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| M.Sc. data science |
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| **SYLLABUS** |
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| **FROM THE ACADEMIC YEAR**  **2023 - 2024** |
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| **TAMILNADU STATE COUNCIL FOR HIGHER EDUCATION, CHENNAI – 600 005** |
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# Testing Pattern

# Different Types of Courses

# Elective Courses (ED from other Department Experts)

# Skill Development Courses

# Institution-Industry-Interaction

1. **Model Syllabus**

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| --- |
| 1. **TANSCHE REGULATIONS ON LEARNING OUTCOMES-BASED CURRICULUM FRAMEWORK FOR POSTGRADUATE EDUCATION**
 |
| **Programme** |  **M.Sc., DATA SCIENCE** |
| **Programme Code** |  |
| **Duration** | **2 years for PG** |
| **Programme Outcomes (Pos)** | **PO1: Problem Solving Skill**Apply knowledge of Management theories and Human Resource practices to solve business problems through research in Global context.**PO2: Decision Making Skill**Foster analytical and critical thinking abilities for data-based decision-making.**PO3: Ethical Value**Ability to incorporate quality, ethical and legal value-based perspectives to all organizational activities.**PO4: Communication Skill**Ability to develop communication, managerial and interpersonal skills.**PO5: Individual and Team Leadership Skill**Capability to lead themselves and the team to achieve organizational goals.**PO6: Employability Skill**Inculcate contemporary business practices to enhance employability skills in the competitive environment.**PO7: Entrepreneurial Skill**Equip with skills and competencies to become an entrepreneur.**PO8: Contribution to Society** Succeed in career endeavors and contribute significantly to society.**PO 9 Multicultural competence** Possess knowledge of the values and beliefs of multiple cultures and  a global perspective.**PO 10: Moral and ethical awareness/reasoning** Ability to embrace moral/ethical values in conducting one’s life.  |
| **Programme Specific Outcomes****(PSOs)** | **PSO1 – Placement**To prepare the students who will demonstrate respectful engagement with others’ ideas, behaviors, beliefs and apply diverse frames of reference to decisions and actions.**PSO 2 - Entrepreneur**To create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations.**PSO3 – Research and Development**Design and implement HR systems and practices grounded in research that comply with employment laws, leading the organization towards growth and development.**PSO4 – Contribution to Business World**To produce employable, ethical and innovative professionals to sustain in the dynamic business world.**PSO 5 – Contribution to the Society**To contribute to the development of the society by collaborating with stakeholders for mutual benefit. |

**Template for P.G., Programmes**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Semester–I** | **Credit** | **Hours** | **Semester-II** | **Credit** | **Hours** | **Semester-III** | **Credit** | **Hours** | **Semester–IV** | **Credit** | **Hours** |
| 1.1. Core-I  | 5 | 7 | 2.1. Core-IV  | 5 | 6 | 3.1. Core-VII | 5 | 6 | 4.1. Core-XI  | 5 | 6 |
| 1.2 Core-II  | 5 | 7 | 2.2 Core-V  | 5 | 6 | 3.2 Core-VIII  | 5 | 6 | 4.2 Core-XII | 5 | 6 |
| 1.3 Core – III  | 4 | 6 | 2.3 Core – VI | 4 | 6 | 3.3 Core – IX | 5 | 6 | 4.3 Project with viva voce | 7 | 10 |
| 1.4 Discipline Centric Elective -I | 3 | 5 | 2.4 Discipline Centric Elective – III | 3 | 4 | 3.4 Core – X  | 4 | 6 | 4.4Elective - VI (Industry / Entrepreneurship) 20% Theory80% Practical  | 3 | 4 |
| 1.5 Generic Elective-II:  | 3 | 5 | 2.5 Generic Elective -IV:  | 3 | 4 | 3.5 Discipline Centric Elective - V  | 3 | 3 | 4.5 Skill Enhancement course / Professional Competency Skill  | 2 | 4 |
|  |  |  | 2.6 NME I | 2 | 4 | 3.6 NME II | 2 | 3 | 4.6 Extension Activity | 1 |  |
|  |  |  |  |  |  | 3.7 Internship/ Industrial Activity | 2 | - |  |  |  |
|  | **20** | **30** |  | **22** | **30** |  | **26** | **30** |  | **23** | **30** |
| **Total Credit Points -91** |

**Choice Based Credit System (CBCS), Learning Outcomes Based Curriculum Framework (LOCF) Guideline Based Credits and Hours Distribution System**

**for all Post – Graduate Courses including Lab Hours**

**First Year – Semester – I**

|  |  |  |  |
| --- | --- | --- | --- |
| **Part** | **List of Courses** | **Credits** | **No. of Hours** |
|  | Core – I | 5 | 7 |
| Core – II | 5 | 7 |
| Core – III | 4 | 6 |
| Elective – I | 3 | 5 |
| Elective – II | 3 | 5 |
|  |  | **20** | **30** |

**Semester-II**

|  |  |  |  |
| --- | --- | --- | --- |
| **Part** | **List of Courses** | **Credits** | **No. of Hours** |
|  | Core – IV | 5 | 6 |
| Core – V | 5 | 6 |
| Core – VI | 4 | 6 |
| Elective – III | 3 | 4 |
| Elective – IV | 3 | 4 |
| Skill Enhancement Course [SEC] - I | 2 | 4 |
|  |  | **22** | **30** |

**Second Year – Semester – III**

|  |  |  |  |
| --- | --- | --- | --- |
| **Part** | **List of Courses** | **Credits** | **No. of Hours** |
|  | Core – VII | 5 | 6 |
| Core – VIII | 5 | 6 |
| Core – IX | 5 | 6 |
| Core (Industry Module) – X | 4 | 6 |
| Elective – V | 3 | 3 |
| Skill Enhancement Course - II | 2 | 3 |
|  | Internship / Industrial Activity [Credits] | 2 | - |
|  |  | **26** | **30** |

**Semester-IV**

|  |  |  |  |
| --- | --- | --- | --- |
| **Part** | **List of Courses** | **Credits** | **No. of Hours** |
|  | Core – XI | 5 | 6 |
| Core – XII | 5 | 6 |
| Project with VIVA VOCE | 7 | 10 |
| Elective – VI (Industry Entrepreneurship)  | 3 | 4 |
| Skill Enhancement Course – III / Professional Competency Skill | 2 | 4 |
| Extension Activity | 1 | - |
|  |  | **23** | **30** |

**Total 91 Credits for PG Courses**

**Credit Distribution for PG Programme in Data Science**

**M.Sc. Data Science**

**Illustration – I**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **First Year Semester-I** | **Credit** | **Hours per week(L/T/P)** |
| Part A | CC1 - Fundamentals of Data Science | 5 | 7 |
| CC2 - Mathematics for Data Science | 5 | 7 |
| CC3 - Statistics – I | 4 | 6 |
|  Elective I(Generic / Discipline Specific)(One from Group A) | 3 | 5( 4L + 1T ) |
| Elective II(Generic / Discipline Specific)(One from Group B) | 3 | 5( 3L + 2P ) |
|  | **Total** | **20** | **30** |

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Semester-II** | **Credit** | **Hours per week(L/T/P)** |
| Part A | CC4 – Python Programming | 5 | 6 |
| CC5 – Python Programming - Lab | 5 | 6 |
| CC6 - Statistics – II | 4 | 6 |
|  Elective III (Generic / Discipline Specific)(One from Group C) | 3 | 4 |
| Elective-IV(Computer / IT related) (One from Group D) | 3 | 4 |
| Part B | Skill Enhancement Course -SEC 2 (One from Group G) | 2 | 4 |
|  | **Total** | **22** | **30** |

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Second Year - Semester-III** | **Credit** |  **Hours per week(L/T/P)** |
| Part A | CC7 - Machine Learning | 5 | 6 |
| CC8 - Machine Learning - Lab | 5 | 6 |
| CC9 – Databases for Data Science | 5 | 6 |
| CC10-Core Industry Module | 4 | 6 |
| Elective V(Generic / Discipline Specific)(One from Group E) | 3 | 3 |
| Part B | Skill Enhancement Course -SEC 3 :Professional Communication Skill -Term paper & Seminar presentation | 2 | 4 |
| Internship / Industrial Activity (Carried out in Summer Vacation at the end of I year – 30 hours) | 2 | - |
|  | **Total** | **26** | **30** |

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Semester-IV** | **Credit** | **Hours per week (L/T/P)** |
| Part A | CC11– Cloud Computing | 5 | 6 |
| CC12 - Big Data Analytics and Big Data Analytics - Lab | 5 | 6 |
| Project with viva voce | 7 | 10 |
| Elective VI (Generic / Discipline Specific)(One from Group F) | 3 | 4 |
| Part B | Professional Competency Skill Enhancement Course (Any One)* Cloud Computing – Lab
* Visualization Tools
* Web Scraping using Python
 | 2 | 4 |
| Part C | Extension Activity | 1 |  |
|  | **Total** | **23** | **30** |

**TOTAL CREDITS: 91**

**Elective Courses**

**Courses are grouped (Group A to Group F) so as to include topics from Data Science, Applied Data Science, Industrial Components and IT Oriented courses for flexibility of choice by the stakeholders / institutions.**

**Semester I: Elective I and Elective II**

**Elective I** to be chosen from Group A and **Elective II** to be chosen from Group B

**Group A:**

1. Research Methodology for Computer Science
2. Data Structures & Algorithms
3. Internet of Things

**Group B:**

1. Web Programming
2. Java Programming
3. Operating Systems (Linux Based Commands for Practicals)

**Semester II: Elective III & Elective IV**

**Elective III** to be chosen from **Group C** and **Elective IV** to be chosen from **Group D**

**Group C**:

1. Information Security and Ethics
2. Distributed Systems
3. Software Engineering for Data Science

**Group D:**

1. Applied Probability
2. Optimisation Techniques
3. Discrete Mathematics

**Semester III: Elective V**

**Elective V** to be chosen from Group E.

**Group E:**

1. Natural Language Processing
2. Reinforcement Learning
3. Social Network Analysis

**Semester IV: Elective VI**

**Elective VI** to be chosen from Group F.

**Group F**

1. Artificial Intelligence and Data Science
2. Image Recognition
3. Deep Learning

# Title of the Course: CORE INDUSTRY MODULES

# Paper Number: CORE X

**Suggestive topics for Core Industry Modules:**

1. Business Analytics
2. Health care Analytics
3. Financial Analytics

**Skill Enhancement Courses**

**Skill Enhancement Courses are chosen so as to keep in pace with the latest developments in the academic / industrial front and provides flexibility of choice by the stakeholders / institutions.**

**Group G (Skill Enhancement Courses) SEC:**

* Data Science using Excel
* Office Automation and ICT Tools
* Research Tools and Techniques
* Mean Stack
* Emerging Technologies in Data Science
* Cloud Computing – Lab
* Visualization Tools
* Web Scraping using Python

**Ability Enhancement Courses**

* Soft Skill courses

**Extra Disciplinary Courses for other Departments (not for Data Science students)**

Students from other Departments may also choose any one of the following as Extra Disciplinary Course.

**Instructions for Course Transaction**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Courses | Lecture hrs | Tutorialhrs | Lab Practice | Totalhrs |
| Core | 75 | 15 | -- | 90 |
| Electives | 75 | 15 | -- | 90 |
| ED | 75 | 15 | -- | 90 |
| Lab Practice Courses | 45 | 15 | 30 | 90 |
| Project  | 20 | -- | 70 | 90 |

# Testing Pattern (25+75)

**Internal Assessment**

**Theory Course:** For theory courses there shall be three tests conducted by the faculty concerned and the average of the best two can be taken as the Continuous Internal Assessment (CIA) for a maximum of 25 marks. The duration of each test shall be one / one and a half hour.

**Computer Laboratory Courses:** For Computer Laboratory oriented Courses, there shall be two tests in Theory part and two tests in Laboratory part. Choose one best from Theory part and other best from the two Laboratory part. The average of the best two can be treated as the CIA for a maximum of 25 marks. The duration of each test shall be one / one and a half hour.

There is no improvement for CIA of both theory and laboratory, and, also for University End Semester Examination.

**Written Examination : Theory Paper (Bloom’s Taxonomy based)**

**Question paper Model**

|  |  |
| --- | --- |
| **Intended Learning Skills** | **Maximum 75 Marks****Passing Minimum: 50%****Duration : Three Hours** |
|  | **Part –A** (**10x 2 = 20 Marks**)Answer ALL questions**Each Question carries 2mark** |
| Memory Recall / Example/ Counter Example / Knowledge about the Concepts/ Understanding  | Two questions from each UNIT |
|  | Question 1 to Question 10 |
|  | **Part – B (5 x 5 = 25 Marks)****Answer ALL questions****Each questions carries 5 Marks** |
| Descriptions/ Application (problems) | Either-or TypeBoth parts of each question from the same UNIT |
|  | **Question 11(a) or 11(b)**To**Question 15(a) or 15(b)** |
|  | **Part-C (3x 10 = 30 Marks)****Answer any THREE questions**Each question carries 10 Marks |
| Analysis /Synthesis / Evaluation | There shall be FIVE questions covering all the five units |
|  | **Question 16 to Question 20** |

Each question should carry the course outcome and cognitive level

For instance,

1. [CO1 : K2] Question xxxx
2. [CO3 : K1] Question xxxx

**Different Types of Courses**

**(i) Core Courses ( Illustrative )**

1. Fundamentals of Data Science
2. Mathematics for Data Science
3. Statistics – I
4. Python Programming
5. Python Programming – Lab
6. Statistics – II
7. Machine Learning
8. Machine Learning – Lab
9. Databases for Data Science
10. Cloud Computing
11. Big Data Analytics
12. Big Data Analytics - Lab

**(ii) Elective Courses (ED within the Department Experts) ( Illustrative )**

**(iii)Elective Courses (ED from other Department Experts)**

**(iv) Skill Development Courses**

**(v) Institution-Industry-Interaction ( Industry aligned Courses)**

Programmes /course work/ field study/ Modelling the Industry Problem/ Statistical Analysis / Commerce-Industry related problems / MoU with Industry and the like activities.

**Model Syllabus for different Courses of M.Sc. Data Science**

|  |  |
| --- | --- |
| Title of the Course | FUNDAMENTALS OF DATA SCIENCE |
| Paper Number  | CORE I |
| **Category** | Core | Year | I | **Credits** | 4 | **Course Code** |  |
| **Semester** | I |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | -- | 5 |
| **Pre-requisite** |  Basic understanding of data and process |
| **Objectives of the Course**  |  To introduce the concepts and fundamentals of data science and its life cycle  |
| **Learning Outcome**  | Students will be able to **CO1 :** Understand the types of data and analytics , data science process, and its life cycle.**CO 2:** Apply math in data science **CO 3:** Analyze the various data intensive operations and tools **CO 4:** Evaluate the tools and methods for analyzing the data **CO 5:** Investigate the recent potential applications and development of data science with real time case studies  |
| **Course Outline** | **UNIT-I :** **INTRODUCTION OF DATA SCIENCE** Data Science – Data science Venn diagram - Basic terminology – Data science case studies- Types of data – levels of data- Types of data analytics - Descriptive analytics-Diagnostic analytics- Predictive analytics- Prescriptive analytics- Five steps of Data science **Book 1 - Chapter 1,2,3**  |
| **UNIT-II :** **MATHEMATICAL PRELIMINARIES**2.1 Basic Maths – mathematics as discipline – basic symbols and terminology –linear algebra 2.2 Basic Probability – definitions- probability – Bayesian vs frequentist – compound events – conditional probability – rules of probability **Book 1: Unit 2.1 – Chapter 4, Unit 2.2 – Chapter 5**  |
| **UNIT-III :** **DATA MINING AND DATA WAREHOUSING** Introduction to Data warehousing – Design consideration of data warehouse - Data loading process – case study – Data mining – Data mining techniques – Tools and platforms – case study**Book 2 – Chapter 3 and 4**  |
| **UNIT-IV :** **VISUALIZING DATA** Exploratory Data Analysis – Developing the visual aesthetic – chart types – Great visualizations – Reading graphs – Interactive visualizations**Book 3 - Chapter 6**  |
| **UNIT-V:** **Data Science – Recent Trends** Applications of Data Science, recent trends in various data collection and analysis techniques, various visualization techniques, application development methods of used in data science.  |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Case study on recent developments and presentation  |
| Skills acquired from this course |  Data Science Process, Fundamentals, Applications  |
| **Recommended Text** | 1. Ozdemir, Sinan. Principles of data science. Packt Publishing Ltd, 2016.(Unit 1- Chapter 1,2,3 Unit 2.1 – Chapter 4, Unit 2.2 – Chapter 5 )2. Maheshwari, Anil. "Data analytics made accessible." Seattle: Amazon Digital Services, 2 nd edition (2023).(Unit 3 – Chapter 3 and 4)3. Skiena, Steven S. The data science design manual. Springer, 2017.(Unit 4- chapter 6) |
| Reference Books | 1. Hadrien Jean.Education, C. (2023). Data Science. Certybox Education.2. Pierson, Lillian. Data science for dummies. John Wiley & Sons, 2021.3. Grus, Joel. Data science from scratch: first principles with python. O'Reilly Media, 2019.4. Blum, Avrim, John Hopcroft, and Ravindran Kannan. Foundations of data science. Cambridge University Press, 2020. |
| **Website and** **e-Learning Source** | <https://www.analyticsvidhya.com/><https://www.simplilearn.com><https://www.ibm.com/in-en/topics/data-science><https://www.mygreatlearning.com/blog/what-is-data-science/> |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **CO/ PSO** | **PSO 1** | **PSO 2** | **PSO 3** | **PSO 4** | **PSO 5** | **PSO 6** |
| **CO1** | **3** | **2** | **2** | **3** | **3** | **2** |
| **CO2** | **3** | **2** | **2** | **3** | **3** | **2** |
| **CO3** | **3** | **2** | **3** | **3** | **3** | **3** |
| **CO4** | **3** | **2** | **3** | **3** | **3** | **3** |
| **CO5** | **3** | **2** | **2** | **3** | **3** | **3** |
| **Weightage of course contributed to each PSO** | **15** | **10** | **12** | **15** | **15** | **13** |

avid Cielen, Arno D. B. Meysman, and Mohamed Ali, “Introducing Data Science”, Manning Publications,

2016.

