

# ACHARIYA

**COLLEGE OF ENGINEERING TECHNOLOGY**

*AN AUTONOMOUS INSTITUTION*

*(Approved by AICTE, New Delhi, and affiliated to Pondicherry University)*

*Accredited by NAAC & ISO 9001:2008 Certified Institution*

**Pondicherry – 605010**



**Curriculum and Syllabus**

**for**

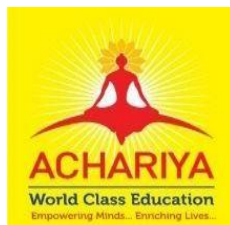
**M. Tech. (Artificial Intelligence and Data Science)**

**REGULATION - 2026**

**(Effective from Academic year 2026-27)**

**(Subject to the Approval of the First Academic Council meeting of Achariya College of Engineering Technology)**

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**DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATASCIENCE  
ACHARIYA COLLEGE OF ENGINEERING TECHNOLOGY**

## **COLLEGE VISION & MISSION**

### **VISION:**

To be a center of excellence in technical education, producing globally competent and ethically strong engineering professionals who contribute to the development of society and nation.

### **MISSION:**

1. Provide high-quality engineering education through state-of-the-art infrastructure.
2. Foster innovation, research, and entrepreneurship among students.
3. Maintain lifelong connection with alumni and industry partners.
4. Inculcate moral values and psychological well-being.

## **DEPARTMENT VISION & MISSION**

### **VISION:**

To be a globally recognized centre of excellence in Artificial Intelligence and Data Science through outstanding teaching, cutting-edge research, industry collaboration, and community service aligned with international standards.

### **MISSION:**

1. To provide cutting-edge education in Artificial Intelligence and Data Science, grounded in ethical principles and lifelong learning.
2. To foster innovation and excellence through impactful research and the application of emerging technologies.
3. To establish strong partnerships with industry, research organizations, and academic institutions to enhance learning, research, and societal impact.
4. To mentor and empower students with technical expertise, critical thinking, leadership, and professional skills to become global trailblazers.
5. To promote community engagement and responsible AI solutions that address real-world challenges and contribute to sustainable development.

## **CURRICULUM AND SYLLABUS**

The Curriculum of M.Tech. (Artificial Intelligence and Data Science) is designed to fulfil the Program Educational Objectives (PEO) and the Program Outcomes (PO) listed below.

### **PROGRAM EDUCATIONAL OBJECTIVES (PEO)**

|             |                                                                                                                                                                                                           |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>PEO1</b> | Graduates will establish successful careers in Artificial Intelligence, Data Science, research, entrepreneurship, and allied domains by applying advanced technical knowledge and problem-solving skills. |
| <b>PEO2</b> | Graduates will engage in lifelong learning, innovation, and impactful research, leveraging emerging technologies to address complex industrial, societal, and global challenges.                          |
| <b>PEO3</b> | Graduates will collaborate effectively with industry, academia, and research organizations, demonstrating technical competence, leadership, and adaptability in a rapidly evolving global environment.    |

### **PROGRAM OUTCOMES (PO)**

|            |                                                    |                                                                                                                                                                                                                        |
|------------|----------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>PO1</b> | <b>Research and Innovation</b>                     | Demonstrate the ability to independently conduct advanced research, investigate complex problems, and develop innovative AI and Data Science solutions that contribute to knowledge creation and societal advancement. |
| <b>PO2</b> | <b>Technical Communication</b>                     | Effectively communicate technical concepts, research findings, and project outcomes through high-quality reports, publications, presentations, and professional documentation.                                         |
| <b>PO3</b> | <b>Advanced Domain Expertise</b>                   | Apply advanced knowledge and specialized skills in Artificial Intelligence, Data Science, Machine Learning, and related technologies to solve complex real-world problems.                                             |
| <b>PO4</b> | <b>Knowledge Integration and Critical Thinking</b> | Acquire, analyze, evaluate, and synthesize multidisciplinary knowledge to formulate innovative and evidence-based solutions with a global perspective.                                                                 |

|             |                                                         |                                                                                                                                                                              |
|-------------|---------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>PO5</b>  | <b>Modern Tools and Emerging Technologies</b>           | Select, develop, and apply modern AI, Data Science, cloud computing, big data, and intelligent computing tools to address complex engineering and research challenges.       |
| <b>PO6</b>  | <b>Ethics and Responsible AI</b>                        | Apply ethical principles, professional integrity, and responsible AI practices while considering privacy, fairness, transparency, accountability, and societal implications. |
| <b>PO7</b>  | <b>Industry Collaboration and Professional Practice</b> | Collaborate effectively with industry, academia, and research organizations to address practical challenges and contribute to technological advancement.                     |
| <b>PO8</b>  | <b>Leadership and Teamwork</b>                          | Demonstrate leadership qualities, project management skills, and the ability to work effectively in multidisciplinary and multicultural teams.                               |
| <b>PO9</b>  | <b>Entrepreneurship and Innovation Management</b>       | Identify opportunities, develop innovative products and solutions, and apply entrepreneurial skills to create value through technology-driven ventures.                      |
| <b>PO10</b> | <b>Lifelong Learning and Adaptability</b>               | Engage in continuous learning, professional development, and self-improvement to adapt to emerging technologies and evolving industry requirements.                          |
| <b>PO11</b> | <b>Sustainability and Societal Impact</b>               | Develop AI and Data Science solutions that contribute to environmental sustainability, social well-being, and inclusive growth while addressing global challenges.           |

