Jennifer Golbeck, Analyzing the social web, Morgan Kaufmann, 2013 |
| 4 | Matthew A. Russell. Mining the Social Web: Data Mining Facebook, Twitter, Linkedin, Google+, Github, and More, 2nd Edition, O'Reilly Media, 2013 |
| 5 | Charu Aggarwal (ed.), Social Network Data Analytics, Springer, 2011 |

| **Term Work:** | |
|---|---|
| 1 | Term work should consist of 8(min) to 12(max) experiments. |
| 2 | The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. |
| 3 | Total 25 Marks for Experiments |
| **Evaluation Exam** | |
| Based on the subject and related lab of Social Media Analytics and Theory | |

| Course Code: | Course Title | Credit |
|---|---|---|
| ADP801 | Major Project 2 | 6 |

| Course Objectives: | |
|---|---|
| 1 | To acquaint with the process of identifying the needs and converting it into the problem. |
| 2 | To familiarize the process of solving the problem in a group. |
| 3 | To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems. |
| 4 | To inculcate the process of self-learning and research. |
| **Course Outcomes:** | |
| 1 | Identify problems based on societal /research needs. |
| 2 | Apply Knowledge and skill to solve societal problems in a group |
| 3 | Draw the proper inferences from available results through theoretical/ experimental/simulations |
| 4 | Analyse the impact of solutions in societal and environmental context for sustainable development. |
| 5 | Demonstrate capabilities of self-learning in a group, which leads to lifelong learning. |
| 6 | Demonstrate project management principles during project work. |

**Guidelines:**

1. Internal guide has to keep track of the progress of the project and also has to maintainattendance report. This progress report can be used for awarding term work marks.

**2. Project Report Format:**

At the end of semester, each group needs to prepare a project report as per the guidelines issued by the University of Mumbai. Report should be submitted in hardcopy. Also, each group should submit softcopy of the report along with project documentation, implementation code, required utilities, software and user Manuals.

A project report should preferably contain at least following details:

- Abstract
- Introduction
- Literature Survey/ Existing system
- Limitation Existing system or research gap
- Problem Statement and Objective
- Proposed System
  - Analysis/Framework/ Algorithm
  - Design details
  - Methodology (your approach to solve the problem) Proposed System
- Experimental Set up

- Details of Database or details about input to systems or selected data
- Performance Evaluation Parameters (for Validation)
- Software and Hardware Setup

- Results and Discussion
- Conclusion and Future Work
- References
- Appendix – List of Publications or certificates

Desirable:
Students should be encouraged -

- to participate in various project competition.
- to write minimum one technical paper & publish in good journal.
- to participate in national / international conference.

**3. Term Work:**

Distribution of marks for term work shall be done based on following:

a. Weekly Log Report
b. Completeness of the project and Project Work Contribution
c. Project Report (Black Book) (both side print)
d. Term End Presentation (Internal)

The final certification and acceptance of TW ensures the satisfactory performance on the above aspects.

**4. Oral & Practical:**

Oral &Practical examination (Final Project Evaluation) of Project 2 should be conducted by Internal and External examiners approved by University of Mumbai at the end of the semester.

**Suggested quality evaluation parameters are as following:**

a. Relevance to the specialization / industrial trends
b. Modern tools used
c. Innovation
d. Quality of work and completeness of the project
e. Validation of results
f. Impact and business value
g. Quality of written and oral presentation
h. Individual as well as teamwork