David Cielen, Arno D. B. Meysman, and Mohamed Ali, “Introducing Data Science”, Manning Publications,

2016.

David Cielen, Arno D. B. Meysman, and Mohamed Ali, “Introducing Data Science”, Manning Publications,

2016.

|  |  |
| --- | --- |
| Title of the Course |  MATHEMATICS FOR DATA SCIENCE |
| Paper Number  | CORE II |
| **Category** | Core | Year | I | **Credits** | 4 | **Course Code** |  |
| **Semester** | I |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | -- | 5 |
| **Pre-requisite** | UG level Mathematics |
| **Objectives of the Course** | To build the mathematical background necessary to understand and implement in data science practical/research work |
| **Learning Outcome** | Students will be able to **CO1:** Demonstrate understanding of basic mathematical concepts in data science, relating to linear algebra**CO2:** Describe properties of linear systems using vectors, perform and interpret matrixoperations.**CO3:** Describe and compute orthogonality and determinants**CO4:** Solve linear differential equations**CO5:** Understand and apply the concept of Linear transformations  |
| **Course Outline** | **UNIT-I:****1.1 Vectors and Matrices**Vectors and Linear Combinations-Lengths and Angles from Dot Products-Matrices and Their Column Spaces-Matrix Multiplication AB and CR **1.2 Solving Linear Equations Ax = b**Elimination and Back Substitution-Elimination Matrices and Inverse Matrices-Matrix Computations and A = LU-Permutations and Transposes |
| **UNIT-II:** **2.2 The Four Fundamental Subspaces** Vector Spaces and Subspaces-Computing the Nullspace by Elimination: A = CR-The Complete Solution to Ax = b-Independence, Basis, and Dimension-Dimensions of the Four Subspaces |
| **UNIT-III:** **3.1 Orthogonality**Orthogonality of Vectors and Subspaces-Projections onto Lines and Subspaces-Least Squares Approximations-Orthonormal Bases and Gram-Schmidt-The Pseudoinverse of a Matrix **3.2 Determinants** 3 by 3 Determinants and Cofactors-Computing and Using Determinants-Areas and Volumes by Determinants |
| **UNIT-IV :** **4.1 Eigenvalues and Eigenvectors**Introduction to Eigenvalues : Ax = λx - Diagonalizing a Matrix-Symmetric Positive Definite Matrices-Complex Numbers and Vectors and Matrices-Solving Linear Differential Equations |
| **UNIT-V:****5.1 The Singular Value Decomposition (SVD)** Singular Values and Singular Vectors-Image Processing by Linear Algebra-Principal Component Analysis (PCA by the SVD)**5.2 Linear Transformations** The Idea of a Linear Transformation-The Matrix of a Linear Transformation-The Search for a Good Basis |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Problems related to the above topics to be solved(To be discussed during the Tutorial hour) |
| Skills acquired from this course |  Knowledge, Problem Solving, Analytical ability, Professional Competency |
| **Recommended Text** | [1] Gilbert Strang, Introduction to Linear Algebra, Wellesley - Cambridge Press, Sixth Edition, 2023 |
| Reference Books | [1] David Lay, Steven Lay, Judi McDonald, Linear Algebra and Its Applications 5th Edition, Pearsons[2] Sheldon Axler, Linear Algebra Done Right (Undergraduate Texts in Mathematics) 3rd ed., Springer, 2015 Edition [3] Jim Hefferon, Linear Algebra, Fourth edition[4] Jeff M Philips, Mathematical Foundations for Data Analysis |
| **Website and** **e-Learning Source** | **https://joshua.smcvt.edu/linearalgebra/** |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **CO/ PSO** | **PSO 1** | **PSO 2** | **PSO 3** | **PSO 4** | **PSO 5** | **PSO 6** |
| **CO1** | **3** | **2** | **2** | **3** | **3** | **3** |
| **CO2** | **3** | **3** | **2** | **3** | **3** | **3** |
| **CO3** | **3** | **2** | **3** | **3** | **3** | **3** |
| **CO4** | **3** | **3** | **2** | **3** | **3** | **3** |
| **CO5** | **3** | **3** | **2** | **3** | **3** | **3** |
| **Weightage of course contributed to each PSO** | **15** | **13** | **11** | **15** | **15** | **15** |

|  |  |
| --- | --- |
| Title of the Course |  STATISTICS - I |
| Paper Number  | CORE III |
| **Category** | Core | Year | I | **Credits** | 4 | **Course Code** |  |
| **Semester** | I |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | -- | 5 |
| **Pre-requisite** |  Basic Statistics |
| **Objectives of the Course** | To develop knowledge and understand fundamental concepts in probability and statistics |
| **Learning Outcome** | Students will be able to **CO1:** Organize, manage and present data.**CO2:** Understand, describe, and calculate the measures of data and correlation.**CO3**: Recognize and understand various probability distribution functions, calculate and interpret expected results**CO4:** Apply the methods of estimating a parameter.**CO5:** Understand the concept of probability and apply for simple events |
| **Course Outline** | **UNIT-I:****1.1 Introduction to Statistics**Introduction-Data Collection and Descriptive Statistics-Inferential Statistics and Probability Models-Populations and Samples-A Brief History of Statistics**1.2 Organization and Presentation of Data**Origin and development of Statistics, Scope, limitation and misuse of statistics. Types of data: primary, secondary, quantitative and qualitative data. Types of Measurements: nominal, ordinal, discrete and continuous data. Presentation of data by tables: construction of frequency distributions for discrete and continuous data, graphical representation of a frequency distribution by histogram and frequency polygon, cumulative frequency distributions |
| **UNIT-II:****2.1 Descriptive statistics**Introduction-Describing Data Sets-Frequency Tables and Graphs-Relative Frequency Tables and Graphs-Grouped Data, Histograms, Ogives, and Stem and Leaf Plots-Summarizing Data Sets-Sample Mean, Sample Median, and Sample Mode-Sample Variance and Sample Standard Deviation-Sample Percentiles and Box Plots-Chebyshev’s Inequality-Normal Data Sets-Paired Data Sets and the Sample Correlation Coefﬁcient**2.2 Correlation**Scatter plot, Karl Pearson coefficient of correlation, Spearman's rank correlation coefficient, multiple and partial correlations (for 3 variates only).  |
| **UNIT-III:****3.1 Random variables and expectation**Random Variables-Types of Random Variables-Jointly Distributed Random Variables-Independent Random Variables-Conditional Distributions-Expectation-Properties of the Expected Value-Expected Value of Sums of Random Variables-Variance-Covariance and Variance of Sums of Random Variables-Moment Generating Functions-Chebyshev’s Inequality and the Weak Law of Large Numbers**3.2 Special random variables**The Bernoulli and Binomial Random Variables-Computing the Binomial Distribution Function-The Poisson Random Variable-Computing the Poisson Distribution Function-The Hypergeometric Random Variable-The Uniform Random Variable- Normal Random Variables-Exponential Random Variables-The Poisson Process-The Gamma Distribution-Distributions Arising from the Normal-The Chi-Square Distribution-The t-Distribution-The F Distribution-The Logistics Distribution |
| **UNIT-IV:** **4.1 Distributions of sampling statistics**Introduction-The Sample Mean-The Central Limit Theorem-Approximate Distribution of the Sample Mean, How Large a Sample Is Needed?-The Sample Variance-Sampling Distributions from a Normal Population-Distribution of the Sample Mean, Joint Distribution of X and S-Sampling from a Finite Population**4.2 Parameter estimation**Introduction-Maximum Likelihood Estimators-Interval Estimates-Conﬁdence Interval for a Normal Mean When the Variance is Unknown-Conﬁdence Intervals for the Variance of a Normal Distribution - Estimating the Difference in Means of Two Normal Populations-Approximate Conﬁdence Interval for the Mean of a Bernoulli Random Variable-Conﬁdence Interval of the Mean of the Exponential Distribution-The Bayes Estimator |
| **UNIT-V :** **5.1 Basics and Elements of Probability**Random experiment, sample point and sample space, event, algebra of events. Definition of Probability: classical, empirical and axiomatic approaches to probability, properties of probability. Theorems on probability, conditional probability and independent events, Laws of total probability, Baye’s theorem and its applications-Introduction-Sample Space and Events-Venn Diagrams and the Algebra of Events-Axioms of Probability-Sample Spaces Having Equally Likely Outcomes |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Problems related to the above topics to be solved(To be discussed during the Tutorial hour) |
| Skills acquired from this course |  Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text** | [1] Sheldon M. Ross, Introduction to Probability and Statistics for Engineers And Scientists, Elsevier Academic Press, UK, Fifth Edition, 2023[2]. Rohatgi V.K and Saleh E, An Introduction to Probability and Statistics, 3rd edition, John Wiley & Sons Inc., New Jersey, 2015.[3]. Gupta S.C and Kapoor V.K, Fundamentals of Mathematical Statistics, 11th edition, Sultan Chand & Sons, New Delhi, 2014. |
| Reference Books | Jim Frost, Introduction to Statistics: An Intuitive Guide for Analyzing Data and Unlocking Discoveries |
| **Website and** **e-Learning Source** | <https://onlinestatbook.com/2/><https://www.simplilearn.com/tutorials/statistics-tutorial><https://towardsdatascience.com/fundamentals-of-statistics-for-data-scientists-and-data-analysts-69d93a05aae7> |

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| **CO/ PSO** | **PSO 1** | **PSO 2** | **PSO 3** | **PSO 4** | **PSO 5** | **PSO 6** |
| **CO1** | **3** | **3** | **2** | **3** | **3** | **3** |
| **CO2** | **2** | **3** | **3** | **3** | **3** | **2** |
| **CO3** | **2** | **3** | **3** | **3** | **3** | **2** |
| **CO4** | **3** | **3** | **3** | **3** | **3** | **2** |
| **CO5** | **3** | **3** | **2** | **3** | **3** | **3** |
| **Weightage of course contributed to each PSO** | **13** | **15** | **13** | **15** | **15** | **12** |

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| Title of the Course | Python Programming |
| Paper Number  | CORE IV |
| **Category** | Core | Year | I | **Credits** | 4 | **Course Code** |  |
| **Semester** | II |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | -- | 5 |
| **Pre-requisite** | NA  |
| **Objectives of the Course** | To be able to think logically and develop interactive programs using the python constructs, functions, data structures, classes and objects, files. |
| **Learning Outcome** | Students will be able to **CO 1:** Recall the components of a computer, demonstrate the appropriate use of data types, mathematical functions and strings in a program**CO 2:** State the use of selection and looping constructs, compare and choose an appropriate construct for a given problem**CO 3:** Define Functions, Classes and Objects, defend the use of functions, classes and objects in a given problem**CO 4:** Define Strings and Lists, implement Lists and Strings appropriately, design new problems using appropriate data structures**CO 5:** Define Tuples, sets, dictionaries and files, compare programs with and without files, develop applications using the different data structures |
| **Course Outline** | **UNIT-I : Introduction to Computers, Programs and Python -**  Introduction - Computer and its components - Programming Languages - Operating Systems - The history of Python - Introduction to python programming - Programming Style and Documentation - Programming Errors - Introduction to Graphics Programming**Chapter - 1****Elementary Programming** - Input - Output - Identifiers - Variables, Assignment Statements and Expressions - Simultaneous Assignments - Named Constants - Numeric Data Types and Operators - Evaluating Expressions and Operator Precedence - Augmented Assignment Operators - Type Conversion and Rounding **Chapter - 2****Mathematical Functions, Strings and Objects -** Introduction - Common Python Functions - Strings and Characters - Introduction to Objects and Methods - Formatting Numbers and Strings - Drawing various shapes with Colors and Fonts **Chapter - 3** |
| **UNIT-II : Selections -** Introduction - Boolean Types, Values and Expressions - Generating Random Numbers - Different forms of if statements - Logical Operators - Conditional Expressions - Operator Precedence and Associativity**Chapter - 4****Loops** - Introduction - while, for , Nested Loops - break and Continue**Chapter - 5** |
| **UNIT-III : Functions -** Introduction - Defining and calling a function - Return single and multiple values - Positional, Keyword and Default Arguments - Passing Arguments by Reference Values - Modularizing Code - Function Abstraction and Stepwise Refinement - Recursion **Chapter - 6, Chapter 15 - 15.1,15.2,15.4****Objects and Classes -** Introduction - Defining Classes for Objects - UML Class Diagrams - Immutable vs Mutable Objects - Hiding Data Fields - Class Abstraction and Encapsulation - Object Oriented Thinking**Chapter - 7****Inheritance and Polymorphism -**  Superclasses and Subclasses - Overriding methods - Object class - Polymorphism and Dynamic binding **Chapter - 12** |
| **UNIT-IV : More on Strings and Special Methods -** Introduction - Str class - Operator Overloading and Special Methods - **Chapter - 8** **Lists -** Basics - Copying Lists - Passing Lists to Functions - Returning a List from a Function - Searching, Sorting Lists - **Chapter 10****Multidimensional Lists** - Processing Two - Dimensional Lists - Passing Two - Dimensional Lists to Functions - Multidimensional Lists**Chapter 10** |
| **UNIT-V: Tuples, Sets and Dictionaries** – Introduction - Tuples - Sets - Comparing the Performance of Sets and Lists - Dictionaries - **Chapter - 14****Files and Exception Handling** – Introduction - Text Input and Output - File Dialogs - Retrieving Data from Web - Exception Handling - Raising Exceptions - Processing Exceptions using Exception Objects - Defining Custom Exception Classes - Binary IO Using Pickling **Chapter - 13** |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) |  Case Studies related to the above topics given in the Text Book to be solved.(To be discussed during the Tutorial hour) |
| Skills acquired from this course | Problem Solving, Analytical ability, Professional Competency, Programming Knowledge |
| **Recommended Text** |  Y. Daniel Lang, *Introduction to Programming using Python*, 2nd Edition, Pearson Education Inc., 2013. |
| Reference Books | 1. Allen B. Downey. Think Python. How to Think Like a Computer Scientist, 2ndedition, O‘Reilly Publishers, 2016.
2. Corey Wade, et al : *The Python Workshop*, 2nd Edition, Packt, 2022.
3. David Beazley, Brian K. Jones. Python Cookbook: Recipes for Mastering Python 3, 3rd Edition, 2013 Harsh Bhasin. Python for Beginners. New Age International Publishers,2018.
4. Martin C. Brown. Python: The Complete Reference. McGraw Hill Education; Fourth edition, 2018.
 |
| **Website and** **e-Learning Source** | https://realpython.com, <http://docs.python.org>, <http://diveintopython.org/>, <https://www.w3schools.com/python/> , <https://www.tutorialspoint.com/python/index.htm> |

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| **CO/ PSO** | **PSO 1** | **PSO 2** | **PSO 3** | **PSO 4** | **PSO 5** | **PSO 6** |
| **CO1** | **3** | **3** | **2** | **3** | **3** | **3** |
| **CO2** | **2** | **3** | **3** | **3** | **3** | **2** |
| **CO3** | **2** | **3** | **3** | **3** | **3** | **2** |
| **CO4** | **3** | **3** | **3** | **3** | **3** | **2** |
| **CO5** | **3** | **3** | **2** | **3** | **3** | **3** |
| **Weightage of course contributed to each PSO** | **13** | **15** | **13** | **15** | **15** | **12** |

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| Title of the Course | Python Programming - Lab |
| Paper Number  | CORE V |
| **Category** | Core | Year | I | **Credits** | 4 | **Course Code** |  |
| **Semester** | II |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| — | — | 5 | 5 |
| **Pre-requisite** | NA  |
| **Objectives of the Course** |  To be able to apply appropriately the python programming knowledge gained and develop computer based solutions for a given problem |
| **Learning Outcome** | Students will be able to **CO 1:** Recall the components of a computer, demonstrate the appropriate use of data types, mathematical functions and strings in a program**CO 2:** State the use of selection and looping constructs, compare and choose an appropriate construct for a given problem**CO 3:**  Develop modular programming using functions , Design program using OO constructs **CO 4:** Demonstrate Strings and Lists, implement Lists and Strings appropriately, design new problems using appropriate data structures**CO 5:** Demonstrate Tuples, sets, dictionaries and files, compare programs with and without files, develop applications using different data structures |
| **Course Outline** | **UNIT-I :**1. Installation of the required software
2. Programs using basic data types and operators
3. Programs involving Mathematical functions
4. Program in String Manipulations
 |
| **UNIT-II :** 1. Programs using different forms of if statement
2. Drawing various shapes using turtle
3. Programs involving repeated execution of a set of statements
4. Programs using break and continue
5. Programs using random
 |
| **UNIT-III :** 1. Modular programming using functions
2. Programs using positional, keyword and default argument
3. Programs using pass by value, pass by reference
4. Programs using classes and objects
5. Programs using Inheritance
 |
| **UNIT-IV :** 1. Programs on Str class and special methods
2. Programs using Lists and List manipulation
3. Programs using Two-Dimensional Lists
 |
| **UNIT-V:** 1. Programs using Tuple and its methods
2. Programs with Set and Set manipulation
3. Programs using Dictionaries
4. Program comparing the performance of Sets and Lists
5. Programs handling Text Files
6. Programs handling Binary Files
7. Programs handling exceptions
 |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) |  Case Studies related to the above topics given in the Text Book to be solved. |
| Skills acquired from this course | Problem Solving, Analytical ability, Professional Competency, Programming Knowledge |
| **Recommended Text** |  Y. Daniel Lang, *Introduction to Programming using Python*, 2nd Edition, Pearson Education Inc., 2013. |
| Reference Books | 1. Allen B. Downey. Think Python. How to Think Like a Computer Scientist, 2ndedition, O‘Reilly Publishers, 2016.
2. Corey Wade, et al : *The Python Workshop*, 2nd Edition, Packt, 2022.
3. David Beazley, Brian K. Jones. Python Cookbook: Recipes for Mastering Python 3, 3rd Edition, 2013 Harsh Bhasin. Python for Beginners. New Age International Publishers,2018.
4. Martin C. Brown. Python: The Complete Reference. McGraw Hill Education; Fourth edition, 2018.
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| **Website and** **e-Learning Source** | https://realpython.com, <http://docs.python.org>, <http://diveintopython.org/>, <https://www.w3schools.com/python/> , <https://www.tutorialspoint.com/python/index.htm> |