### **KNOWLEDGE AND ATTITUDE PROFILE (WK)**

|            |                                                   |                                                                                                                                                                                |
|------------|---------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>WK1</b> | <b>Mathematical and Computational Foundations</b> | Apply advanced knowledge of mathematics, statistics, probability, optimization techniques, and computational principles required for Artificial Intelligence and Data Science. |
| <b>WK2</b> | <b>Computing and AI Fundamentals</b>              | Demonstrate in-depth understanding of Computer Science principles, algorithms, data structures, machine learning, deep learning, and intelligent systems.                      |

|            |                                              |                                                                                                                                                                                    |
|------------|----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>WK3</b> | <b>Data Science and Analytics</b>            | Apply advanced techniques for data acquisition, processing, visualization, predictive analytics, and data-driven decision-making.                                                  |
| <b>WK4</b> | <b>Specialized and Emerging Technologies</b> | Acquire expertise in contemporary and emerging technologies such as Generative AI, Computer Vision, Natural Language Processing, Big Data Analytics, Cloud Computing, and Edge AI. |
| <b>WK5</b> | <b>Research and Innovation</b>               | Apply research methodologies, experimental design, analytical thinking, and innovation practices to solve complex engineering and societal problems.                               |
| <b>WK6</b> | <b>Modern Engineering Tools</b>              | Select and utilize appropriate software tools, programming frameworks, simulation environments, and AI platforms for developing intelligent solutions.                             |
| <b>WK7</b> | <b>Interdisciplinary Knowledge</b>           | Integrate knowledge from multiple domains to address real-world challenges in healthcare, agriculture, education, finance, manufacturing, and smart systems.                       |
| <b>WK8</b> | <b>Ethics, Sustainability and Society</b>    | Understand ethical principles, responsible AI practices, legal frameworks, sustainability concerns, and the societal impact of emerging technologies.                              |
| <b>WK9</b> | <b>Global and Industrial Perspectives</b>    | Recognize global technological trends, industry practices, standards, and professional requirements in Artificial Intelligence and Data Science.                                   |

### **PROGRAM SPECIFIC OUTCOMES (PSO)**

|             |                                       |                                                                                                                                                                                         |
|-------------|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>PSO1</b> | <b>AI and Data Science Competency</b> | Apply advanced Artificial Intelligence, Data Science, and Computer Science principles to design intelligent systems and solve complex real-world problems using data-driven approaches. |
| <b>PSO2</b> | <b>Research and Innovation</b>        | Conduct impactful research and develop innovative solutions using emerging technologies to address industrial, societal, and sustainable development challenges.                        |

## **SUSTAINABLE DEVELOPMENT GOALS**

|              |                                                 |                                                                                                                                    |
|--------------|-------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| <b>SDG01</b> | <b>No Poverty</b>                               | End poverty in all its forms everywhere (eradicate extreme poverty currently measured as people living on less than \$1.25 a day.) |
| <b>SDG02</b> | <b>Zero Hunger</b>                              | End hunger, achieve food security and improved nutrition and promote sustainable agriculture                                       |
| <b>SDG03</b> | <b>Good Health and Well-being</b>               | Ensure healthy lives and promote well-being for all at all ages                                                                    |
| <b>SDG04</b> | <b>Quality Education</b>                        | Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all                               |
| <b>SDG05</b> | <b>Gender Equality</b>                          | Achieve gender equality and empower all women and girls                                                                            |
| <b>SDG06</b> | <b>Clean Water and Sanitation</b>               | Ensure availability and sustainable management of water and sanitation for all                                                     |
| <b>SDG07</b> | <b>Affordable and Clean Energy</b>              | Ensure access to affordable, reliable, sustainable and modern energy for all                                                       |
| <b>SDG08</b> | <b>Decent Work and Economic Growth</b>          | Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all               |
| <b>SDG09</b> | <b>Industry, Innovation, and Infrastructure</b> | Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation                          |
| <b>SDG10</b> | <b>Reduced Inequalities</b>                     | Reduce inequality within and among countries                                                                                       |
| <b>SDG11</b> | <b>Sustainable Cities and Communities</b>       | Make cities inclusive, safe, resilient, and sustainable.                                                                           |
| <b>SDG12</b> | <b>Responsible Consumption and Production</b>   | Ensure sustainable consumption and production patterns.                                                                            |
| <b>SDG13</b> | <b>Climate Action</b>                           | Ensure sustainable consumption and production patterns.                                                                            |
| <b>SDG14</b> | <b>Life Below Water</b>                         | Conserve and sustainably use marine resources.                                                                                     |

|              |                                                |                                                                                         |
|--------------|------------------------------------------------|-----------------------------------------------------------------------------------------|
| <b>SDG15</b> | <b>Life on Land</b>                            | Protect ecosystems, manage forests, combat desertification, and halt biodiversity loss. |
| <b>SDG16</b> | <b>Peace, Justice, and Strong Institutions</b> | Promote peaceful societies, access to justice, and effective institutions.              |
| <b>SDG17</b> | <b>Partnerships for the Goals</b>              | Strengthen the global partnership for sustainable development.                          |

**List of Program Offered**

| SL.No.                             | Programme                                                                                                     | Programme Code |
|------------------------------------|---------------------------------------------------------------------------------------------------------------|----------------|
| <b>UNDER GRADUATE</b>              |                                                                                                               |                |
| <b>B.Tech., Programmes Offered</b> |                                                                                                               |                |
| 1                                  | B.Tech., - Artificial Intelligence and Data Science                                                           | AD             |
| 2                                  | B.Tech., - Computer Science Engineering                                                                       | CS             |
| 3                                  | B.Tech., - Electronics and Communication Engineering                                                          | EC             |
| 4                                  | B.Tech., - Electrical and Electronics Engineering                                                             | EE             |
| 5                                  | B.Tech., - Mechanical Engineering                                                                             | ME             |
| 6                                  | B.Tech., - Information Technology                                                                             | IT             |
| 7                                  | B.Tech., - Robotics and Automation                                                                            | RA             |
| 8                                  | B.Tech., - Computer Science Engineering<br>( <i>IOT including Cyber Security and Block Chain Management</i> ) | CB             |
| <b>POST GRADUATE</b>               |                                                                                                               |                |
| <b>M.Tech., Programmes Offered</b> |                                                                                                               |                |
| 1                                  | M.Tech., - Artificial Intelligence and Data Science                                                           | PAI            |
| <b>MBA</b>                         |                                                                                                               |                |
| 1                                  | MBA - General                                                                                                 | MA             |

## **STRUCTURE FOR POSTGRADUATE ENGINEERING PROGRAM**

| <b>SL. No</b> | <b>Course Category</b>         | <b>Breakdown of Credits</b> |
|---------------|--------------------------------|-----------------------------|
| 1             | Professional Core (PCC)        | 33                          |
| 2             | Professional Electives (PEL)   | 12                          |
| 3             | Open Electives (OEL)           | 3                           |
| 4             | Dissertation and Internship    | 22                          |
| 5             | NPTEL / Internship / Hackathon | 3                           |
| 6             | Career Development Skill       | 3                           |
| <b>Total</b>  |                                | <b>76</b>                   |

## **SCHEME OF CREDIT DISTRIBUTION – SUMMARY**

| <b>SL. No</b> | <b>Course Category</b>         | <b>Credits per Semester</b> |           |            |           | <b>Breakdown of Credits</b> |
|---------------|--------------------------------|-----------------------------|-----------|------------|-----------|-----------------------------|
|               |                                | <b>I</b>                    | <b>II</b> | <b>III</b> | <b>IV</b> |                             |
|               |                                | <b>I</b>                    | <b>II</b> | <b>III</b> | <b>IV</b> | -                           |
| 1.            | Professional Core (PCC)        | 16                          | 13        | 4          |           | 33                          |
| 2.            | Professional Electives (PEL)   | 3                           | 6         | 3          |           | 12                          |
| 3.            | Open Electives (OEL)           |                             |           | 3          |           | 3                           |
| 4.            | Dissertation                   |                             |           | 6          | 16        | 22                          |
| 5.            | NPTEL / Internship / Hackathon | 1                           | 1         | 1          |           | 3                           |
| 6.            | Career Development Skill       | 1                           | 1         | 1          |           | 3                           |
| <b>Total</b>  |                                | <b>21</b>                   | <b>21</b> | <b>18</b>  | <b>16</b> | <b>76</b>                   |

## SEMESTER-WISE COURSES AND CREDITS

### I SEMESTER

| Course Code  | Course Title                                                    | L         | T        | P        | C         | Hrs/Wk    | SL        | CIA | SEE | Total | Category |
|--------------|-----------------------------------------------------------------|-----------|----------|----------|-----------|-----------|-----------|-----|-----|-------|----------|
| PAI26101     | Advanced Data Structures and Algorithms                         | 3         | 0        | 0        | 3         | 3         | 1         | 40  | 60  | 100   | PCC      |
| PAI26102     | Mathematical Foundations for Data Science                       | 2         | 1        | 0        | 3         | 3         | 1         | 40  | 60  | 100   | PCC      |
| PAI26103     | Next Generative AI                                              | 3         | 0        | 0        | 3         | 3         | 1         | 40  | 60  | 100   | PCC      |
| PAI26104     | Advanced DBMS                                                   | 3         | 0        | 0        | 3         | 3         | 1         | 40  | 60  | 100   | PCC      |
| PEL2610X     | Elective -I                                                     | 3         | 0        | 0        | 3         | 3         | 1         | 40  | 60  | 100   | PEL      |
| PAIL2601     | Laboratory - I<br>(Advanced Data Structures and Algorithms Lab) | 0         | 0        | 2        | 2         | 4         | 1         | 60  | 40  | 100   | PCC      |
| PAIL2602     | Laboratory - II<br>(Next Generative AI Lab)                     | 0         | 0        | 2        | 2         | 4         | 1         | 60  | 40  | 100   | PCC      |
| PCD26101     | Audit Course-01                                                 | 0         | 0        | 0        | 0         | 2         | 1         | -   | -   | 100   | -        |
| NIH26101     | NPTEL / Internship / Hackathon                                  | 0         | 0        | 0        | 1         | -         | 1         | -   | 100 | 100   | 100      |
| CDC26101     | Career Development Skill – I                                    | 0         | 0        | 2        | 1         | 2         | 1         | -   | 100 | 100   | 100      |
| <b>TOTAL</b> |                                                                 | <b>14</b> | <b>1</b> | <b>6</b> | <b>21</b> | <b>27</b> | <b>10</b> |     |     |       |          |