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| **CO/ PSO** | **PSO 1** | **PSO 2** | **PSO 3** | **PSO 4** | **PSO 5** | **PSO 6** |
| **CO1** | **3** | **3** | **1** | **3** | **3** | **3** |
| **CO2** | **3** | **3** | **3** | **3** | **3** | **3** |
| **CO3** | **3** | **3** | **2** | **3** | **3** | **3** |
| **CO4** | **3** | **3** | **2** | **3** | **3** | **2** |
| **CO5** | **3** | **3** | **3** | **3** | **3** | **3** |
| **Weightage of course contributed to each PSO** | **15** | **15** | **11** | **15** | **15** | **14** |

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| Title of the Course |  STATISTICS - II |
| Paper Number  | CORE VI |
| **Category** | Core | Year | I | **Credits** | 4 | **Course Code** |  |
| **Semester** | II |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | -- | 5 |
| **Pre-requisite** | Statistics in Semester I |
| **Objectives of the Course** | To develop knowledge and understand fundamental concepts in probability and statistics |
| **Learning Outcome**  | Students will be able to **CO1:** Identify the four steps of hypothesis testing.**CO2:** Gain a thorough understanding of applied principles of statistics.**CO3**: To develop knowledge and skills in theoretical, computational and application-oriented statistics**CO4:** Apply the methods of analysis of variance**CO5:** Understand and apply the concept of non-parametric tests  |
| **Course Outline** | **UNIT-I:****1.1 INTRODUCTION**Population and Statistics – Finite and Infinite population – Parameter and Statistics – Types of sampling - Sampling Distribution – Sampling Error - Standard Error – Test of significance –concept of hypothesis – types of hypothesis – Errors in hypothesis-testing – Critical region – level of significance - Power of the test – p-value.**1.2 Hypothesis testing**Introduction-Signiﬁcance Levels-Tests Concerning the Mean of a Normal Population-Case of Known Variance-Case of Unknown Variance: The t-Test-Testing the Equality of Means of Two Normal Populations-Case of Known Variances-Case of Unknown Variances-Case of Unknown and Unequal Variances-The Paired t-Test- Hypothesis Tests Concerning the Variance of a Normal Population-Testing for the Equality of Variances of Two Normal Populations-Hypothesis Tests in Bernoulli Populations-Testing the Equality of Parameters in Two Bernoulli Populations-Tests Concerning the Mean of a Poisson Distribution-Testing the Relationship Between Two Poisson Parameters |
| **UNIT-II:** **2.1 Hypothesis Testing-II**Students t-distribution and its properties (without proofs) – Single sample mean test – Independent sample mean test – Paired sample mean test – Tests of proportion (based on t distribution) – F distribution and its properties (without proofs) – Tests of equality of two variances using F-test – Chi-square distribution and its properties (without proofs) – chisquare test for independence of attributes – Chi-square test for goodness of fit. |
| **UNIT-III:****3.1 Regression**Introduction-Least Squares Estimators of the Regression Parameters-Distribution of the Estimators-Statistical Inferences About the Regression Parameters-Inferences Concerning β -Inferences Concerning α- Inferences Concerning the Mean Response α+β x 0 - Prediction Interval of a Future Response-Summary of Distributional Results- The Coefﬁcient of Determination and the Sample Correlation Coefﬁcient-Analysis of Residuals: Assessing the Model-Transforming to Linearity- Weighted Least squares-Polynomial Regression - Multiple Linear Regression-Predicting Future Responses - Logistic Regression Models for Binary Output Data |
| **UNIT-IV:** **4.1 Analysis of variance**Introduction-An Overview-One-Way Analysis of Variance-Multiple Comparisons of Sample Means-One-Way Analysis of Variance with Unequal Sample Sizes-Two-Factor Analysis of Variance: Introduction and ParameterEstimation-Two-Factor Analysis of Variance: Testing Hypotheses-Two-Way Analysis of Variance with Interaction**4.2 Goodness of fit tests and categorical data analysis**Introduction-Goodness of Fit Tests When All Parameters Are Speciﬁed-Determining the Critical Region by Simulation-Goodness of Fit Tests When Some Parameters Are Unspeciﬁed-Tests of Independence in Contingency Tables -Tests of Independence in Contingency Tables Having Fixed Marginal Totals-The Kolmogorov–Smirnov Goodness of Fit Test for Continuous Data |
| **UNIT-V :** **5.1 Nonparametric hypothesis tests**Introduction-The Sign Test-The Signed Rank Test-The Two-Sample Problem-The Classical Approximation and Simulation-Wilcoxon Signed Rank Test for one and paired samples-The Runs Test for Randomness -Median test and Mann-Whitney-Wilcoxon tests for two samples. |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Problems related to the above topics to be solved(To be discussed during the Tutorial hour) |
| Skills acquired from this course |  Knowledge, Problem Solving, Analytical ability, Professional Competency |
| **Recommended Text** | [1] Sheldon M. Ross, Introduction to Probability and Statistics for Engineers And Scientists, Elsevier Academic Press, UK, Fifth Edition, 2023[2] Gupta S.C and Kapoor V.K, Fundamentals of Mathematical Statistics, 12th edition, Sultan Chand & Sons, New Delhi, 2020.[3] Brian Caffo, Statistical Inference for Data Science, Learnpub, 2016. |
| Reference Books | 1. Allen B. Downey, Think Stats- Exploratory data analysis, O’reilly, 2nd Edition
2. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley Publications, Tenth Edition

[3] Jim Frost, Introduction to Statistics: An Intuitive Guide for Analyzing Data and Unlocking Discoveries |
| **Website and** **e-Learning Source** | <https://onlinestatbook.com/2/><https://www.simplilearn.com/tutorials/statistics-tutorial><https://towardsdatascience.com/fundamentals-of-statistics-for-data-scientists-and-data-analysts-69d93a05aae7> |

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| **CO/ PSO** | **PSO 1** | **PSO 2** | **PSO 3** | **PSO 4** | **PSO 5** | **PSO 6** |
| **CO1** | **2** | **3** | **1** | **1** | **2** | **2** |
| **CO2** | **3** | **3** | **2** | **2** | **2** | **2** |
| **CO3** | **3** | **2** | **2** | **3** | **2** | **2** |
| **CO4** | **3** | **2** | **2** | **2** | **2** | **3** |
| **CO5** | **3** | **3** | **2** | **3** | **2** | **3** |
| **Weightage of course contributed to each PSO** | **14** | **13** | **9** | **11** | **10** | **12** |

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| Title of the Course | Machine Learning  |
| Paper Number  | CORE VIII |
| **Category** | Core | Year | II | **Credits** | 4 | **Course Code** |  |
| **Semester** | III |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | -- | 5 |
| **Pre-requisite** | Basic Programming Skill and Data Knowledge  |
| **Objectives of the Course** | To understand the different types, steps and algorithms involved in Machine Learning Process |
| **Learning Outcome** | **CO1:** Describe the data, essential steps for creating a typical ML model and the fundamentals of pattern classification**CO2:** Able to examine different ML algorithms and unprocessed data and features**CO3:** Implement the essential techniques to reduce the number of features in a dataset and test the performance of predictive models**CO4:** Select multiple algorithms, combine and produce ensembles, discuss the essential techniques for modeling linear relations**CO5:** Discuss the clustering algorithms, develop a Web application embedding a ML model |
| **Course Outline** | **UNIT-I : Data Analytics with pandas and NumPy -** NumPy and basic stats - Matrices - pandas library - Working with data - Null Values - Creating statistical graphs**Book 1, Chapter -10****Giving Computers the ability to learn from data -** Introduction - Building intelligent systems to transform data into knowledge - The three different types of Machine Learning(ML) - Introduction to basic terminology and notations - A roadmap for building ML systems - Using Python for ML**Book 2, Chapter - 1****Training Simple ML Algorithms for Classification -** Early History of ML - Implementing a Perceptron learning algorithm - Adaptive linear neurons and the convergence of learning **Book 2, Chapter - 2** |
| **UNIT-II : ML Classifiers using sckikit-learn** - Choosing a classification algorithm - Training a perceptron - Modeling class probabilities via logistic regression - Maximum margin classification with support vector machines(SVM) - Solving nonlinear problems using a kernel SVM - Decision tree learning - K-nearest neighbours: a lazy learning algorithm**Book 2 , Chapter 3** **Data Preprocessing -**  Missing data - Categorical data - Partitioning a dataset into separate training and test datasets - Bringing features onto the same scale - Selecting meaningful features - Assessing feature importance with random forests**Book 2, Chapter - 4** |
| **UNIT-III : Compressing Data via Dimensionality Reduction -** Unsupervised dimensionality reduction via principal component analysis - Supervised data compression via linear discriminant analysis - Using kernel principal component analysis for nonlinear mappings**Book 2, Chapter - 5** **Learning Best Practices for Model Evaluation and Hyperparameter Tuning -** Streamlining workflows with pipelines - Using k-fold cross-validation to assess model performance - Debugging algorithms with learning and validation curves - Fine-tuning ML models via grid search - Looking at different performance evaluation metrics**Book 2, Chapter - 6** |
| **UNIT-IV : Combining different models for ensemble learning** - Learning with ensembles - Combining classifiers via majority vote - Bagging: building an ensemble of classifiers from bootstrap samples - Leveraging weak learners via adaptive boosting**Book 2, Chapter - 7** **Predicting Continuous Target Variables with Regression Analysis - Introducing Linear regression -** Implementing an ordinary least squares linear regression model - Fitting a robust regression model using RANSAC - Evaluating the performance of linear regression models - Using regularised methods for regression - Turning a linear regression model into a curve -polynomial regression - Dealing with nonlinear relationships using random forests**Book 2, Chapter - 10** |
| **UNIT-V: Working with Unlabelled Data** – Grouping objects by similarity using k-means - Organising clusters as a hierarchical tree - Locating regions of high density via DBSCAN**Book 2, Chapter - 11****Introduction to Embedding a ML model into a Web Application -** Serialising fitted scikit-learn estimators - Setting up an SQLite database for data storage - Developing a web application with Flask - Turning any classifier into a web application - Deploying the web application to a public server**Book 2, Chapter - 9** |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Mini project applying ML concepts in existing / real time data |
| Skills acquired from this course | Preprocessing, ML steps, Prediction and Performance evaluation , Embedding ML model into a web application |
| **Recommended Text** | 1. Corey Wade et al, Vahid Mirjalili, The Python Workshop, 2nd Edition, packs publishing, 2022 2. Sebastian Raschka and Vahid Mirjalili, Python Machine Learning, 3rd Edition, packt publishing, 2019 |
| Reference Books | 1. Andreas C. Mueller, Sarah Guido. Introduction to Machine Learning with Python. O’Reilly Media, Inc., 2016.
2. Ethem Alpaydin, Introduction to Machine Learning, 2nd Edition, http://mitpress.mit.edu/catalog/item/default.asp?ttype=2&tid=12012, 2010
3. Wes McKinney. Python for Data Analysis. O’Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, second edition, 2018
 |
| **Website and** **e-Learning Source** | 1. <https://data-flair.training/blogs/machine-learning-tutorial/>
2. <https://www.geeksforgeeks.org/machine-learning/>
 |

**Course Outcome**

Upon completion of the course, the student will be able to

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| **CO/ PSO** | **PSO 1** | **PSO 2** | **PSO 3** | **PSO 4** | **PSO 5** | **PSO 6** |
| **CO1** | **3** | **3** | **2** | **2** | **2** | **2** |
| **CO2** | **3** | **3** | **2** | **3** | **3** | **2** |
| **CO3** | **3** | **2** | **3** | **2** | **3** | **3** |
| **CO4** | **3** | **2** | **3** | **2** | **3** | **3** |
| **CO5** | **3** | **3** | **3** | **3** | **3** | **3** |
| **Weightage of course****contributed to each PSO** | **15** | **13** | **13** | **12** | **14** | **13** |

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| Title of the Course | Machine Learning - Lab |
| Paper Number  | CORE VII |
| **Category** | Core | Year | II | **Credits** | 4 | **Course Code** |  |
| **Semester** | III |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| — | 1 | 5 | 5 |
| **Pre-requisite** | Basic Programming Skill and Data Knowledge  |
| **Objectives of the Course** | To preprocess the data and build ML models using appropriate techniques and evaluate the model |
| **Learning Outcome** | Upon completion of the course, the student will be able to**CO1:** Apply pandas, NumPy and Matplotlib to read in , process and visualise data, implement linear classification algorithms**CO2:** Compare classifiers with linear and non-linear decision boundaries, select relevant features for the model construction**CO3:** Apply data compression and best practices for model evaluation and hyper parameter tuning**CO4:** Select appropriate algorithms and ensemble**CO5:** Apply clustering algorithms on unlabelled data, construct a web application embedding a ML model |
| **Course Outline** | **UNIT-I :** 1. Programs using NumPy and pandas
2. Visualising using graphs
3. Perceptron learning algorithm
4. Adaline
 |
| **UNIT-II :** **5.** Training a perceptron6. Modeling class probabilities via logistic regression 7. Maximum margin classification with support vector machines(SVM) 8. Solving nonlinear problems using a kernel SVM 9. Decision tree |
| **UNIT-III :** 10. Unsupervised dimensionality reduction via principal component analysis 11. Supervised data compression via linear discriminant analysis 12. Using k-fold cross-validation to assess model performance 13. Debugging algorithms with learning and validation curves 14. Fine-tuning ML models via grid search 15. Implementing different performance evaluation metrics |
| **UNIT-IV :** **16.** Ensemble Learning17. Ordinary least squares linear regression model18. Evaluating the performance of linear regression models 19. Regularised methods for regression20. Nonlinear relationships using random forests |
| **UNIT-V:** **21.** Grouping objects by similarity using k-means 22. Organising clusters as a hierarchical tree23. Locating regions of high density via DBSCAN24. Embedding a ML model into a Web Application |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | 1. Mini project applying ML concepts in existing / real time data2. Comparing the performance of different ML algorithms on a given dataset |
| Skills acquired from this course | Preprocessing, ML steps, Prediction and Performance evaluation , Embedding ML model into a web application |
| **Recommended Text** | 1. Corey Wade et al, Vahid Mirjalili, The Python Workshop, 2nd Edition, packs publishing, 2022 2. Sebastian Raschka and Vahid Mirjalili, Python Machine Learning, 3rd Edition, packt publishing, 2019 |
| Reference Books | 1. Andreas C. Mueller, Sarah Guido. Introduction to Machine Learning with Python. O’Reilly Media, Inc., 2016.
2. Ethem Alpaydin, Introduction to Machine Learning, 2nd Edition, http://mitpress.mit.edu/catalog/item/default.asp?ttype=2&tid=12012, 2010
3. Wes McKinney. Python for Data Analysis. O’Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, second edition, 2018
 |
| **Website and** **e-Learning Source** | 1. <https://machinelearningmastery.com/machine-learning-in-python-step-by-step/>
2. <https://www.tutorialspoint.com/machine_learning_with_python/index.htm>
3. <https://pythonprogramming.net/machine-learning-tutorial-python-introduction/>
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| **CO/ PSO** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** |
| **CO1** | **3** | **3** | **2** | **3** | **3** | **3** |
| **CO2** | **3** | **3** | **2** | **3** | **2** | **2** |
| **CO3** | **3** | **2** | **3** | **3** | **2** | **2** |
| **CO4** | **3** | **2** | **3** | **2** | **3** | **2** |
| **CO5** | **3** | **3** | **2** | **3** | **3** | **2** |
| **Weightage of course contributed to each PSO** | **15** | **13** | **12** | **14** | **13** | **11** |

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| Title of the Course | Databases for Data Science |
| Paper Number  | CORE IX |
| **Category** | Core | Year | II | **Credits** | 4 | **Course Code** |  |
| **Semester** | III |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 3 | -- | 2 | 5 |
| **Pre-requisite** | Fundamental computer knowledge including computer storage and hardware |
| **Objectives of the Course** | To provide fundamentals of database design, modeling systems, data storage, world of data warehousing and NoSQL |
| **Learning Outcome**  | Students will be able to **CO1:** Understand and discuss the importance of relational data modeling and conceptual  modelling**CO2:** Experiment with various database and compose effective queries**CO3**: Analyse the process of OLAP system construction**CO4:** Evaluate the use of NOSQL and its approach to the database**CO5:** Develop applications using Relational and NoSQL databases |
| **Course Outline** | **Unit 1****1.1 Fundamental Concepts of Database Management**Applications of Database Technology - Key Definitions - File versus Database Approach to Data Management - Elements of a Database System - Advantages of Database Systems and Database Management - Architecture and Categorization of DBMSs**1.2 Conceptual Data Modeling using the ER Model and UML Class Diagram**Phases of Database Design - The Entity Relationship Model - UML Class Diagram |
| **Unit 2****2.1 Types of Database Systems**Legacy Databases - Relational Databases: The Relational Model - Normalization**2.2 Relational Databases**Structured Query Language - SQL Data Definition Language - SQL Data Manipulation LanguageLab: SQL DDL and DML |
| **Unit 3****3.1 Data Warehousing and Business Intelligence**Operational versus Tactical/Strategic Decision-Making - Data Warehouse Definition - Data Warehouse Schemas - The Extraction, Transformation, and Loading (ETL) Process - Data Marts - Virtual Data Warehouses and Virtual Data Marts - Operational Data Store - Data Warehouses vs Data Lakes - Business Intelligence**3.2 Introduction of NO SQL**Overview and History of NoSQL Databases. Definition of the Four Types of NoSQL Database, The Value of Relational Databases, Getting at Persistent Data, Concurrency, Integration, Impedance Mismatch, Application and Integration Databases, Attack of the Clusters, The Emergence of NoSQL, Key Points Comparison of relational databases to new NoSQL stores, Mongo DB, Cassandra, HBASE, Neo4j use and deployment, Application, RDBMS approach, Challenges NoSQL approach, Key-Value and Document Data Models, Column-Family Stores, AggregateOriented Databases. sharding, MapReduce on databases. Distribution Models, Single Server, Sharding, Master-Slave Replication, Peer-to-Peer replication, Combining Sharding and Replication. |
| **Unit 4****4.2 Key Value Data Stores**NoSQL Key/Value databases using MongoDB, Document Databases, Document oriented Database Features, Consistency, Transactions, Availability, Query Features, Scaling, Suitable Use Cases, Event Logging, Content Management Systems, Blogging Platforms, Web Analytics or Real-Time Analytics, E-Commerce Applications, Complex Transactions Spanning Different Operations, Queries against Varying Aggregate Structure.Lab: Key-value databases, Replica of existing database, Backup of existing database, Restore database from the backupDemonstration: Connecting python with mongodb and inserting, retrieving, updating and deleting. |
| **Unit 5****5.1 Document Oriented Database** Column- oriented NoSQL databases using Apache HBASE, Column-oriented NoSQL databases using Apache Cassandra, Architecture of HBASE, Column-Family Data Store Features, Consistency, Transactions, Availability, Query Features, Scaling, Suitable Use Cases, Event Logging, Content Management Systems, Blogging Platforms, Counters, Expiring Usage.**5.2 Data Modeling with Graph** Comparison of Relational and Graph Modeling, Property Graph Model Graph Analytics: Link analysis algorithm- Web as a graph, Page RankMarkov chain, page rank computation, Topic specific page rank Page Ranking Computation techniques iterative processing, Random walk distribution Querying Graphs Lab: Implement with column-family stores (cassandra), Graph databases (neo4j)Aggregate function, Push and addtoset expression, First and last expression. |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Case studies to understand the limitations of Relational DBMS and the need for NoSQL databaseMini project - create a data store and process the data |
| Skills acquired from this course | Database designer, Data owner of different types of data, Data Scientist fluent in data, Business Professional |
| **Recommended Text** | Lemahieu, W., Broucke, S.vanden and Baesens, B. (2018) Principles of database management: The Practical Guide to storing, managing and analyzing big and small data. Cambridge, United Kingdom: Cambridge University Press.Sadalage, P. & Fowler,NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence, Wiley Publications,1st Edition,2022 |
| Reference Books | 1. SQL for Data Scientists: A Beginner's Guide for Building Datasets for Analysis Renee M. P. Teate
2. SQL for Data Science: Data cleaning, wrangling and analytics with relational databases, Antonio Badia
3. Guy Harrison, Next Generation Database: NoSQL and big data,