### II SEMESTER

| Course Code  | Course Title                                    | L         | T        | P        | C         | Hrs/Wk    | SL        | CIA      | SEE      | Total    | Category |
|--------------|-------------------------------------------------|-----------|----------|----------|-----------|-----------|-----------|----------|----------|----------|----------|
| PAI 26201    | Machine Learning and Deep Learning              | 3         | 0        | 0        | 3         | 3         | 1         | 40       | 60       | 100      | PCC      |
| PAI 26202    | Exploratory Data Analytics                      | 3         | 1        | 0        | 3         | 3         | 1         | 40       | 60       | 100      | PCC      |
| PAI 26203    | Security for Data Science                       | 3         | 0        | 0        | 3         | 3         | 1         | 40       | 60       | 100      | PCC      |
| PEL2620X     | Elective-II                                     | 3         | 0        | 0        | 3         | 3         | 1         | 40       | 60       | 100      | PE       |
| PEL2620X     | Elective-III                                    | 3         | 0        | 0        | 3         | 3         | 1         | 40       | 60       | 100      | PE       |
| PAIL2603     | Laboratory- III<br>(ML and DL Lab)              | 0         | 0        | 2        | 2         | 4         | 1         | 60       | 40       | 100      | PCC      |
| PAIL2604     | Laboratory- IV (Exploratory Data Analytics Lab) | 0         | 0        | 2        | 2         | 4         | 1         | 60       | 40       | 100      | PCC      |
| PCD26202     | Audit Course-02                                 | 0         | 0        | 0        | 0         | 2         | 1         | -        | -        | 100      | -        |
| NIH26202     | NPTEL / Internship / Hackathon                  | 0         | 0        | 0        | 1         | -         | 1         | -        | 100      | 100      | 100      |
| CDC26201     | Career Development Skill – II                   | 0         | 0        | 2        | 1         | 2         | 1         | -        | 100      | 100      | 100      |
| <b>TOTAL</b> |                                                 | <b>15</b> | <b>0</b> | <b>6</b> | <b>21</b> | <b>27</b> | <b>10</b> | <b>-</b> | <b>-</b> | <b>-</b> |          |

### III SEMESTER

| Course Code  | Course Title                   | L        | T        | P        | C         | Hrs/Wk    | SL       | CIA      | SEE      | Total    | Category |
|--------------|--------------------------------|----------|----------|----------|-----------|-----------|----------|----------|----------|----------|----------|
| PEL2630X     | Elective-4                     | 3        | 0        | 0        | 3         | 3         | 1        | 40       | 60       | 100      | PE       |
| OEL26301     | Open Elective-1*               | 3        | 0        | 0        | 3         | 3         | 1        | 40       | 60       | 100      | OEL      |
| PAI26301     | Research Methodology           | 3        | 1        | 0        | 4         | 4         | 1        | 40       | 60       | 100      | PCC      |
| PAI26302     | Dissertation (Phase-1)         |          |          |          | 6         | 4         | 1        | 50       | 50       | 100      | PROJ     |
| NIH26303     | NPTEL / Internship / Hackathon | 0        | 0        | 0        | 1         | -         | 1        | -        | 100      | 100      | NIH      |
| CDC26301     | Career Development Skill – III | 0        | 0        | 2        | 1         | 2         | 1        | -        | 100      | 100      | CDC      |
| <b>TOTAL</b> |                                | <b>9</b> | <b>1</b> | <b>2</b> | <b>18</b> | <b>16</b> | <b>6</b> | <b>-</b> | <b>-</b> | <b>-</b> | <b>-</b> |

**\*Students will be doing summer internship during the second semester vacation.**

### IV SEMESTER

| Course Code  | Course Title                                         | L | T | P | C         | Hrs/Wk   | CIA      | SEE      | Total    | Category |
|--------------|------------------------------------------------------|---|---|---|-----------|----------|----------|----------|----------|----------|
| PAI 26 401   | Dissertation (Phase-2), Project Report and Viva voce | - | - | - | 16        | 8        | 50       | 50       | 100      | PROJ     |
| <b>TOTAL</b> |                                                      |   |   |   | <b>16</b> | <b>8</b> | <b>-</b> | <b>-</b> | <b>-</b> |          |

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## LIST OF ELECTIVES

| SL.No.              | Code        | Course Title                          |
|---------------------|-------------|---------------------------------------|
| <b>Semester I</b>   |             |                                       |
| 1                   | PEL 26 1 01 | Business Analytics                    |
| 2                   | PEL 26 1 02 | Web Analytics                         |
| 3                   | PEL 26 1 03 | Social Networking Analytics           |
| 4                   | PEL 26 1 04 | Data Visualization and Interpretation |
| 5                   | PEL 26 1 05 | Recommender Systems                   |
| 6                   | PEL 26 1 06 | Responsible AI                        |
| <b>Semester-II</b>  |             |                                       |
| 7                   | PEL 26 2 01 | Parallel and GPU Computing            |
| 8                   | PEL 26 2 02 | Cloud Computing                       |
| 9                   | PEL 26 2 03 | Multimodal Analytics                  |
| 10                  | PEL 26 2 04 | IoT and Predictive Analytics          |
| 11                  | PEL 26 2 05 | Optimization Techniques for Analytics |
| 12                  | PEL 26 2 06 | Financial and Risk Analytics          |
| 13                  | PEL 26 2 07 | Computational Intelligence            |
| 14                  | PEL 26 2 08 | Blockchain and Cryptocurrency         |
| <b>Semester-III</b> |             |                                       |
| 15                  | PEL 26 3 01 | Big Data Security                     |
| 16                  | PEL 26 3 02 | Explainable AI                        |
| 17                  | PEL 26 3 03 | Natural Language Processing           |
| 18                  | PEL 26 3 04 | Reinforcement Learning                |
| 19                  | PEL 26 3 05 | Federated Learning                    |
| 20                  | PEL 26 3 06 | Computer Vision                       |
| 21                  | PEL 26 3 07 | Time Series Data Analysis             |
| 22                  | PEL 26 3 08 | Large Language Models                 |
| 23                  | PEL 26 3 09 | Quantum Artificial Intelligence       |
| 24                  | PEL 26 3 10 | Robotics                              |
| 25                  | PEL 26 3 11 | Agentic AI                            |
| 26                  | PEL 26 3 12 | Digital Twins                         |
| 27                  | PEL 26 3 13 | MLOPS                                 |
| 28                  | PEL 26 3 14 | Generative AI                         |

**\*Open Elective Student can credit one course**

# **SEMESTER - I**

|                    |                                                        |                 |          |          |          |               |
|--------------------|--------------------------------------------------------|-----------------|----------|----------|----------|---------------|
| <b>PAI 26 1 01</b> | <b>ADVANCED DATA<br/>STRUCTURES AND<br/>ALGORITHMS</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                                                        | PCC             | 3        | 0        | 0        | 3             |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Basic knowledge of data structures and algorithm design                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <ul style="list-style-type: none"> <li>Understand advanced data structures and their applications.</li> <li>Analyze the time and space complexity of advanced algorithms.</li> <li>Study efficient algorithmic design paradigms.</li> <li>Apply advanced data structures to solve computational problems.</li> <li>Analyze graph, randomized, greedy, and dynamic programming algorithms.</li> <li>Understand complexity classes, NP-completeness, and approximation techniques.</li> </ul> |

|                       |                                                                                                                                    |    |
|-----------------------|------------------------------------------------------------------------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                                                                                    |    |
| CO1                   | Analyze the complexity of advanced algorithms using asymptotic and probabilistic analysis.                                         | K3 |
| CO2                   | Implement and analyze advanced data structures such as balanced trees, skip lists, hash tables, heaps and priority queues.         | K3 |
| CO3                   | Apply divide-and-conquer, greedy, dynamic programming and randomized techniques to solve computational problems.                   | K4 |
| CO4                   | Design and analyze algorithms for graph traversal, shortest paths, spanning trees, matching and network-related problems.          | K3 |
| CO5                   | Analyze computational complexity and identify NP-hard/NP-complete problems and appropriate approximation or randomized approaches. | K5 |

|                                                                                                                                                                                                                                                |                                       |            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|------------|
| <b>Syllabus</b>                                                                                                                                                                                                                                |                                       |            |
| <b>Unit 1</b>                                                                                                                                                                                                                                  | <b>Advanced Searching and Hashing</b> | <b>(9)</b> |
| Dictionaries and abstract data types – Binary Search Trees – Probabilistic analysis of Binary Search Trees – Balanced Search Trees – Red-Black Trees – Skip Lists – Hashing – Universal Hashing – Hash Tables – Probabilistic Data Structures. |                                       |            |
| <b>Unit 2</b>                                                                                                                                                                                                                                  | <b>Heaps and Algorithm Analysis</b>   | <b>(9)</b> |