Apress |
| **Website and** **e-Learning Source** | [**https://www.geeksforgeeks.org/introduction-to-nosql/**](https://www.geeksforgeeks.org/introduction-to-nosql/) |

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| **CO/ PSO** | **PSO 1** | **PSO 2** | **PSO 3** | **PSO 4** | **PSO 5** | **PSO 6** |
| **CO1** | **2** | **3** | **2** | **2** | **3** | **3** |
| **CO2** | **2** | **3** | **2** | **2** | **3** | **3** |
| **CO3** | **2** | **3** | **2** | **2** | **3** | **3** |
| **CO4** | **3** | **3** | **2** | **2** | **3** | **3** |
| **CO5** | **3** | **3** | **2** | **2** | **3** | **3** |
| **Weightage of course contributed to each PSO** | **12** | **15** | **10** | **10** | **15** | **15** |

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| Title of the Course | Cloud Computing |
| Paper Number  | CORE XI |
| **Category** | Core | Year | II | **Credits** | 4 | **Course Code** |  |
| **Semester** | IV |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | -- | 5 |
| **Pre-requisite** | Basic concepts of Operating System. Familiar with using computers for different office duties |
| **Objectives of the Course** | To provide an understanding of how cloud computing evolved, its acceptance world-wide and integral part of several organization  |
| **Learning Outcome** | Students will be able to **CO1:** Understand the models, principles, and benefits of Cloud Computing**CO2:** Understand virtualization foundations to cater the needs of elasticity, portability and  resilience by cloud service providers.**CO3:** Identify the applications of Cloud Computing**CO4:** Analyse the security aspects of Cloud Computing**CO5:** Evaluate the importance of message passing and map reduce in Cloud Computing |
| **Course Outline** | **Unit 1****1.1 Introduction to Cloud Computing** Introduction – History - Fundamentals of Cloud computing – characteristics - Advantages and Disadvantages- Comparison of traditional and cloud computing paradigms- Evaluating the impact and economics - Business drivers- Future of cloud**1.2 Services and Deployment model**Cloud deployment models - Cloud service models – Cloud infrastructure mechanisms - Cloud service management |
| **Unit 2****2.1 Cloud Computing Architecture** Cloud computing architecture - Design principle - Life cycle (CCLC) -Reference architecture - Load balancing approach - Mobile cloud computing (MCC) - Case study of oracle cloud management**2.2 Virtualization**Understanding - Adoption – Techniques – Working of Virtualizaton - Kernel-based virtual machine (KVM) – VMware – VirtualBox – Citrix - Types of virtualization - Virtualisation in cloud |
| **Unit 3****3.1 Service Oriented Architecture**Objectives - SOA foundation - Web services and SOA - SOA communication - SOA components - SOA Infrastructure - Need of SOA - Business Process Management (BPM) – Services of BPM**3.2 Cloud Computing Applications** Introduction - Google App Engine - Google Apps - Google CloudData store - Dropbox Cloud - Apple iCloud - Microsoft Windows Azure Cloud - Amazon Web Services (AWS) |
| **Unit 4****4.1 Cloud Security and Privacy**Cloud Security - Cloud CIA security model - Cloud computing securityArchitecture - Service provider security issues - Security issues in Virtualization - Data security in cloud – Data privacy risks - Business continuity and disaster recovery - Threats in cloud – Security techniques for threats - Cloud service level agreements (SLA): Components – Types - Cloud vendors - Quality of Cloud Services -Techniques – Migration - Trust management |
| **Unit 5****5.1 Cloud Computing Technologies**Cloud Computing Technologies - High performance Computing - Message Passing Interface(MPI) - MapReduce programming model -Dryad and Dryad LINQ -Eucalyptus cloud platform: Components – OpenNebula: Layers – Features – OpenStack: components - Benefits – The Apache Hadoop ecosystem**5.2 Adoption of Cloud Computing**Factors affecting the adoption - Existing areas of application - Case studies -Certifications. |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | More Case studies and Demonstration(To be discussed during the Lecture hour) |
| Skills acquired from this course | Platform expertise, selecting the right services, Managing an integrated environment and Securing the cloud environment |
| **Recommended Text** | Kant Hiran, Kamal, Ruchi Doshi, Temitayo Fagbola, Mehul Mahrishi, Cloud Computing: Master the Concepts, Architecture and Applications with Real-world examples and Case studies, BPB Publishers, 2019 |
| Reference Books | Ben Piper and David Clinton, AWS Certified Solutions Architect Study Guide: Associate SAA-C01 Exam, Googel Book, 2019Legorie Rajan Ps, Steven Porter, and Ted Hunter, Building Google Cloud Platform Solutions: Develop Scalable Applications from Scratch and Make Them Globally Available in Almost Any Language, Packt,2019Rajkumar Buyya, Christian Vecchiola, S. Thamarai Selvi, Mastering Cloud Computing, Tata McGraw Hill Education Private Limited, 2013 |
| **Website and** **e-Learning Source** | [**https://acloudguru.com**](https://acloudguru.com)[**https://www.cloudcomputing-news.net/**](https://www.cloudcomputing-news.net/)**https://cloudtweaks.com/** |

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| **CO/ PSO** | **PSO 1** | **PSO 2** | **PSO 3** | **PSO 4** | **PSO 5** | **PSO 6** |
| **CO1** | **3** | **3** | **2** | **3** | **3** | **2** |
| **CO2** | **3** | **3** | **2** | **3** | **3** | **2** |
| **CO3** | **3** | **3** | **2** | **3** | **3** | **2** |
| **CO4** | **3** | **3** | **2** | **3** | **3** | **2** |
| **CO5** | **3** | **3** | **2** | **3** | **3** | **2** |
| **Weightage of course contributed to each PSO** | **15** | **15** | **10** | **15** | **15** | **10** |

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| Title of the Course | BIG DATA ANALYTICS |
| Paper Number  | CORE 12 |
| **Category** | Core | Year | II | **Credits** | 4 | **Course Code** |  |
| **Semester** | IV |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | -- | 5 |
| **Pre-requisite** | Basic understanding of programming and logical thinking  |
| **Objectives of the Course**  | To introduce the concepts of big data analytics and developing a real time applications  |
| **Learning Outcome**  | Students will be able to **CO 1:** Understand the basic concepts of big data analytics and technologies**CO 2:** Apply the concept of HDFS, Map reduce for storing and processing of Big data**CO 3:** Analyze and perform different operations on data using Pig, Hive, and Hbase **CO 4:** Evaluate the tools and methods for analyzing Big data analytics model **CO 5:** Develop real time big data analytics applications  |
| **Course Outline** | **UNIT-I :** **INTRODUCTION TO BIG DATA ANALYTICS** Classification of Digital Data, Structured and Unstructured Data - Introduction to Big Data: Characteristics – Evolution – Definition - Challenges with Big Data - Other Characteristics of Data - Why Big Data - Traditional Business Intelligence versus Big Data - Data Warehouse and Hadoop Environment Big Data Analytics: Classification of Analytics – Challenges - Big Data Analytics important - Data Science - Data Scientist - Terminologies used in Big Data Environments. **Book 1 - Chapter 1,2,3**  |
| **UNIT-II :** **BIG DATA TECHNOLOGY LANDSCAPE** NoSQL, Comparison of SQL and NoSQL, Hadoop -RDBMS Versus Hadoop - Distributed Computing Challenges – Hadoop Overview - Hadoop Distributed File System - Processing Data with Hadoop - Managing Resources and Applications with Hadoop YARN - Interacting with Hadoop Ecosystem**Book 1: Chapter 4, 5**  |
| **UNIT-III :** **HADOOP AND HDFS**Introduction to Hadoop – RDBMS vs Hadoop- distributed computing challenges - A Brief History of Hadoop- The Hadoop Distributed Filesystem- Processing Data with Hadoop - Anatomy of a MapReduce Works - Anatomy of a MapReduce Job Run- Job Scheduling- Shuffle and Sort- Task Execution**Book 2 – Chapter 1, 3,6**  |
| **UNIT-IV :** **HADOOP ECO SYSTEM** Hive: Introduction – Architecture - Data Types - File Formats - Hive Query Language Statements – Partitions – Bucketing – Views - Sub- Query – Joins – Aggregations - Group by and Having - RCFile Implementation - Hive User Defined Function - Serialization and Deserialization. Pig: Introduction - Anatomy – Features – Philosophy - Use Case for Pig - Pig Latin Overview - Pig Primitive Data Types - Running Pig - Execution Modes of Pig - HDFS Commands - Relational Operators - Eval Function - Complex Data Types - Piggy Bank - User-Defined Functions - Parameter Substitution - Diagnostic Operator - Word Count Example using Pig - Pig at Yahoo! - Pig Versus HiveHbase - HBasics, Concepts.**Book 1 - Chapter 9, 10****Book 2 - Chapter 11, 12,13** |
| **UNIT-V:** **Case Studies** Hadoop Usage at Last.fm - Hadoop and Hive at Facebook- Nutch Search Engine- Log Processing at Rackspace – Cascading - TeraByte Sort on Apache Hadoop 601 - Using Pig and Wukong to Explore Billion-edge Network Graphs - Recent Trends in Big Data Analytics**Book 2 - Chapter 16** |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Case study on recent developments and presentation  |
| Skills acquired from this course | Developing application using big data analytic techniques  |
| **Recommended Text** | 1. Big Data and Analytics, Seema Acharya, Subhashini Chellappan, First Edition, 2015,Wiley.2. Tom White, Hadoop: The Definitive Guide, O’Reilly Media Inc., 2015. |
| Reference Books | 1. Lublinsky, Boris, Kevin T. Smith, and Alexey Yakubovich. Professional hadoop solutions. John Wiley & Sons, 2013.2. Big Data Analytics, RadhaShankarmani, M Vijayalakshmi, Second Edition, 2017, Wiley3. Hadoop Essentials: A Quantitative Approach, Henry H. Liu, First Edition, 2012, PerfMathPublishers |
| **Website and** **e-Learning Source** | <https://www.ibm.com/analytics/big-data-analytics><https://www.simplilearn.com/what-is-big-data-analytics-article><https://azure.microsoft.com/en-us/resources/cloud-computing-dictionary/what-is-big-data-analytics> |

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| **CO/ PSO** | **PSO 1** | **PSO 2** | **PSO 3** | **PSO 4** | **PSO 5** | **PSO 6** |
| **CO1** | **3** | **3** | **2** | **3** | **3** | **3** |
| **CO2** | **3** | **3** | **2** | **3** | **3** | **3** |
| **CO3** | **3** | **3** | **2** | **3** | **3** | **3** |
| **CO4** | **3** | **3** | **2** | **3** | **3** | **3** |
| **CO5** | **3** | **3** | **2** | **3** | **3** | **3** |
| **Weightage of course contributed to each****PO/PSO** | **15** | **15** | **10** | **15** | **15** | **15** |

id Cielen, Arno D. B. Meysman, and Mohamed Ali, “Introducing Data Science”, Manning Publications,

2016.

David Cielen, Arno D. B. Meysman, and Mohamed Ali, “Introducing Data Science”, Manning Publications,

2016.

David Cielen, Arno D. B. Meysman, and Mohamed Ali, “Introducing Data Science”, Manning Publications,

2016.

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| Title of the Course | BIG DATA ANALYTICS LAB |
| Paper Number  | CORE 12 |
| **Category** | Core | Year | II | **Credits** | 4 | **Course Code** |  |
| **Semester** | IV |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| - | - | 5 | 5 |
| **Pre-requisite** | Basic understanding of programming and logical thinking  |
| **Objectives of the Course**  | To introduce the concepts of big data analytics and developing a real time applications  |
| **Learning Outcome**  | Students will be able to **CO 1:** Configure Hadoop and perform File Management**CO 2:** Apply Map Reduce program to real time issues.**CO 3:** Critically analyze huge data set using Hadoop distributed file systems and MapReduce **CO 4:** Experimenting different data processing tools like Pig, Hive. **CO 5:** Develop real time big data analytics applications  |
| **Course Outline** | **UNIT-I :** 1. Install Apache Hadoop2. Perform setting up and Installing Hadoop in its three operating modes:StandalonePseudo DistributedFully Distributed3. To use Web Based Tools to Manage Hadoop Set-up4. Implement the following file management tasks in Hadoop:Adding files and directoriesRetrieving filesDeleting Files  |
| **UNIT-II :** 4. Develop a MapReduce program to calculate the frequency of a given word in a given file. 5. Develop a MapReduce program to find the maximum temperature in each year. 6. Develop a MapReduce program to find the grades of student’s. 7. Develop a MapReduce program to implement Matrix Multiplication. 8. Develop a MapReduce to find the maximum electrical consumption in each year given electrical consumption for each month in each year. |
| **UNIT-III :**9. Develop a MapReduce to analyze weather data set and print whether the day is shinny or cool day. (National Climatic Data Centre (NCDC) Data set) 10. Develop a MapReduce program to find the number of products sold in each country by considering sales data containing fields like Tranction \_Date Product Price Payment\_Type Name City\State Country Account\_Created Last\_Login Latitude Longi 11. Data sets from different sources as Input12. Develop a MapReduce program to find the tags associated with each movie by analyzing movie lens data. (https://www.kaggle.com/datasets/grouplens/movielens-20m-dataset)12. Sorting the data using MapReduce 13. Count the number of missing and invalid values through joining two large given datasets.  |
| **UNIT-IV :** 14. Install and Run Pig then write Pig Latin scripts to sort, group, join, project and filter the data.15. Install and Run Hive then use Hive to Create, alter and drop databases, tables, views, functions and Indexes.16. Develop a program to calculate the maximum recorded temperature by year wise for the weather dataset in Pig Latin 17. Develop a program to calculate the maximum recorded temperature by year wise for the weather dataset in Pig Latin18. Write queries to sort and aggregate the data in a table using HiveQL19. Develop a MapReduce to find the maximum electrical consumption in each year given electrical consumption for each month in each year. 20. Write a program to implement combining and partitioning in hadoop to implement a custom partitioner and Combiner |
| **UNIT-V:** 21. Analyze the sentiment for product reviews, this work proposes a MapReduce technique provided by Apache Hadoop 22. Trend Analysis based on Access Pattern over Web Logs using Hadoop.23. Implementation of decision tree algorithms using MapReduce. 24. Implementation of K-means Clustering using MapReduce. 25. Generation of Frequent Itemset using MapReduce.  |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Mini Project – Application development  |
| Skills acquired from this course | Developing application using big data analytic techniques  |
| **Recommended Text** | 1. Big Data and Analytics, Seema Acharya, Subhashini Chellappan, First Edition, 2015,Wiley.2. Tom White, Hadoop: The Definitive Guide, O’Reilly Media Inc., 2015. |
| Reference Books | 1. Lublinsky, Boris, Kevin T. Smith, and Alexey Yakubovich. Professional hadoop solutions. John Wiley & Sons, 2013.2. Big Data Analytics, RadhaShankarmani, M Vijayalakshmi, Second Edition, 2017, Wiley3. Hadoop Essentials: A Quantitative Approach, Henry H. Liu, First Edition, 2012, PerfMathPublishers |
| **Website and** **e-Learning Source** | <https://www.ibm.com/analytics/big-data-analytics><https://www.simplilearn.com/what-is-big-data-analytics-article><https://azure.microsoft.com/en-us/resources/cloud-computing-dictionary/what-is-big-data-analytics> |

**Course Learning Outcome (for Mapping with POs and PSOs)**

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| --- | --- |
|  | **PSOs** |
|  | **1** | **1** | **2** | **3** | **4** | **5** | **6** |
| **CO1** | 3 | 3 | 3 | 3 | 2 | 1 | 1 |
| **CO2** | 3 | 3 | 3 | 3 | 2 | 1 | 1 |
| **CO3** | 3 | 3 | 3 | 3 | 2 | 1 | 1 |
| **CO4** | 3 | 3 | 3 | 3 | 2 | 1 | 1 |
| **CO5** | 3 | 3 | 3 | 3 | 2 | 1 | 1 |
| **Weightage of course contributed to each****PO/PSO** | **15** | **15** | **15** | **15** | **10** | **5** | 5 |

David Cielen, Arno D. B. Meysman, and Mohamed Ali, “Introducing Data Science”, Manning Publications,

2016.

David Cielen, Arno D. B. Meysman, and Mohamed Ali, “Introducing Data Science”, Manning Publications,

2016.

David Cielen, Arno D. B. Meysman, and Mohamed Ali, “Introducing Data Science”, Manning Publications,

2016.

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| Title of the Course |  PROJECT WITH VIVA VOCE |
| Paper Number  |  |
| **Category** | Core | Year | II | **Credits** | 3 | **Course Code** |  |
| **Semester** | IV |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
|  |  | 5 | 5 |
| **Pre-requisite** |  Programming and Logical reasoning |

**GROUP A**

Elective I to be chosen from Group A

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| **Title of the Course** | **Research Methodology for Computer Science** |
| **Paper Number**  | **Group A** |
| **Category** | Elective-I | **Year** | I | **Credits** | 3 | **Course Code** |  |
| **Semester** | I |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | -- | 5 |
| **Pre-requisite** | **Not Required** |
| **Objectives of the Course** | To develop an understanding of the research methods relevant to effectively address a research problem |
| **Course Outline** | **UNIT-I:****1.1 Introduction to Research**Meaning, Objectives and Characteristics of research - Research Methods Vs. Methodology - Types of research- Research process - Criteria of good research**1.2 Research Project**Shaping a Research Project-Research Planning-Students andAdvisors – Checklist |
| **UNIT-II:****2.1 Literature Review**Reading and Reviewing - Hypotheses, Questions, and Evidence |
| **UNIT-III:****3.1 Experiments for Computing**Experimentation-Statistical Principles **3.2 Writing a Paper**Organization-Good Style-Style Specifics-Punctuation-Mathematics-Algorithms- Graphs, Figures, and Tables -Other Professional Writing |
| **UNIT-IV:** **4.1 Presentation**Editing- Presentations-Slides-Posters-Ethics |
| **UNIT-V:** **5.1 Report writing**Report writing using LATEX for a research problem |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Literature Review and Problem IdentificationWriting a research Paper (To be discussed during the Tutorial hour) |
| Skills acquired from this course |  Knowledge, Problem Solving, Analytical ability, Professional Competency, Research skill, Professional Communication and Transferrable Skill |
| **Recommended Text** | [1] Kothari C. R. Research Methodology Methods and Techniques. 2nd ed. New Delhi: New Age, 2004. (Unit 1.1)[2] Justin Zobel. Writing for Computer Science.3rd ed. Springer-Verlag,2014 |
| **Reference Books** | [1] Ranjit Kumar. Research Methodology -a step-by-step guide for beginners. 3rd ed. SAGE Publications India Pvt Ltd, 2011.[2] Panneerselvam R. Research Methodology. 2nd ed. New Delhi: Prentice Hall, 2014. |
| **Website and** **e-Learning Source** |  <https://www2.le.ac.uk/offices/red/rd/research-methods-and-methodologies> <http://www.socscidiss.bham.ac.uk/methodologies.html>  |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

**CLO1:** Develop an understanding of research methods

**CLO2:** Formulate a research problem

**CLO3**: Collect and analyse data

**CLO4:** Effectively write a research paper

**CLO5:** Present the Paper more professionally.

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| **CO/PSO** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** |
| **CLO1** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO2** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO3** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO4** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO5** | 3 | 3 | 3 | 2 | 1 | 1 |
| **Weightage of course contribute to each PSO** |  |  |  |  |  |  |

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| **Title of the Course** |  **Data Structures and Algorithms** |
| **Paper Number**  | **Group A** |
| **Category** | Elective-I | **Year** | I | **Credits** | 3 | **Course Code** |  |
| **Semester** | I |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | -- | 5 |
| **Pre-requisite** | **Not Required** |
| **Objectives of the Course** | To develop an understanding of the research methods relevant to effectively address a research problem |
| **Course Outline** | **UNIT-I:****1.1 Basic Concepts**Basic steps in complete development of Algorithm - Analysisand complexity of Algorithm – Asymptotic notations - Problem Solving techniques and examples**1.2 ADT**List ADT, Stacks ADT, Queue ADT |
| **UNIT-II:****2.1 Algorithm Design Model**Greedy Method - Divide and Conquer - Dynamic Programming – Backtracking – Branch and Bound**2.2 Trees**Preliminaries Binary Tree, Search Tree ADT, Binary Search Trees, AVL Trees, Tree Traversals, B-Trees  |
| **UNIT-III:****3.1 Hashing**General Idea, Hash Function, Separate Chaining, Open Addressing,Rehashing, Extendible Hashing, Priority Queues, Model, SimpleImplementations, Binary Heap, Applications |
| **UNIT-IV:** **4.1 Sorting**Sorting - Preliminaries, Insertion Sort, Shell Sort, Heap Sort, Merge Sort, Quick Sort, External Sorting |
| **UNIT-V:** **5.1 Graphs**Definitions, Topological Sort, Shortest Path Algorithm, Minimum Spanning Tree, Application of Depth First Search**5.2 Theory of NP-Completeness**Formal language framework, Complexity classes – P, NP - NP Reducibility and NP-Complete, NP-Hard |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Problems related to above topics to be solved(To be discussed during the Tutorial hour) |
| Skills acquired from this course |  Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text** | [1] Aho, J. E. Hopcroft and J. D. Ullman. Design and Analysis of Computer Algorithms. 1st ed. Addison-Wesley, 2009.[2] Horowitz and Sahani. Fundamentals of Computer Algorithms. 2nd ed. Galgotia, 2008.[3] Weiss, M. A. Data Structure and Algorithm analysis in C. 2nd ed. Pearson Education Asia, 2002. |
| **Reference Books** | [1] Baase, S. and Allen Van Gelder. Computer Algorithms-Introduction to Design and Analysis.New Delhi: Pearson Education, 2008[2] Goodrich, M.T. and R. Tamassia. Algorithm Design: Foundations, Analysis, and Internet Examples. New Delhi: Wiley, 2006. |
| **Website and** **e-Learning Source** |   |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

**CLO1:** To understand the design of algorithms and analysis techniques

**CLO2:** To enable the students to analyse the time and space complexity of algorithms

**CLO3**: To have a good understanding on different data structures

**CLO4:** To understand the kinds of problems that uses the data structures and the

algorithms for solving them

**CLO5:** Identify appropriate data structures for real time applications

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| **CO/PSO** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** |
| **CLO1** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO2** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO3** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO4** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO5** | 3 | 3 | 3 | 2 | 1 | 1 |
| **Weightage of course contribute to each PSO** |  |  |  |  |  |  |

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| **Title of the Course** | **Internet of Things** |
| **Paper Number**  | **Elective 1** |
| **Category** | Core | **Year** | I | **Credits** | 3 | **Course Code** |  |
| **Semester** | I |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | -- | 5 |
| **Pre-requisite** | Knowledge in Computing and Networking |
| **Objectives of the Course** | To understand the concepts, data, framework, standards, protocols, reliability, security and privacy involved in IOT |
| **Course Outline** | **UNIT-I : IoT Ecosystem Concepts and Architectures** Introduction – IoT definition and evolution – IoT Architectures - OpenIoT Architecture for IoT/Cloud Convergence - Resource Management – IoT Data Management and Analytics - Communication Protocols – Internet of Things applications-Scheduling Process and IoT Services Lifecycle - IoT enabling technologies – IoT levels and Deployments templates – Introduction to M2M - Difference between IoT and M2M – SDN and NFV for IoT |
| **UNIT-II : IoT Data and Framework Essentials -** Introduction - Programming framework for IoT– The foundation of Stream processing in IoT - Continuous Logic processing system – Challenges and Future directions – Anomaly detection – Problem statement and definitions – Efficient incremental local modelling – IoT Governance. |
| **UNIT-III : RF Protocols RFID, NFC;IEEE 802.15.4:** ZigBee - ZWAVE, THREAD - Bluetooth Low Energy (BLE) - IPv6 for Low Power and Lossy Networks (6LoWPAN) - Routing Protocol for Low power and lossy networks (RPL) - CoAP - XMPP - Web Socket- AMQP – MQTT – WebRTC - PuSH Architectural Considerations in Smart Object Networking - TinyTO Protocol. 3.2 Introduction to IoT based applications – Scenarios – Architecture overview – Sensors – The gateway – Data Transmission – Internet of Vehicles (IoV) – IoV Characteristics, technologies and its application. |
| **UNIT-IV : Developing Internet of Things :**Introduction – IoT Design Methodology – Case study on IoT system for Weather monitoring – IoT Device - IoT physical devices and endpoints - Exemplary Device: Raspberry Pi - Linux on Raspberry Pi - Raspberry Pi interfaces – Programming Raspberry Pi and with python – Other IoT devices. |
| **UNIT-V: IoT Reliability, Security and Privacy:** Introduction - Concepts - IoT Security Overview – Security Frameworks for IoT – Privacy in IoT networks – IoT characteristics and reliability issues - Addressing reliability |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) |  Case Studies(To be discussed during the Tutorial hour) |
| Skills acquired from this course | Knowledge on IOT Technology and its reliability, security and privacy, Developing a basic IOT system |
| **Recommended Text** | 1. Arshdeep Bahga, Vijay Madisetti, “Internet of Things, A Hands -on Approach”, 1st Edition 2015, University Press, ISBN: 978-81-7371- 954-7 2. Buyya, Rajkumar, and Amir Vahid Dastjerdi, eds. Internet of Things: Principles and paradigms. Elsevier, 2016. 3. Hersent, Olivier, David Boswarthick, and Omar Elloumi. The internet of things: Key applications and protocols. John Wiley & Sons, 2011. |
| **Reference Books** | 1. Bernd Scholz-Reiter, Florian Michahelles, “Architecting the Internet of Things”, ISBN 978- 3-642-19156-5 e-ISBN 978-3-642-19157-2, Springer
2. Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stefan Avesand, StamatisKarnouskos, David Boyle, “From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence”, 1st Edition, Academic Press, 2014.
3. Peter Waher, “Learning Internet of Things”, PACKT publishing, BIRMINGHAM – MUMBAI
 |
| **Website and** **e-Learning Source** | <https://thingsee.com/blog/quality-hardware-list-for-your-iot-projects><https://tools.ietf.org/html/rfc7452>. <http://dret.net/lectures/iot-spring15/protocols><http://iot.intersog.com/blog/overview-of-iot-development-standards-andframeworks>. |

Course Outcomes

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

CLO1: To describe the concepts of IoT

CLO2: To describe the essentials IOT data and framework

CLO3: To discuss IOT protocols

CLO4: To design a basic IOT system

CLO5: To examine the reliability, security and privacy of an IOT system

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| --- | --- |
|  | PSOs |
|  | 1 | 2 | 3 | 4 | 5 | 6 |
| CLO1 | 3 | 3 | 1 | 2 | 2 | 3 |
| CLO2 | 3 | 3 | 1 | 2 | 2 | 3 |
| CLO3 | 3 | 3 | 1 | 2 | 2 | 3 |
| CLO4 | 3 | 3 | 3 | 2 | 2 | 3 |
| CLO5 | 3 | 3 | 1 | 2 | 2 | 3 |

**Group B**

Elective II to be chosen from Group B

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| **Title of the Course** | **WEB PROGRAMMING** |
| **Paper Number**  | **GROUP B** |
| **Category** | Elective II | **Year** | I | **Credits** | 3 | **Course Code** |  |
| **Semester** | I |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 3 | -- | 2 | 5 |
| **Pre-requisite** |  Basic programming knowledge |
| **Objectives of the Course**  | To introduce students about web application and state management |
| **Course Outline** | **UNIT-I:** **1.1 Overview of .NET Framework:**CLR-CTS- Metadata and Assemblies-.NET Framework Class Library – BCL- Windows Forms – ASP.NET and ASP.NET AJAX-ADO.NET – Tools in the .NET Framework- New Features of .NET Framework: Portable Class Libraries.**1.2 Introducing Windows Application**Introduction – Creating WindowsForms- Customizing a Form**1.3 Collecting User Input in windows Forms and Events**Buttons-Text Boxes- Check Boxes- Radio Buttons –Combo Boxes –Date and TimePicker – Calendar-List Boxes –Checked List Box –List View – Tree View |
| **UNIT-II:****2.1 Presentation and Informational Controls in Windows Forms and Events**Labeling- Link Label- Status Bar- Picture Box-Image List-Progress Bar-Tool Tip –MDI and Menus Creation**2.2 Data Types in C#**Type Conversions – Boxing and Unboxing**2.3 Namespaces**Introduction – Adding a reference to the Namespace – Accessing a predefined Namespace through the using Directive**2.4 Introducing to ADO.net**Understanding ADO.NET- Creating Connection Strings –Creating a Connection to a Database- Creating a Command Object- Working with DataAdapters –Using DataReader work with Database. |
| **UNIT-III:** **3.1 ASP.NET**Life cycle- Specifying a Location for a Web Application -Single-File Page Model - Code-Behind Page Model- Adding controls to web form.**3.2 Web Server Controls**The Control Class - The WebControl Class - The Button Control - The TextBox Control -The Label Control - The HyperLink Control -The LinkButton Control -The PlaceHolder Control -The HiddenField Control - The CheckBox Control -The RadioButton Control -The ListBox Control -The DropDownList Control -The Image Control -The ImageButton Control - The Table Control - Menus - Validation ServerControls - Master Page - Web.Config |
| **UNIT-IV :** **4.1 State Management**Understanding the session object Sessions and the Event Model, Configuring, In-Process Session State, Out-of-Process Session state Application Object, Query strings, Cookies, ViewState, Global.asax.**4.2 XML and .NET**Basics of XML, Create XML Document - Reading XML with XmlReader – Reading XML with XmlDocument - Working with XmlNode**4.3 Animations**Understanding WPF’s Animation services – The Role of the Animation class types-The To, From and by properties – The Role of the Timeline Base Class – Authoring and Animation in C# Code – Controlling the pace of an animation – Reversing and Looping an Animation – The Role of StoryBoards |
| **UNIT-V:** **5.1 LINQ**Introducing LINQ Queries- Standard Query Operators- Introducing LINQ to Dataset, SQL and XML- The LinqDataSource Control. Data Binding – Grid View, Details view, Forms view**5.2 ASP. NET AJAX**Understanding the need for AJAX, Building a simple ASP.NET page without AJAX, Building a simple ASP.NET page with AJAX |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Lab Exercises  |
| Skills acquired from this course | Website creation |
| **Recommended Text** | [1] C# 2012 Programming Covers .NET 4.5 Black Book. Dreamtech press, Kogent Learning Solutions, 2013.(Unit 1.1,Unit 2.2,Unit 2.3,Unit 2.4, Unit 3,Unit 4, Unit 5)[2] Liberty, Jesse, and Dan Hurwitz. Programming. NET Windows Applications. " O'Reilly Media, Inc.", 2004. (Unit 1.2,1.3, 2.1)[3] Troelsen, Andrew, and Philip Japikse, C# 6.0 and the .NET 4.6 Framework. Apress, 2015. (Unit 4.3) |
| **Reference Books** | [1] Albahan Joseph, and Ben Albahari. C# 5.0 in a NutShell: The Definitive Reference. “Orielly Media Inc”, 2012[2] Anne Boehm . Joel. Murach’s C# 2015. United States of America: Murach's,2016.[3] Delamater. Mary. Anne Boehm. ASP.NET 4.5 Web Programming with C# 2012. United States of America: Murach's, 2013.[4] John Sharp. Microsoft Visual C# Step by Step. United States of America: Pearson Edition,2018.[5] Price, Jason, and Mike Gunderlov. Mastering Visual C#.Net. John Wiley & Sons, 2006 |
| **Website and** **e-Learning Source** | http://www.w3schools.com/aspnet/aspnet.asphttp://csharp.net-tutorials.com/xml/introduction/http://ajax.net-tutorials.com/basics/introduction/http://www.c-sharpcorner.com/ |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

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| **CO’s** | **Course Outcomes**  |
| **CLO1** | Comprehend.NET Framework and Windows Application |
| **CLO2** | Know about presentation controls and namespaces |
| **CLO3** | Connect with backend using ADO.NET |
| **CLO4** | Get the knowledge about web application and state management |
| **CLO5** | Gain knowledge on connecting XML, LINQ and AJAX |

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| **CO/PSO** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** |
| **CLO1** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO2** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO3** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO4** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO5** | 3 | 3 | 3 | 2 | 1 | 1 |
| **Weightage of course contribute to each PSO** |  |  |  |  |  |  |

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| **Title of the Course** | **JAVA PROGRAMMING** |
| **Paper Number**  | **GROUP B** |
| **Category** | Elective -II | **Year** | I | **Credits** | 3 | **Course Code** |  |
| **Semester** | II |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 3 | -- | 2 | 5 |
| **Pre-requisite** |  Basic programming knowledge |
| **Objectives of the Course**  | To enable the students to understand and appreciate the need for Object Oriented Programming |
| **Course Outline** | **UNIT-I:** **1.1 Introduction to Java**Overview – Features - Fundamental OOPS concepts – JDK – JRE – JVM -Structure of a Java program - Data types – Variables – Arrays – Operators –Keywords - Naming Conventions - Control statements, Type conversion and Casting - Scanner - String - equals(), equalsIgnoreCase(), length() |
| **UNIT-II:****2.1 Classes and Objects**Class – Objects – Methods - Method Overloading - Constructors – Constructor Overloading - this keyword - usage of static with data and methods – Garbage Collection - Access Control**2.2 Inheritance**Concept – extends keyword - Single and Multilevel Inheritance – Composition – super keyword - Method Overriding - Abstract Classes - Dynamic Method Dispatch – Usage of final with data, methods and classes**2.3 Packages and Interfaces**Concepts - package and import keywords - Defining, Creating and Accessing a Package – Interfaces - Multiple Inheritance in Java, Extending and Initialising fields in Interfaces |
| **UNIT-III:** **3.1 Exception Handling**Exception handling- Types of Exceptions- try, catch, throw, throws and finally keywords - User defined Exceptions**3.2 JDBC**Database Connectivity- Types of JDBC drivers- Executing statements- Prepared statements- Callable statements - Mapping SQL types to Java- ResultSetMetadata |
| **UNIT-IV :** **4.1 Multithreading**Introduction - Life Cycle of a Thread, Thread class and Runnable Interface, Thread Priorities, Synchronisation**4.2 GUI Programming with JavaFX**JavaFX Basic Concepts – Packages - Stage and Scene Classes - Nodes and Scene Graphs – Layouts - The Application Class and the Lifecycle Methods - Launching a JavaFX Application - JavaFX Application Skeleton - Compiling and Running -Application Thread**4.3 JavaFX Controls**Label – Button – Image – RadioButton – CheckBox – ListView- ComboBox- TextField – ScrollPane |
| **UNIT-V:** **5.1 Event**Event Handling – Input Event, Action Event and Window Event**5.2 Java Library**Java.util – List, ArrayList |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Lab Exercises  |
| Skills acquired from this course | Object oriented Programming knowledge |
| **Recommended Text** | Schildt, Herbert. Java: The Complete Reference. McGraw-Hill Education Group, 2014 |
| **Reference Books** | Eckel, Bruce. Thinking in Java. 4th ed. Pearson Education, 2006.Liang, Y. Daniel. Intro to Java Programming, Brief Version. Pearson Higher Ed, 2015.Holmes, J. Barry, Joyce, T. Daniel. Object-oriented Programming with Java. Jones &Bartlett Learning. 2001 |
| **Website and** **e-Learning Source** | http://docs.oracle.com/javase/tutorial/java/index.html/http://www.java2s.com/Tutorial/Java/CatalogJava.htm/https://www.edureka.co/blog/object-oriented-programming/ |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