|                                                                                                                                                                                                                                                                                                                        |                                           |            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|------------|
| Heaps and heap operations – Priority Queues – Binomial Heaps – Fibonacci Heaps – Amortized Analysis – Aggregate, Accounting and Potential Methods – Lower Bounds for Comparison-Based Algorithms – Average-Case Analysis – Recurrence Relations – Asymptotic Analysis.                                                 |                                           |            |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                          | <b>Algorithm Design Paradigms</b>         | <b>(9)</b> |
| Divide and Conquer – Merge Sort – Quick Sort – Randomized Algorithms – Randomized Quicksort – Greedy Algorithms – Activity Scheduling – Minimum Spanning Tree Algorithms – Disjoint Set and Union-Find Data Structures – Dynamic Programming – Matrix Chain Multiplication – Longest Common Subsequence – Rod Cutting. |                                           |            |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                          | <b>Graph Algorithms</b>                   | <b>(9)</b> |
| Graph Representations – Breadth First Search – Depth First Search – Topological Sorting – Spanning Trees – Minimum Spanning Trees – Shortest Path Algorithms – Dijkstra’s Algorithm – Bellman-Ford Algorithm – Bipartite Matching – Network Flow – Online Algorithms.                                                  |                                           |            |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                          | <b>Complexity and Advanced Algorithms</b> | <b>(9)</b> |
| Number-Theoretic Algorithms – Euclid’s Algorithm – Primality Testing – Complexity Classes P and NP – NP-Hard and NP-Complete Problems – Polynomial-Time Reductions – Approximation Algorithms – Vertex Cover Approximation – Max-Cut – Steiner Tree – Randomized Algorithms                                            |                                           |            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <ol style="list-style-type: none"> <li>1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein – Introduction to Algorithms, MIT Press.</li> <li>2. Jon Kleinberg and Éva Tardos – Algorithm Design.</li> <li>3. Steven S. Skiena – The Algorithm Design Manual.</li> <li>4. Mark Allen Weiss – Data Structures and Algorithm Analysis.</li> <li>5. Jeff Erickson – Algorithms / online lecture notes.</li> </ol>                         |
| <b>Reference:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <ol style="list-style-type: none"> <li>1. Jeff Erickson, Algorithms, University of Illinois Urbana-Champaign, Online Lecture Notes.</li> <li>2. Rajeev Motwani and Prabhakar Raghavan, Randomized Algorithms, Cambridge University Press, 1995.</li> <li>3. Alfred V. Aho, John E. Hopcroft and Jeffrey D. Ullman, Data Structures and Algorithms, Addison-Wesley.</li> <li>4. Adam Drozdek, Data Structures and Algorithms in C++, Cengage Learning.</li> </ol> |
| <b>Web / NPTEL Resources:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <ol style="list-style-type: none"> <li>1. Introduction to Data Structures and Algorithms: <a href="https://nptel.ac.in/courses/106104697">nptel.ac.in/courses/106104697</a></li> </ol>                                                                                                                                                                                                                                                                           |

2. Data Structures and Algorithms Design, IIT Kanpur: [nptel.ac.in/courses/106102064](https://nptel.ac.in/courses/106102064)

| CO-PO Mapping |     |     |     |     |     |     |     |     |     |      |      |      |      |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| COs \ POs     | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
| CO1           | 3   | 3   | 2   | 2   | 2   | –   | –   | –   | –   | –    | –    | 3    | 2    |
| CO2           | 3   | 3   | 3   | 2   | 3   | –   | –   | –   | 1   | –    | –    | 3    | 3    |
| CO3           | 3   | 3   | 3   | 2   | 3   | –   | 1   | –   | 1   | –    | –    | 3    | 3    |
| CO4           | 3   | 3   | 3   | 3   | 3   | –   | –   | –   | 1   | –    | –    | 3    | 3    |
| CO5           | 3   | 3   | 3   | 2   | 3   | 1   | 1   | –   | 1   | 1    | 1    | 3    | 3    |

| Assessment Methodology |                     |       |
|------------------------|---------------------|-------|
| Assessment Methodology | Assessment Tools    | Marks |
| Internal Test I        | Written Examination | 10    |
| Internal Test II       | Written Examination | 10    |
| Internal Test III      | Written Examination | 10    |
| Assessment             | Assignment          | 05    |
| Attendance             | Performance         | 05    |
| Total                  |                     | 40    |

|                    |                                                          |                 |          |          |          |               |
|--------------------|----------------------------------------------------------|-----------------|----------|----------|----------|---------------|
| <b>PAI 26 1 02</b> | <b>MATHEMATICAL<br/>FOUNDATIONS FOR DATA<br/>SCIENCE</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                                                          | PCC             | 2        | 1        | 0        | 3             |

|                                                                                                                                                                                                                                                                                                                                                                                                                                 |  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                           |  |
| Basic understanding of linear algebra, calculus, and probability                                                                                                                                                                                                                                                                                                                                                                |  |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                         |  |
| <ul style="list-style-type: none"> <li>To develop strong understanding of linear algebra concepts for data representation.</li> <li>To apply matrix decompositions and dimensionality reduction techniques.</li> <li>To formulate and solve optimization problems.</li> <li>To apply probability theory in modeling uncertainty in data.</li> <li>To perform statistical analysis for inference and decision-making.</li> </ul> |  |

|                       |                                                                                            |    |
|-----------------------|--------------------------------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                                            |    |
| CO1                   | Understand and apply linear algebra concepts.                                              | K3 |
| CO2                   | Analyze and implement matrix decompositions and dimensionality reduction techniques.       | K4 |
| CO3                   | Solve optimization problems.                                                               | K3 |
| CO4                   | Apply probability concepts in data analysis.                                               | K3 |
| CO5                   | Perform statistical analysis using sampling, hypothesis testing, and confidence intervals. | K4 |