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| **CO’s** | **Course Outcomes**  |
| **CLO1** | Understand the concepts of object‐oriented programming |
| **CLO2** | Use Java programming language at a basic level and construct simple software applications |
| **CLO3** | Understand classes, objects and implementing inheritance |
| **CLO4** | Analyze and understand the functionality of Inheritance, Interface and develop simple applications |
| **CLO5** | To develop software applications and services using Java code |

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| **CO/PSO** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** |
| **CLO1** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO2** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO3** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO4** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO5** | 3 | 3 | 3 | 2 | 1 | 1 |
| **Weightage of course contribute to each PSO** |  |  |  |  |  |  |

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| **Title of the Course** | **Operating Systems** |
| **Paper Number**  | **GROUP B** |
| **Category** | Elective | **Year** | I | **Credits** | 3 | **Course Code** |  |
| **Semester** | II |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 3 | -- | 2 | 5 |
| **Pre-requisite** |  Basic programming knowledge |
| **Objectives of the Course**  | To introduce students about web application and state management |
| **Course Outline** | **UNIT-I:** **1.1 Introduction to Operating System**Introduction to OS - Structure, Operations, Protection and Security, Kernel Data Structures, Computing Environments, Services, System Calls and its types, System Programs, OS Design and Implementation OS Debugging Operating, System Generation, System Boot**1.2 UNIX Operating System**History of UNIX, Shell, UNIX File System Structure**1.3 Basic UNIX Commands**Commands for files and directories cd, cp, mv, rm, mkdir, more, less, creating and viewing files, using cat, date, who, pwd - filter commands –head tail, cut, paste, grep – regular expression - sort |
| **UNIT-II:****2.1 Process Management**Process - Concept, Process Control Block, Process operations, Scheduling Algorithms - Short term and long term process scheduling policies – Scheduling Criteria - Multiple Processor Scheduling**2.2 CPU Scheduling**Scheduling Criteria – Scheduling Algorithms : FCFS, SJF, Priority and Round Robin Scheduling**2.3 Process Synchronization and Deadlocks**The Critical-section Problem – Petersons solution – Mutex locks - Semaphores – Monitors, Deadlock Prevention and Avoidance, Deadlock Detection and Deadlock Recovery**2.4 Process Utilities** sh process, Parents and children, Process status, Systemprocess, Mechanism of process creation, Internal and external commands, running jobs in background, KILL, NICE, Job control, at and batch, cron - Case Study on Processes in LINUX |
| **UNIT-III:** **3.1 File Organisation**File organisation and Access methods - Logical and Physical File structure – File Allocation methods, -Linked and Index Allocation - File Protection and Security - Directory structure - Single level, Two level, Tree structure - Free Space Management - Allocation Methods - Efficiency and Performance – Recovery – FAT32 and NTFS**3.2 File System**File Access Permission – chmod, chown, chgrp - File Comparisons - View Files – Listing files with attributes – Wildcards - Translating Characters - Links and its types - The File System – Partitions, File Systems, Kernel Accesses – Mounting – umask, ulimit - I/O redirection – Pipes - Case Study on LINUX File System |
| **UNIT-IV :** **4.1 Memory Management**Memory Management Techniques, Single Partition Allocation, Multiple Partition Allocation – Swapping - Paging and Segmentation - Segmented-Paged Memory Management Techniques - Logical and Physical Address space – Address Mapping - Demand paging - Virtual memory, protection and address mapping hardware, Page fault, Page replacement and Page removal algorithms**4.2 Device Management**Classification of device according to speed, Disk structure - Disk scheduling – FCFS scheduling, SSTF scheduling - Access method and storage capacity**4.3 Disk Utilities**Disk usage, disk free, dd, Backups- cpio, tar, System calls for file management, directory management - Case Study on Memory Management in LINUX |
| **UNIT-V:** **5.1 Security**The Security Enviroment – Operating System Security – Controlling Access to resources – Formal models of Secure systems - Basics of cryptography – Authentication – Exploiting Software – Insider Attacks – Malware - Defenses**5.2 Virtualization and the Cloud**History – Requirements for virtualization – Type 1 and Type 2 Hypervisors – Techniques for efficient virtualization – Memory virtualization – I/O Virtualization –Virtual Appliances – Virtual machines on multicore CPUs – Clouds: Clouds as service – Virtual machine migration – checkpointing - Case Study on Security in LINUX |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Linux based Commands  |
| Skills acquired from this course | Knowledge and working of different operating system |
| **Recommended Text** | Silberschatz, Abraham, Peter Baer Galvin and Greg Gagne. Operating System Concepts. 10th ed. Addison Wesley. (Units 1 to 4 - Chapters 1-4, 6-13)Sumitabha Das. UNIX – Concepts & Applications. 3rd ed. New Delhi: TataMcGraw Hill, 2000. (Chapters 4-13,15,16)Tanenbaum S., Andrew, Herbert Bos. Modern Operating Systems. 4th ed. Pearson (Unit 5 - Chapter 7, 9, Case Studies – Chapter 10)Yukun Liu,Yong Yue,Liwei Guo UNIX Operating System The Development Tutorial via UNIX Kernel Services. Beijing: Higher Education Press (Chapters 1,2, 6-10) |
| **Reference Books** | Kanetkar Yashwant. UNIX Shell Programming. BPB.Rosen Kenneth, Douglas Host, Rachel Klee and Richard Rosinski.UNIX: The Complete Reference. 2nd ed. McGraw Hill/Osborne, 2007.Sobell M. G. A Practical Guide to Linux Commands, Editors, and Shell Programming. USA: Pearson Education |
| **Website and** **e-Learning Source** | www.tutorialspoint.com/unixwww.unixtutorial.org/[www.guru99.com/unix-linux-tutorial.html](http://www.guru99.com/unix-linux-tutorial.html) |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

|  |  |
| --- | --- |
| **CO’s** | **Course Outcomes**  |
| **CLO1** | Describe the basic components of an operating system and its services |
| **CLO2** | Define the concepts of processes, threads, asynchronous signals and competitive system resource allocation |
| **CLO3** | Outline standard scheduling algorithms for multi-tasking |
| **CLO4** | Describe secondary storage management |
| **CLO5** | Describe memory management and File management concepts |

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| **CO/PSO** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** |
| **CLO1** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO2** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO3** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO4** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO5** | 3 | 3 | 3 | 2 | 1 | 1 |
| **Weightage of course contribute to each PSO** |  |  |  |  |  |  |

**Group C**

Elective III to be chosen from Group C

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| --- | --- |
| **Title of the Course** | **Information Security and Ethics** |
| **Paper Number**  | **Group C** |
| **Category** | Core | **Year** | I | **Credits** | 3 | **Course Code** |  |
| **Semester** | II |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | -- | 5 |
| **Pre-requisite** | Knowledge of Computer Basics |
| **Objectives of the Course** | To introduce and familiarize the students to security issues in computing, core concepts and vocabulary of computer security |
| **Course Outline** | **UNIT-I :****1.1 Security Problem in Computing**Meaning of "Secure" – Attacks - Meaning of Computer and information Security - Computer Criminals - Methods of Defense**1.2 Cryptography**Terminology and Background - Principles of Cryptography - Cryptography tools - Substitution Ciphers - Transpositions (Permutations) – Making "Good" Encryption Algorithms - The Data Encryption Standard (DES) – The AES Encryption Algorithm - Public Key Encryption - The Uses of Encryption - Digital Signatures and Certificates - Hybrid Cryptography Systems - Steganography - Protocols for secure communication |
|  | **UNIT-II :** **2.1 Program Security**Secure Programs - Nonmalicious Program Errors - Viruses and Other Malicious Code - Targeted Malicious Code - Controls against Program Threats**2.2 Security Issues in Social Networking**Acceptable Use Policies - Reasons for social media being hazardous to the corporate network - Balancing Security and Social Networking in business - Precautions that can be taken to secure the private information |
| **UNIT-III :****3.1 Database and Data Mining Security**Introduction to Databases - Security Requirements - Reliability and Integrity – Sensitive Data - Inference - Multilevel Databases - Proposals for Multilevel Security – Data Mining**3.2 Security in Networks**Network Concepts - Threats in Networks - Network Security Controls - Firewalls – Intrusion Detection Systems - Secure E-Mail |
| **UNIT-IV :****4.1 Administering Security**Security Planning - Risk Analysis - Organisational Security Policies - Physical Security**4.2 The Economics of Cyber security**Making a Business Case - Quantifying Security - Modeling Cyber security |
| **UNIT-V:****5.1 Privacy in Computing**Privacy Concepts - Privacy Principles and Policies - Authentication and Privacy – Data Mining - Privacy on The Web - E-Mail Security - Impacts on Emerging Technologies**5.2 Legal and Ethical Issues in Computer Security**Protecting Programs and Data - Information and the Law - Rights of Employees and Employers - Redress for Software Failures - Computer Crime - Ethical Issues in Computer Security - Case Studies of Ethics |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Demonstration on computer security Case Studies(To be discussed during the Tutorial hour) |
| Skills acquired from this course | Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text** | Pfleeger ,Charles P and Shari Lawrence Pfleeger. Security in Computing, Released January 2015, Pearson, ISBN: 9780134085074 |
| **Reference Books** | Bahadur ,Gary. Securing the Clicks Network Security in the Age of Social Media. 1st ed. McGraw-Hill, 2012.Daswani, Neil, Christoph Kern and Anita Kesavan. Foundations of Security: What Every Programming Needs to Know. Apress, 2007 |
| **Website and** **e-Learning Source** |  http://www.trendmicro.fr/media/wp/securityguide-social-networks-whitepaper-en.pdfhttp://paper.ijcsns.org/07\_book/201306/20130619.pdf |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

|  |  |
| --- | --- |
| **CO’s** | **Course Outcomes**  |
| **CLO1** | Understand all aspects of computer security, including users, software, devices, operating systems, networks, law, and ethics |
| **CLO2** | Apply cryptography an essential tool that is critical to computer security |
| **CLO3** | Analyse the different aspects of computer security and privacy  |
| **CLO4** | Evaluate the aspects of computer security  |
| **CLO5** | Develop a system that uses user authentication, prevents malicious code execution, encrypts the data, protects privacy, implements firewall, detects intrusion, and more. |

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| **CO/PSO** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** |
| **CLO1** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO2** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO3** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO4** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO5** | 3 | 3 | 3 | 2 | 1 | 1 |
| **Weightage of course contribute to eachPSO** |  |  |  |  |  |  |

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| --- | --- |
| **Title of the Course** | **Distributed Systems** |
| **Paper Number**  | **Elective 3** |
| **Category** | Core | **Year** | I | **Credits** | 3 | **Course Code** |  |
| **Semester** | II |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | -- | 5 |
| **Pre-requisite** | Fundamentals of Operating Systems concepts and Networking |
| **Objectives of the Course** | To learn the principles, architectures, Processes, Communication, Co-ordination, consistency and Replication in Distributed Systems |
| **Course Outline** | **UNIT-I :Introduction -** Introduction to Distributed Systems - Design Goals - Types of Distributed Systems**Chapter 1** |
| **UNIT-II : Architectures -** Architectural Styles - Middleware Organization - System Architecture - Example Architectures**Chapter 2** |
| **UNIT-III :Processes :** Threads - Virtualisation - Clients - Servers - Code Migration**Chapter 3** |
| **UNIT-IV : Communications :** Foundations - Remote Procedure Call -Basic RPC operation, Parameter Passing, RPC based Application Support - Message Oriented Communication - Simple transient Messaging with Sockets, Advanced Transient Messaging, Message Oriented Persistent Communication — Multicast Communication**Chapter 4****Naming:** Names, Identifiers and Addresses - Flat naming - Structured naming - Attribute-based naming**Chapter 5** |
| **UNIT-V: Co-ordination:** Clock Synchronisation - Logical Clocks - Mutual Exclusion - Election Algorithms - Distributed Event Management **Chapter 6 - 6.1,6.2,6.3,6.4,6.6****Consistency and Replication:** Introduction - Data-centric Consistency Models - Client- Centric Consistency Models - Replica Management**Chapter 7-7.1 to 7.4****Fault Tolerance: Introduction****Chapter 8-8.1** |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Applications of Distributed Systems(To be discussed during the Tutorial hour) |
| Skills acquired from this course | Knowledge of Distributed Systems Concepts and its Architecture |
| **Recommended Text** | 1. Andrew S. Tannenbaum and Maarten Van Steen, “Distributed Systems: Principles and Paradigms”, Third Edition, Pearson, 2017. |
| **Reference Books** | 1. George Coulouris, Jean Dollimore, Tim Kindberg, and Gordon Blair, “Distributed Systems: Concepts and Design”, Fifth Edition, Addison Wesley, 2011.
2. James E. Smith, and Ravi Nair, “Virtual Machines: Versatile Platforms for Systems and Processes”, First Edition, Morgan Kaufmann, 2005.
 |
| **Website and** **e-Learning Source** | 1. <https://www.tutorialspoint.com/Distributed-Systems>
2. <https://link.springer.com/article/10.1007/s00607-016-0508-7>
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Course Outcomes

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

CLO1: To explain the significance of Distributed Systems

CLO2: To explain the architecture of Distributed Systems

CLO3: To relate the different types of Processes’s role in Distributed Systems

CLO4: To describe the rules the communicating processes must adhere to

CLO5: To examine the issues in Distributed Systems

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|  | PSOs |
|  | 1 | 2 | 3 | 4 | 5 | 6 |
| CLO1 | 3 | 3 | 2 | 2 | 1 | 1 |
| CLO2 | 3 | 3 | 2 | 2 | 1 | 1 |
| CLO3 | 3 | 3 | 2 | 2 | 1 | 1 |
| CLO4 | 3 | 3 | 2 | 2 | 1 | 1 |
| CLO5 | 3 | 3 | 2 | 2 | 2 | 3 |

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| **Title of the Course** | **Software Engineering for Data Science** |
| **Paper Number**  | **Elective III** |
| **Category** | Core | **Year** | I | **Credits** | 3 | **Course Code** |  |
| **Semester** | II |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | -- | 5 |
| **Pre-requisite** | Basic Knowledge in Programming |
| **Objectives of the Course** | To understand the software engineering principles and ensure software quality |
| **Course Outline** | **UNIT-I :****Software and Software Engineering:** The nature of software - Software Engineering - The Software Process - Software Engineering Practice - Software Myths**Chapter 1****Process Models :** A Generic Process Model - Process Assessment and Improvement - Prescriptive Process Models - Product and Process**Chapter 2****Agile Development :** Introduction - Agility and Cost of Change - Agile Process - Scrum - Other Agile Frameworks**Chapter 3** |
| **UNIT-II : Recommended Process Model** : Requirements Definition - Preliminary Architectural Design - Resource Estimation - First Prototype Construction - Prototype Evaluation - Prototype Evolution - Prototype Release - Maintain Release Software**Chapter 4****Human Aspects of Software Engineering:** Characteristics of a Software Engineer - The Psychology of Software Engineer - The Software Team - Team Structures - The impact of Social Media - Global Teams**Chapter 5****Principles that guide practice** : Core Principles - Principles that guide each Framework Activity - Communication Principles - Planning Principles - Modeling Principles - Construction Principles - Deployment Principles **Chapter 6** |
| **UNIT-III :** **Understanding Requirements:** Requirements Engineering - Establishing the groundwork - Requirements Gathering - Developing Use Cases -Building the Analysis Model - Negotiating Requirements - Requirements Monitoring - Validating Requirements**Chapter 7****Requirements Modeling - A Recommended Approach:** Requirements Analysis - Scenario-Based Modeling - Class-Based Modeling - Functional Modeling - Behavioural Modeling**Chapter 8** |
| **UNIT-IV : Design Concepts:** Design within the context of Software Engineering - The Design Process - Design Concepts - The Design Model**Chapter 9****Quality and Security** : Introduction - Software Quality - The Software Quality Dilemma - Achieving Software Quality**Chapter 15****Software Quality Assurance:** Background Issues - Elements of Software Quality Assurance - SQA Process and Product Characteristics - SQA Tasks, Goals and Metrics - Formal Approaches - Statistical SQA - Software Reliability - ISO 9000 Quality standards - SQA Plan**Chapter 17** |
| **UNIT-V: Software Testing -Component Level:** A Strategic Approach to Software Testing - Planning and RecordKeeping - Test-Case Design - White-box Testing - Black-Box Testing - Object-oriented Testing **Chapter 19****Software Testing - Integration Level:**  Software Testing Fundamentals - Integration Testing - Artificial Intelligence and Regression Testing - Integration Testing in the OO context - Validation Testing - Testing Patterns**Chapter 20****Data Science for Software Engineers****Appendix 2** |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) |  Case Studies(To be discussed during the Tutorial hour) |
| Skills acquired from this course | Software Engineering approaches for tradition software and Data Science |
| **Recommended Text** | 1. Pressman, Roger S., and Bruce R. Maxim. Software Engineering: A Practitioner’s Approach, Ninth Edition, 2020. |
| **Reference Books** | 1. Martin, Robert C. Agile software development: principles, patterns, and practices. Prentice Hall, 2002.
2. Schach, Stephen R. Object-oriented software engineering. McGraw-Hill, 2008.
3. Sommerville, Ian. "Software engineering 9th Edition." ISBN-10 137035152 (2011).
 |
| **Website and** **e-Learning Source** | <https://www.d.umn.edu/~gshute/softeng/principles.html> |

**Course Outcomes**

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

CLO1: To describe the Software Engineering Principles

CLO2: To apply Software Life Cycle Models for Software Development

CLO3: To use Requirements Engineering skills and gather Requirements

CLO4: To develop a quality Software

CLO5: To apply appropriate testing methodologies

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|  | PSOs |
|  | 1 | 2 | 3 | 4 | 5 | 6 |
| CLO1 | 3 | 3 | 1 | 2 | 2 | 1 |
| CLO2 | 3 | 3 | 1 | 2 | 2 | 3 |
| CLO3 | 3 | 3 | 1 | 2 | 2 | 2 |
| CLO4 | 3 | 3 | 3 | 2 | 2 | 2 |
| CLO5 | 3 | 3 | 1 | 2 | 2 | 2 |

 **Group D**

Elective IV to be Chosen from Group D

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| **Title of the Course** |  **Applied Probability** |
| **Paper Number**  | **Group D** |
| **Category** | Elective-IV | **Year** | I | **Credits** | 3 | **Course Code** |  |
| **Semester** | II |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | -- | 5 |
| **Pre-requisite** |  Basic Probability |
| **Objectives of the Course** | To develop knowledge and understand fundamental concepts and applications of probability  |
| **Course Outline** | **UNIT-I:****1.1 Basic Notions of Probability Theory** Introduction-Probability and Expectation-Sample Spaces and Events-Random Experiments, Sample Spaces, Events, Counting Techniques-Interpretations and Axioms of Probability-Addition Rules-Conditional Probability-Multiplication and Total Probability Rules-Independence-Bayes’ Theorem-Random Variables-Distributions, Densities, and Moments-Convolution-Random Vectors-Multivariate Normal Random Vectors **1.2 Calculation of Expectations** Introduction-Indicator Random Variables and Symmetry-Conditioning-Moment Transforms-Tail Probability Methods-Moments of Reciprocals and Ratios-Reduction of Degree-Spherical Surface Measure |
| **UNIT-II:****Convexity and Combinatorics** Introduction-Convex Functions-Minimization of Convex Functions-The MM Algorithm-Moment Inequalities-Combinatorics-Introduction-Bijections-Inclusion-Exclusion -Applications to Order Statistics-Catalan Numbers-Pigeonhole Principle-Combinatorial Optimization-Introduction-Quick Sort-Data Compression and Huffman Coding-Graph Coloring |
| **UNIT-III:** **3.1 Discrete Random Variables**Probability Distributions and Probability Mass Functions-Cumulative Distribution Functions-Mean and Variance of a Discrete Random Variable-Discrete Uniform Distribution-Binomial Distribution-Geometric and Negative Binomial Distributions-Hypergeometric Distribution-Poisson Distribution**3.2 Continuous Random Variables**Probability Distributions and Probability Density Functions-Cumulative Distribution Functions-Mean and Variance of a Continuous Random Variable-Continuous Uniform Distribution-Normal Distribution - Normal Approximation to the Binomial and Poisson Distributions-Exponential Distribution-Erlang and Gamma Distributions-Weibull Distribution-Lognormal Distribution-Beta Distribution |
| **UNIT-IV:** **4.1 Two or More Random Variables** Joint Probability Distributions-Marginal Probability Distributions-Conditional Probability Distributions-Independence-More Than Two Random Variables-Covariance and Correlation-Common Joint Distributions-Multinomial Distribution-Bivariate Normal Distribution-Linear Functions of Random Variables-General Functions of Random Variables**4.2 Sampling Distributions and Point Estimation of Parameters**Point Estimation-Sampling Distributions and the Central Limit Theorem-General Concepts of Point Estimation-Unbiased Estimators-Variance of a Point Estimator -Standard Error: Reporting a Point Estimate-Mean Squared Error of an Estimator-Methods of Point Estimation-Method of Moments-Method of Maximum Likelihood-Bayesian Estimation of Parameters |
| **UNIT-V:** **5.1 Discrete-Time Markov Chains**Introduction-Definitions and Elementary Theory-Examples-Coupling-Convergence Rates for Reversible Chains-Hitting Probabilities and Hitting Times-Markov Chain Monte Carlo-simulated annealing**5.2 Continuous-Time Markov Chains** Introduction-Finite-Time Transition Probabilities-Derivation of the Backward Equations-Equilibrium Distributions and Reversibility-Examples-Calculation of Matrix Exponentials-Kendall’s Birth-Death-Immigration Process |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Problems related to the above topics to be solved(To be discussed during the Tutorial hour) |
| Skills acquired from this course |  Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text** | [1] Lange, Kenneth. Applied probability. Vol. 224. New York: Springer, 2003.[2] Douglas C. Montgomery, George C. Runger,Applied Statistics and Probability for Engineers, Fifth Edition, John Wiley & Sons, Inc. |
| **Reference Books** | [1] Mario Lefebvre, Applied Probability and Statistics, Springer Newyork, 2006[2] Michael Mitzenmacher Eli Upfal, Probability and Computing Randomized Algorithms and Probabilistic Analysis, Cambridge University press, 2005 |
| **Website and** **e-Learning Source** | <https://open.umn.edu/opentextbooks/textbooks/256><https://www.intechopen.com/books/12021> |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

**CLO1:** Define the principal concepts about probability.

**CLO2:** Understand combinatorics and convexity

**CLO3**: Understand the nature and properties of density functions and hence determine the moments and moment generating functions of any random variable

**CLO4:** Obtain the value of the point estimators using the method of moments and method of maximum likelihood

**CLO5:** Define and formulate discrete-time and continuous-time Markov chains

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| **CO/PSO** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** |
| **CLO1** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO2** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO3** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO4** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO5** | 3 | 3 | 3 | 2 | 1 | 1 |
| **Weightage of course contribute to each PSO** |  |  |  |  |  |  |

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| **Title of the Course** |  **Optimization Techniques** |
| **Paper Number**  | **Group D** |
| **Category** | Elective-IV | **Year** | I | **Credits** | 3 | **Course Code** |  |
| **Semester** | II |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | -- | 5 |
| **Pre-requisite** |  Fundamentals of optimization and Linear algebra |
| **Objectives of the Course** | To study of model formulation and apply the mathematical results and numerical techniques of optimization theory to real world problems |
| **Course Outline** | **UNIT-I:****1.1 Modelling with Linear programming**Two variable LP model – Graphical LP solution – Applications. **1.2 Simplex method and sensitivity analysis**Simplex method- Artificial starting solution - Special cases in simplex method- Graphical sensitivity analysis. |
| **UNIT-II:****2.1 Duality and post-optimal Analysis** Definition of Dual problem - Primal-Dual Relationships-Additional Simplex algorithms- Post optimal analysis**2.2 Advanced Linear Programming**Simplex method fundamentals-Revised Simplex Method, Bounded-Variable Algorithm, Duality, Parametric programming |
| **UNIT-III:****3.1 Goal Programming**Goal programming formulation - Goal Programming algorithms **3.2 Integer Programming**Formulation and Applications-Cutting Plane Algorithm-Branch and Bound Method |
| **UNIT-IV:** **4.1 Heuristic Programming**Greedy Heuristics- Meta heuristic - Tabu Search algorithm - Constraint programming**4.2 Deterministic dynamic programming**Recursive nature of Dynamic programming computations - Forward and backward recursion- Selected DP applications - Knapsack/Fly-away kit/cargo-loading model- Investment models-Inventory models |
| **UNIT-V:** **5.1 Queuing Systems** Pure birth and Pure death models- Generalized Poisson queuing model, single server models.**5.2 Classical optimization theory**Unconstrained problems - Constrained problems |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Implement Lab Exercises in python and solve problems related to the above topics(To be discussed during the Tutorial hour) |
| Skills acquired from this course |  Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text** | [1] Hamdy A.Taha, Operations Research- An Introduction, 10th Edition, Pearson Education – 2017. |
| **Reference Books** | [1] L.R.Foulds, Optimization Techniques , Springer ,Utm , 1981[2] Garrido José M. Introduction to Computational Models with Python. CRC Press, 2016. |
| **Website and** **e-Learning Source** | <https://www.pre-scient.com/knowledge-center/optimization-problems/optimization-problems.html><https://www.shsu.edu/~eco_dgf/web_chapter_a.pdf> |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

**CLO1:** Explain the fundamental knowledge of Linear Programming

**CLO2:** Use classical optimization techniques and numerical methods of optimization.

**CLO3**: Enumerate fundamentals of Integer programming technique and apply different

techniques to solve various optimization problems

**CLO4:** Describe the basics of different Heuristic algorithms and solve dynamic

programming problems.

**CLO5:** Understand Queuing systems and understand constrained and unconstrained problems

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| **CO/PSO** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** |
| **CLO1** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO2** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO3** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO4** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO5** | 3 | 3 | 3 | 2 | 1 | 1 |
| **Weightage of course contribute to each PSO** |  |  |  |  |  |  |

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| **Title of the Course** |  **Discrete Mathematics** |
| **Paper Number**  | **Group D** |
| **Category** | Elective-IV | **Year** | I | **Credits** | 3 | **Course Code** |  |
| **Semester** | II |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | -- | 5 |
| **Pre-requisite** | Basic mathematics |
| **Objectives of the Course** | To develop knowledge and understand concepts of mathematical induction, logic, functions and relations |
| **Course Outline** | **UNIT-I:****1.1 Sets, Sequences and Functions** Sets-Some Special Sets-Set Operations-Functions-Sequences-Properties of Functions-Propositions-Conditional Propositions and Logical Equivalence-Arguments and Rules of Inference-Quantifiers-Nested Quantifiers**1.2 Elementary Logic** Informal Introduction-Propositional Calculus-Getting Started with Proofs-Methods of Proof-Logic in Proofs-Analysis of Arguments |
| **UNIT-II:****2.1 Relations** Relations-Digraphs and Graphs-Matrices-Equivalence Relations and Partitions-The Division Algorithm and Integers Mod p**2.2 Induction and Recursion** Loop Invariants-Mathematical Induction-Big-Oh Notation-Recursive Definitions-Recurrence Relations-More Induction-The Euclidean Algorithm |
| **UNIT-III:** **3.1 Counting** Basic Counting Techniques-Elementary Probability-Inclusion-Exclusion and Binomial Methods-Counting and Partitions-Permutations and Combinations, Binomial Coefficients and Identities, Equivalence Relations, Generalized Permutations and Combinations, Generating Functions, Inclusion-Exclusion, Applications of Inclusion-Exclusion-Pigeon-Hole Principle**3.2 Algorithms**Introduction-Examples of Algorithms-Analysis of Algorithms-Recursive Algorithms |
| **UNIT-IV:** **4.1 Graphs** Graphs-Paths and Cycles-Edge Traversal Problems-Hamiltonian Cycles and the Traveling Salesperson Problem-A Shortest-Path Algorithm-Representations of Graphs-Isomorphisms of Graphs-Planar Graphs **4.2 Trees**Trees-Terminology and Characterizations of Trees-Rooted Trees-Vertex Traversal Problems-Spanning Trees-Minimal Spanning Trees-Binary Trees- Tree Traversals-Decision Trees and the Minimum Time for Sorting - Isomorphism of Trees |
| **UNIT-V:** **Recursion and Digraphs**General Recursion-Depth-First Search Algorithms-Polish Notation-Weighted Trees-Digraphs-Digraphs Revisited-Weighted Digraphs and Scheduling Networks-Digraph Algorithms |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Problems related to the above topics to be solved(To be discussed during the Tutorial hour) |
| Skills acquired from this course |  Knowledge, Problem Solving, Analytical ability, Professional Competency, Professional Communication and Transferrable Skill |
| **Recommended Text** | [1] Kenneth A. Ross and Charles R. B. Wright, Discrete Mathematics, Pearson Education,Fifth Edition[2] Richard Johnsonbaugh, Discrete Mathematics, Pearson Education,Eighth Edition, 2018 |
| **Reference Books** | [1] Discrete Mathematics and its Applications (6th edition), Kenneth H. Rosen, Tata McGraw Hill, Bombay, India[2] Discrete Mathematics with Applications Susanna S. Epp, Brooks/Cole 2011[3] Discrete Mathematics an Introduction to Proofs and Combinatorics, Kevin Ferland, Houghton Mifflin Company, 2009 |
| **Website and** **e-Learning Source** | <https://www.tutorialspoint.com/discrete_mathematics/discrete_mathematics_introduction.htm><https://www.cs.odu.edu/~toida/nerzic/content/intro2discrete/intro2discrete.html>  |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

**CLO1:** To introduce Mathematical Logic to understand the equivalence of statements

**CLO2:** To acquaint the students with Inference Theory and predicate calculus to understand partial order and partition.

**CLO3**: To introduce fundamental principles of Combinatorial Counting techniques

**CLO4:** To explain generating functions and their utility in solving recurrence relations

**CLO5:** To introduce graph models and tree structures with basics and significance of traversability.

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| **CO/PSO** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** |
| **CLO1** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO2** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO3** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO4** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO5** | 3 | 3 | 3 | 2 | 1 | 1 |
| **Weightage of course contribute to each PSO** |  |  |  |  |  |  |

**Group E**

Elective V to be chosen from Group E

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| **Title of the Course** | **NATURAL LANGUAGE PROGRAMMING**  |
| **Paper Number**  | **Group E** |
| **Category** | ELECTIVE V | **Year** | II | **Credits** | 3 | **Course Code** |  |
| **Semester** | III |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | -- | 5 |
| **Pre-requisite** | Basic understanding of programming and machine learning  |
| **Objectives of the Course**  | To explore the concepts and fundamentals of Natural Language Programming  |
| **Course Outline** | **UNIT-I:** **INTRODUCTION TO NLP**Knowledge in Speech and Language Processing – Ambiguity - Models and Algorithms- Language, Thought, and Understanding - The State of the Art - History - Applications – Basic NLP**Book1 : Chapter 1, Book 2: Chapter 1** |
| **UNIT-II:** **WORD ANALYSIS** Regular Expressions - Words & Transducers- Survey of English Morphology- Finite-State Morphological Parsing - Word and Sentence Tokenization- N-grams- Counting Words in Corpora- Simple (Unsmoothed) N-grams- Training and Test Sets- Part-of-Speech Tagging- English Word Classes- Tagsets for English- Part-of-Speech Tagging- Rule-Based Part-of-Speech Tagging- Evaluation and Error Analysis**Book1 : Chapter 2, 3,4,5**  |

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|  | **UNIT-III:** **SYNTACTIC ANALYSIS** Formal Grammars of English- Constituency- Context-Free Grammars- Grammar Rules for English - Treebanks - Finite-State and Context-Free Grammars - Dependency Grammars - Parsing with Context-Free Grammars - Parsing as Search- Dynamic Programming Parsing Methods- Statistical Parsing- Probabilistic Context-Free Grammars- Probabilistic CKY Parsing of PCFGs- Learning PCFG Rule Probabilities  **Book1 : Chapter 12, 13, 14** |
| **UNIT-IV:** **SEMANTICS AND PRAGMATICS**Computational Desiderata for Representations- First-Order Logic, Computational Semantics –Syntax Driven Semantic analysis, Semantic attachments Semantic Attachments for a Fragment of English, Lexical Semantics- Word Senses, Relations between Senses, WordNet: A Database of Lexical Relations- Event Participants: Semantic Roles and Selectional Restriction**Book1: Chapter 17, 18,19** |
| **UNIT-V:** **APPLICATIONS** Applications - Information Extraction, Question Answering and Summarization, Dialogue and Conversational Agents **Book1 : Chapter 22, 23,24** |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Case study on recent developments and presentation  |
| Skills acquired from this course | Apply NLP programming to real time problems.  |
| **Recommended Text** | 1. Daniel Jurafsky, James H. Martin―Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech, Pearson Publication, 2014.2. Patel, Ankur A., and Ajay Uppili Arasanipalai. Applied Natural Language Processing in the Enterprise. " O'Reilly Media, Inc.", 2021. |
| **Reference Books** | 1. Breck Baldwin, ―Language Processing with Java and LingPipe Cookbook, Atlantic Publisher, 2015.2. Richard M Reese, ―Natural Language Processing with Java‖, O‗Reilly Media, 2015.3. Nitin Indurkhya and Fred J. Damerau, ―Handbook of Natural Language Processing, Second Edition, Chapman and Hall/CRC Press, 2010.4. Tanveer Siddiqui, U.S. Tiwary, ―Natural Language Processing and Information Retrieval‖, Oxford University Press, 2008. |
| **Website and** **e-Learning Source** | <https://www.simplilearn.com/tutorials/artificial-intelligence-tutorial/what-is-natural-language-processing-nlp><https://towardsdatascience.com/your-guide-to-natural-language-processing-nlp-48ea2511f6e1><https://www.oracle.com/in/artificial-intelligence/what-is-natural-language-processing/> |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

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| **CO’s** | **Course Outcomes**  |
| **CLO1** | Understand the fundamentals of Natural Language Processing. |
| **CLO2** | Apply the NLP techniques for word and syntactic analysis.  |
| **CLO3** | Analyze the natural language text. |
| **CLO4** | Evaluate the tools and methods for understanding semantics of sentences and pragmatics. |
| **CLO5** | Develop an innovative application using NLP components |

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| **CO/PSO** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** |
| **CLO1** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO2** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO3** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO4** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO5** | 3 | 3 | 3 | 2 | 1 | 1 |
| **Weightage of course contribute to each PSO** |  |  |  |  |  |  |