|                                                                                                                                                                                                                                                                                                                                                            |                                 |            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|------------|
| <b>Syllabus</b>                                                                                                                                                                                                                                                                                                                                            |                                 |            |
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                                              | <b>Basics of Linear Algebra</b> | <b>(9)</b> |
| Representation of vectors - Linear dependence and independence - vector space and subspaces (definition, examples, and concepts of basis) - linear transformations - range and null space - matrices associated with linear transformations - special matrices - eigenvalues and eigenvectors with applications to data problems - Least square solutions. |                                 |            |

|                                                                                                                                                                                                                                                                                                       |                                                |            |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|------------|
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                         | <b>Matrices in Machine Learning Algorithms</b> | <b>(9)</b> |
| Projection transformation - orthogonal decomposition - singular value decomposition - principal component analysis and linear discriminant analysis. Gradient Calculus: Basic concepts of calculus: partial derivatives - gradient - directional derivatives - Jacobian-Hessian matrix.               |                                                |            |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                         | <b>Optimization</b>                            | <b>(9)</b> |
| Convex sets - convex function-properties - Unconstrained and Constrained Optimization - Numerical Optimization Techniques for Constrained/Unconstrained Optimization - Methods using Derivatives (Newton's Method - Steepest Descent Method) - Penalty Function Methods for Constrained Optimization. |                                                |            |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                         | <b>Probability</b>                             | <b>(9)</b> |
| Basic concepts of probability - conditional probability - total probability - independent events - Bayes' theorem - random variable - Moments - moment generating functions - distributions - Joint distribution - conditional distribution - covariance - correlation.                               |                                                |            |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                         | <b>Statistics</b>                              | <b>(9)</b> |
| Random sample - sampling techniques - statistics - sampling distributions - Hypothesis testing of means and proportions - variances and correlations - confidence intervals.                                                                                                                          |                                                |            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <ol style="list-style-type: none"> <li>1. Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong, Mathematics for Machine Learning, Cambridge University Press, First Edition, 2020.</li> <li>2. Sheldon Axler, Linear Algebra Done Right, Springer International Publishing, Fourth Edition, 2024.</li> <li>3. Jorge Nocedal and Stephen J. Wright, Numerical Optimization, Springer, Second Edition, 2006.</li> <li>4. Richard A. Johnson, Irwin Miller, and John E. Freund, Miller &amp; Freund's Probability and Statistics for Engineers, Pearson, Ninth Edition, 2023.</li> </ol> |
| <b>Reference:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <ol style="list-style-type: none"> <li>1. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley &amp; Sons, Tenth Edition, 2020.</li> <li>2. Chander Mohan and Kusum Deep, Optimization Techniques, New Age International Publishers, First Edition, 2009.</li> </ol>                                                                                                                                                                                                                                                                                                               |
| <b>Web / NPTEL Resources:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <ol style="list-style-type: none"> <li>1. Mathematical Foundations of Machine Learning: <a href="#">Preview: Mathematical Foundations for Machine Learning   SWAYAM</a></li> </ol>                                                                                                                                                                                                                                                                                                                                                                                                         |

2. Mathematical Foundations of Machine Learning: [https://onlinecourses.nptel.ac.in/e-learning/preview/noc26\\_cs02](https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_cs02)

| CO-PO Mapping |     |     |     |     |     |     |     |     |     |      |      |      |      |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| COs           | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
| CO1           | 3   | 2   | 2   | 2   | 3   | 2   | –   | –   | –   | 2    | 1    | 3    | 2    |
| CO2           | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO3           | 3   | 3   | 3   | 3   | 3   | 3   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO4           | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | 3    | 2    | 3    | 3    |
| CO5           | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 1   | 3    | 3    | 3    | 3    |

| Assessment Methodology |                     |       |
|------------------------|---------------------|-------|
| Assessment Methodology | Assessment Tools    | Marks |
| Internal Test I        | Written Examination | 10    |
| Internal Test II       | Written Examination | 10    |
| Internal Test III      | Written Examination | 10    |
| Assessment             | Assignment          | 05    |
| Attendance             | Performance         | 05    |
| Total                  |                     | 40    |

|                    |                           |                 |          |          |          |               |
|--------------------|---------------------------|-----------------|----------|----------|----------|---------------|
| <b>PAI 26 1 03</b> | <b>NEXT GENERATIVE AI</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                           | PCC             | 3        | 0        | 0        | 3             |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                                               |
| Basic knowledge of databases, data structures, algorithms and statistics.                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <ul style="list-style-type: none"> <li>To understand the fundamentals and scope of AI and data mining systems.</li> <li>To apply preprocessing techniques for real-world data preparation.</li> <li>To implement association rule mining and classification algorithms.</li> <li>To apply clustering techniques for pattern discovery in datasets.</li> <li>To analyze complex data types such as text, web, spatial, and temporal data.</li> </ul> |

|                       |                                                                                                                      |    |
|-----------------------|----------------------------------------------------------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                                                                      |    |
| CO1                   | Explain the evolution, foundations, architectures, and emerging paradigms of Next Generation AI.                     | K2 |
| CO2                   | Analyze and apply generative AI, foundation models, transformers, and LLM-based techniques.                          | K3 |
| CO3                   | Design multimodal and knowledge-augmented AI systems using RAG and modern representation-learning techniques.        | K3 |
| CO4                   | Develop agentic AI systems capable of reasoning, planning, tool usage, memory, and autonomous task execution.        | K3 |
| CO5                   | Evaluate AI systems based on accuracy, robustness, fairness, interpretability, safety, and computational efficiency. | K4 |