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| **Title of the Course** | **REINFORCEMENT LEARNING** |
| **Paper Number**  | **Group E** |
| **Category** | ELECTIVE V | **Year** | II | **Credits** | 3 | **Course Code** |  |
| **Semester** | III |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | -- | 5 |
| **Pre-requisite** |  Basic understanding of machine learning types |
| **Objectives of the Course**  |  To introduce the concepts and fundamentals of reinforcement learning and methods  |
| **Course Outline** | **UNIT-I: INTRODUCTION AND BASICS OF REINFORCEMENT LEARNING**The Reinforcement Learning Problem - Reinforcement Learning- Examples- Elements of Reinforcement Learning- Limitations and Scope -An extended example – History of Reinforcement Learning - Applications - Ethics in RL- Applying RL for real-world problems- Meta-learning- Multi-Agent Reinforcement Learning**Book 1- Chapter 1** |
| **UNIT-II: TABULAR METHODS**Finite Markov Decision Processes **-** Dynamic Programming - Monte Carlo Methods **Book 1- Chapter 3,4,5** |
| **UNIT-III: Q-NETWORKS AND LEARNING**Temporal difference learning – n-step Bootstrapping- Planning and learning with tabular methods, Deep Q-networks- DQN, DDQN, Dueling DQN, Prioritised Experience Replay**Book 1- Chapter 6,7,8** |
| **UNIT-IV: APPROXIMATE SOLUTION METHODS**On-policy prediction with approximation – on-policy control with approximation – policy gradient methods **Book 1- Chapter 9,10,13** |
| **UNIT-V:** **PSYCHOLOGY AND NEUROSCIENCE**Prediction and control - Classical conditioning – neuroscience – basics- reward and prediction -case studies **Book 1- Chapter 14,15,16**  |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Case study on recent developments and presentation  |
| Skills acquired from this course | Apply Reinforcement Learning core principals and tasks for real time problems. |
| **Recommended Text** | 1. Sutton, Richard S., and Andrew G. Barto. Reinforcement learning: An introduction. MIT press, 2018. |
| **Reference Books** | 1. Szepesvári, Csaba. "Algorithms for reinforcement learning." Synthesis lectures on artificial intelligence and machine learning 4.1 (2010): 1-103.2. Winder, Phil. Reinforcement learning. O'Reilly Media, 2020.3. Bilgin, Enes. Mastering Reinforcement Learning with Python: Build next-generation, self-learning models using reinforcement learning techniques and best practices. Packt Publishing Ltd, 2020. |
| **Website and** **e-Learning Source** | <https://developer.ibm.com/learningpaths/get-started-automated-ai-for-decision-making-api/what-is-automated-ai-for-decision-making/><https://towardsdatascience.com/reinforcement-learning-101-e24b50e1d292><https://www.analyticsvidhya.com/blog/2021/02/introduction-to-reinforcement-learning-for-beginners/> |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

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| **CO’s** | **Course Outcomes**  |
| **CLO1** | Understand the fundamentals of Reinforcement Learning tasks and the core principals including policies, value and functions. |
| **CLO2** | Apply the tabular and approximation methods to solve classical control problems. |
| **CLO3** | Analyse policy gradient methods to solve more complex cases. |
| **CLO4** | Evaluate the tools and methods used for prediction and control. |
| **CLO5** | Investigate the current advanced techniques and applications in Reinforcement Learning. |

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| **CO/PSO** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** |
| **CLO1** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO2** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO3** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO4** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO5** | 3 | 3 | 3 | 2 | 1 | 1 |
| **Weightage of course contribute to each PSO** |  |  |  |  |  |  |

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| **Title of the Course** | **SOCIAL NETWORK ANALYSIS** |
| **Paper Number**  | **ELECTIVE V** |
| **Category** | Core | **Year** | II | **Credits** | 3 | **Course Code** |  |
| **Semester** | III |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | -- | 5 |
| **Pre-requisite** |  Basic understanding of social networks  |
| **Objectives of the Course**  |  To introduce the concepts and fundamentals of social network components and analysis  |
| **Course Outline** | **UNIT-I: INTRODUCTION TO SEMANTIC WEB AND SOCIAL NETWORKS**Introduction to Semantic Web: Limitations of current Web - Development of Semantic Web - Emergence of the Social Web - Social Network analysis: Development of Social Network Analysis - Key concepts and measures in network analysis - Electronic sources for network analysis: Electronic discussion networks, Blogs and online communities - Web-based networks - Applications of Social Network Analysis- Brief history of Social network analysis**Book 1- Chapter 1,2,3 Book 2: Chapter 1** |
| **UNIT-II: MODELLING, AGGREGATING AND KNOWLEDGE REPRESENTATION** Knowledge Representation on the semantic web- Ontology and their role in the Semantic Web - Ontology languages for the Semantic Web- Modelling and aggregating social network data: State-of-the-art in network data representation - Ontological representation of social individuals - Ontological representation of social relationships - Aggregating and reasoning with social network data - Advanced representations **Book 1: Chapter 4,5,6**  |
| **UNIT-III: DATA COLLECTION** Boundary specification – Data collection process- Information bias and issue of reliability – Archival data – Understanding SNA data – Managing SNA data **Book2 : Chapter 2** |
| **UNIT-IV : METHODS IN SOCIAL NETWORK ANALYSIS** Descriptive methods – Graph – Density- Centrality – cliques – MDS- structural equivalence – Two mode networks – Inferential methods – QAP- ERGM**Book 2- Chapter 3, 4**  |
| **UNIT-V:** **CASE STUDIES**Case studies – Evaluation of web-based social network extraction – semantic – based social network analysis in the sciences – emergent semantics **Book 1: Chapter 7,8,9** |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Case study on recent developments and presentation  |
| Skills acquired from this course | Apply social network in real time applications |
| **Recommended Text** | 1. Peter Mika, “Social Networks and the Semantic Web”, Springer 2007.2. Yang, Song, Franziska B. Keller, and Lu Zheng. Social network analysis: Methods and examples. Sage Publications, 2016. |
| **Reference Books** | 1. Guandong Xu ,Yanchun Zhang and Lin Li, ―Web Mining and Social Networking – Techniques and applications‖, First Edition, Springer, 2011.2. Dion Goh and Schubert Foo, ―Social information Retrieval Systems: Emerging Technologies and Applications for Searching the Web Effectively‖, IGI Global Snippet, 2008. |
| **Website and** **e-Learning Source** | <https://bookdown.org/chen/snaEd/ch4.html><https://www.sciencedirect.com/topics/social-sciences/social-network-analysis><https://www.publichealth.columbia.edu/research/population-health-methods/social-network-analysis><https://www.ibm.com/docs/en/spss-modeler/18.0.0?topic=analysis-about-social-network> |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

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| **CO’s** | **Course Outcomes**  |
| **CLO1** | Understand the fundamentals of social web and elements of social network analysis. |
| **CLO2** | Apply and visualize the knowledge representation in social network. |
| **CLO3** | Analyse the various methods in social network analysis. |
| **CLO4** | Evaluate the tools and methods for analysing the social network data.  |
| **CLO5** | Investigate the recent potential applications and development of social network with real time case studies. |

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| **CO/PSO** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** |
| **CLO1** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO2** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO3** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO4** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO5** | 3 | 3 | 3 | 2 | 1 | 1 |
| **Weightage of course contribute to each PSO** |  |  |  |  |  |  |

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| **Title of the Course** | **Artificial Intelligence and Data Science** |
| **Paper Number**  | **Group F** |
| **Category** | Core | **Year** | II | **Credits** | 3 | **Course Code** |  |
| **Semester** | IV |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | -- | 5 |
| **Pre-requisite** | knowledge of Computer Science and Mathematics |
| **Objectives of the Course** | To explore the approaches and principles of Artificial Intelligence (AI) algorithms, and apply them to Data Science |
| **Course Outline** | **UNIT-I :****1.1 Artificial Intelligence**The AI Problems - The Underlying Assumptions – What is an AI Technique – TheLevel of the Model – Criteria for Success.**1.2 Problems, Problem Spaces & Search**Defining the problem as a State Space Search – Production systems – ProblemCharacteristics - Production Systems Characteristics – Issues in the Design of SearchPrograms.**1.3 Heuristic Search Techniques**Generate and Test – Hill Climbing – Best First Search – Problem Reduction -Constraint Satisfaction – Means ends Analysis. |
|  | **UNIT-II :** **2.1 Knowledge Representation Issues**Representations and Mappings – Approaches to KR – Issues in KR – The FrameProblem.**2.2 Using Predicate Logic**Representing Simple Facts in Logic - Representing Instances and ISA Relationships– Computable Functions and Predicates – Resolutions – Natural Deductions.**2.3 Representing Knowledge using Rules**Procedural versus Declarative Knowledge – Logic Programming – Forward VersusBackward Reasoning – Matching – Control Knowledge.**2.4 Statistical Reasoning**Probability and Bayes Theorem - Certainty Factors and Rule based Systems –Bayesian Networks – Dempsters Shafer Theory - Fuzzy Logic. |
| **UNIT-III :****3.1 Learning**What is Learning - Rote Learning – Learning by Taking Advice – Learning by Problem Solving – Learning from Examples: Induction – Explanation based Learning – Discovery – Analogy – Formal Learning Theory – Neural Net Learning and Genetic Learning**3.2 Parallel and Distributed AI**Psychological Modelling – Parallelism in Reasoning Systems – Distributed Reasoning Systems |
| **UNIT-IV :****4.1 Deep Learning Frameworks and AI Methodologies**Working – Framework – programming Languages – applications – optimization – fuzzy inference systems – artificial creativity – additional AI methodologies – glimpse into the future**4.2 Building DL network using MXNet, TensorFlow and Keras**Core components – MXNet, TensorFlow and Keras in action – Summary and Visualization  |
| **UNIT-V:** **5.1 Building and optimizer based on PSO and GA**Algorithm - implementation - variants - PSO and GA in action - Framework and tips**5.2 Building an Advanced DL system**CNN - RNN**5.3 Alternative AI frameworks in DS**ELMs - CapsNets - Fuzzy logic and Fuzzy inference systems |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Demonstration, Case studies, Real time projects |
| Skills acquired from this course | AI methodologies & Techniques for data science related problems |
| **Recommended Text** | Kevin Night, Elaine Rich, Nair B., “Artificial Intelligence (SIE)”, McGraw Hill2008. (Unit- 1, 2, 3) |
| **Reference Books** | Russell, Stuart J., and Peter Norvig. Artificial intelligence: a modern approach. Malaysia; Pearson Education Limited, 2016.Prolog Programming for Artificial Intelligence (International Computer Science Series), Addison-Wesley Educational Publishers Inc; 4th edition, 2011 By Ivan Bratko |
| **Website and** **e-Learning Source** | <http://www.aispace.org/index.html><https://www.britannica.com/technology/artificial-intelligence><https://www.sas.com/en_in/insights/analytics/what-is-artificial-intelligence.html> |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

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| **CO’s** | **Course Outcomes**  |
| **CLO1** | Understand and identify problems that are amenable to solution by AI methods |
| **CLO2** | Analyse and apply appropriate AI methods to solve a given problem. |
| **CLO3** | Analyse and formalize a given problem in the language/framework of different AI and learning methods |
| **CLO4** | Evaluate the AI methodologies and DL networks |
| **CLO5** | Develop AI framework to tackle projects in our increasingly complex world |

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| **CO/PSO** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** |
| **CLO1** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO2** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO3** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO4** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO5** | 3 | 3 | 3 | 2 | 1 | 1 |
| **Weightage of course contribute to eachPSO** |  |  |  |  |  |  |

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| **Title of the Course** | **Image Recognition** |
| **Paper Number**  | **Group F** |
| **Category** | Core | **Year** | II | **Credits** | 3 | **Course Code** |  |
| **Semester** | IV |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | 0 | 5 |
| **Pre-requisite** | Knowledge on Mathematics and Programming Language like python |
| **Objectives of the Course** | To understand the fundamentals of real time images, image transformations, detect edges and recognize objects in the image |
| **Course Outline** | **UNIT-I :****1.1 Introduction**The Human Vision System - Practical Applications of Computer Vision - The Future of Computer Vision**1.2 Images**The Simple Pinhole Camera Model - Images - Sampling- Quantization- Color Images- Noise – Smoothing |
|  | **UNIT-II :** **2.1 Histograms**1D Histograms - Histogram/Image Equalization- Histogram Comparison-k-means Clustering**2.2 Binary Vision**Thresholding- Threshold Detection Methods- Mathematical Morphology |
| **UNIT-III :****3.1 Geometric Transformations**Affine Transformations - Perspective Transformations – Interpolation**3.2 Edges**Edge Detection - Contour Segmentation - Hough Transform |
| **UNIT-IV :****4.1 Features**Moravec Corner Detection - Harris Corner Detection - FAST Corner Detection- SIFT - Recognition |
| **UNIT-V:** **5.1 Recognition**Template Matching - Chamfer Matching - Statistical Pattern Recognition - Cascade ofHaar Classifiers - Other Recognition Techniques - Performance**5.2 Vision Problems**Abandoned and Removed Object Detection - Traffic Lights - Real Time Face Tracking - Road Sign Recognition - License Plates |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Demonstration, Case studies, Real time project analysis |
| Skills acquired from this course | Real time research projects related to Image recognition |
| **Recommended Text** | Kenneth Dawson. A Practical Introduction to Computer Vision with OpenCV. John Wiley & Sons Ltd, 2014. |
| **Reference Books** | David A. Forsyth, Jean Ponce. Computer Vision: A Modern  Approach. Pearson Edition,2015.Jan Erik Solem. Programming Computer Vision with Python: Tools  and Algorithms for Analyzing Images. O'Reilly Media, 2012.Richard Szeliski. Computer Vision: Algorithms and Applications.  Springer Publications, 2011.Simon J. D. Prince. Computer Vision: Models, Learning, and  Inference. Cambridge University Press,2012. |
| **Website and** **e-Learning Source** | https://www.cs.toronto.edu/~urtasun/courses/CV/lecture01.pdfhttps://www.cl.cam.ac.uk/teaching/0809/CompVision/CompVisNotes.pdf |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

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| **CO’s** | **Course Outcomes**  |
| **CLO1** | Understand fundamentals of images, Computer Vision and Geometric transformations |
| **CLO2** | Apply Histograms in real time images and recognize features |
| **CLO3** | Analyse the edge detection techniques |
| **CLO4** | Evaluate the vision related problems in further research |
| **CLO5** | Develop real time projects related image recognition |

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| **CO/PSO** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** |
| **CLO1** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO2** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO3** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO4** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO5** | 3 | 3 | 3 | 2 | 1 | 1 |
| **Weightage of course contribute to eachPSO** |  |  |  |  |  |  |

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| **Title of the Course** | **DEEP LEARNING** |
| **Paper Number**  | **GROUP F** |
| **Category** | Core | **Year** | II | **Credits** | 3 | **Course Code** |  |
| **Semester** | IV |
| **Instructional Hours****per week** | **Lecture** | **Tutorial** | **Lab Practice**  | **Total** |
| 4 | 1 | -- | 5 |
| **Pre-requisite** | Mathematics, Machine Learning and Programming |
| **Objectives of the Course** | To provide fundamental knowledge of neural networks and deep learning |
| **Course Outline** | **UNIT-I :****Introduction to Artificial Neural Networks**Neural Networks-Application Scope of Neural Networks- Fundamental Concept of ANN: The Artificial Neural Network-Biological Neural Network-Comparison between Biological Neuron and Artificial Neuron-Evolution of Neural Network. Basic models of ANN-Learning Methods-Activation Functions-Importance Terminologies of ANN. |
|  | **UNIT-II :** **Supervised Learning Network**Shallow neural networks- Perceptron Networks-Theory-Perceptron Learning RuleArchitecture-Flowchart for training Process-Perceptron Training Algorithm for Single and Multiple Output Classes. Back Propagation Network- Theory-Architecture-Flowchart for training process -Training Algorithm-Learning Factors for Back-Propagation Network. Radial Basis Function Network RBFN: Theory, Architecture, Flowchart and Algorithm. |
| **UNIT-III :****Convolutional Neural Network**Introduction - Components of CNN Architecture - Rectified Linear Unit (ReLU) Layer - Exponential Linear Unit (ELU, or SELU) - Unique Properties of CNN -Architectures of CNN -Applications of CNN. |
| **UNIT-IV :****Recurrent Neural Network**Introduction- The Architecture of Recurrent Neural Network- The Challenges of Training Recurrent Networks- Echo-State Networks- Long Short-Term Memory (LSTM) - Applications of RNN. |
| **UNIT-V:** **Auto Encoder and Restricted Boltzmann Machine**Introduction - Features of Auto encoder Types of Autoencoder Restricted Boltzmann Machine- Boltzmann Machine - RBM Architecture -Example - Types of RBM. |
| Extended Professional Component (is a part of internal component only, Not to be included in the External Examination question paper) | Demonstration, case studies, real time projects(To be discussed during the Tutorial hour) |
| Skills acquired from this course | Knowledge and Skill for real time research problems |
| **Recommended Text** | S.N.Sivanandam, S. N. Deepa, Principles of Soft Computing,  Wiley-India, 3rd Edition, 2018.Dr. S Lovelyn Rose, Dr. L Ashok Kumar, Dr. D Karthika Renuka,  Deep Learning using Python, Wiley-India, 1st Edition, 2019. |
| **Reference Books** | Charu C. Aggarwal, Neural Networks and Deep Learning, Springer,  September 2018.Francois Chollet, Deep Learning with Python, Manning  Publications; 1st edition,2017John D. Kelleher, Deep Learning (MIT Press Essential Knowledge  series), The MIT Press, 2019. |
| **Website and** **e-Learning Source** | <https://onlinecourses.nptel.ac.in/noc22_cs22/preview><https://arxiv.org/abs/1506.06579><https://arxiv.org/abs/1605.06211><https://cs230.stanford.edu/lecture/> |

**Course Learning Outcome (for Mapping with POs and PSOs)**

Students will be able to

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| **CO’s** | **Course Outcomes**  |
| **CLO1** | Understand the major technology trends in neural networks and deep learning |
| **CLO2** | Analyse neural networks and fully connected deep neural networks |
| **CLO3** | Apply neural networks and fully connected deep neural networks |
| **CLO4** | Evaluate efficient (vectorized) neural networks and deep learning for real time application |
| **CLO5** | Build efficient (vectorized) neural networks and deep learning for real time application |

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| **CO/PSO** | **PSO1** | **PSO2** | **PSO3** | **PSO4** | **PSO5** | **PSO6** |
| **CLO1** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO2** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO3** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO4** | 3 | 3 | 3 | 2 | 1 | 1 |
| **CLO5** | 3 | 3 | 3 | 2 | 1 | 1 |
| **Weightage of course contribute to eachPSO** |  |  |  |  |  |  |

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