|                                                                                                                                                                                                                                                                                                                                                                                                                    |                                          |            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|------------|
| <b>Syllabus</b>                                                                                                                                                                                                                                                                                                                                                                                                    |                                          |            |
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Foundations of Next Generation AI</b> | <b>(9)</b> |
| Evolution of Artificial Intelligence – Symbolic AI – Generative AI – Limitations of Conventional AI – Emerging AI Paradigms – Foundation Models – Large Language Models –Agentic AI – AI reasoning and decision-making – Self-supervised and representation learning – Transfer Learning – Few-shot and Zero-shot Learning – AI applications in healthcare, education, finance, robotics, science and engineering. |                                          |            |

|                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                      |            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|------------|
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                            | <b>Generative AI and Foundation Models</b>           | <b>(9)</b> |
| Generative Models – Autoencoders – Variational Autoencoders – Generative Adversarial Networks – Diffusion Models – Transformer Architecture – Self-Attention and Multi-Head Attention – Encoder and Decoder Models – BERT, GPT and T5 – Large Language Models – Pre-training and Fine-tuning – Instruction Tuning – Parameter-Efficient Fine-Tuning – LoRA and PEFT – Prompt Engineering – Structured Output Generation. |                                                      |            |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                            | <b>Multimodal AI and Knowledge-Augmented AI</b>      | <b>(9)</b> |
| Multimodal Artificial Intelligence – Vision-Language Models – Vision Transformers – Multimodal Transformers – Image and Video Generation – Speech and Audio Generation – Document Intelligence – Optical Character Recognition – Retrieval-Augmented Generation – Embeddings – Vector Databases – Chunking and Retrieval Strategies – Semantic Search – Hybrid Search – RAG Evaluation and Optimization.                 |                                                      |            |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                            | <b>Agentic AI and Autonomous Intelligent Systems</b> | <b>(9)</b> |
| Introduction to AI Agents – Intelligent Agent Architecture – Tool-Augmented LLMs – ReAct Framework – Memory for AI Agents – Agentic RAG – Workflow-based Agents – Multi-Agent Systems – Agent Collaboration and Orchestration – Autonomous Research Agents – Coding Agents – Decision-Making Agents – LangChain and LangGraph – Agent Evaluation and Failure Analysis.                                                   |                                                      |            |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                            | <b>Trustworthy, Responsible and Emerging AI</b>      | <b>(9)</b> |
| AI Safety and Responsible AI – Explainable AI – Interpretability – Fairness and Bias – Privacy-Preserving AI – AI Security – Adversarial Attacks – Model Evaluation and Benchmarking – Human-AI Collaboration – AI Governance and Regulation – Edge AI – Federated Learning – Quantum AI – Embodied AI and Robotics                                                                                                      |                                                      |            |

|                                                                                                                                                                                                                                                                                                                                                             |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                                                                                                                                                                                                          |
| <ol style="list-style-type: none"> <li>1. Ian Goodfellow, Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press, 2016.</li> <li>2. Chip Huyen, AI Engineering: Building Applications with Foundation Models, O'Reilly Media, 2025.</li> <li>3. Sebastian Raschka, Build a Large Language Model (From Scratch), Manning Publications, 2024.</li> </ol> |
| <b>Reference:</b>                                                                                                                                                                                                                                                                                                                                           |
| <ol style="list-style-type: none"> <li>1. Christopher M. Bishop and Hugh Bishop, Deep Learning: Foundations and Concepts, Springer, 2024.</li> <li>2. François Chollet, Deep Learning with Python, 3rd Edition, Manning Publications, 2025.</li> </ol>                                                                                                      |

3. Jay Alamar and Maarten Grootendorst, Hands-On Large Language Models: Language Understanding and Generation, O'Reilly Media, 2024.
4. David Foster, Generative Deep Learning: Teaching Machines to Paint, Write, Compose, and Play, 2nd Edition, O'Reilly Media, 2023.
5. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 4th Edition, Pearson, 2021.

**Web / NPTEL Resources:**

1. <https://nptel.ac.in/courses/106102576>
2. [https://onlinecourses.nptel.ac.in/e-learning/preview/noc25\\_cs22](https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_cs22)

**CO-PO Mapping**

| CO  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3   | 2   | 2   | 2   | 2   | –   | –   | 1   | –   | –    | –    | 3    | 2    |
| CO2 | 3   | 3   | 3   | 2   | 3   | –   | –   | 1   | –   | –    | –    | 3    | 3    |
| CO3 | 3   | 3   | 3   | 3   | 3   | –   | –   | 1   | 1   | –    | –    | 3    | 3    |
| CO4 | 3   | 3   | 3   | 3   | 3   | 1   | –   | 1   | 2   | 1    | –    | 3    | 3    |
| CO5 | 3   | 3   | 2   | 3   | 3   | 2   | 1   | 3   | 1   | 1    | 1    | 3    | 3    |

**Assessment Methodology**

| Assessment Methodology | Assessment Tools    | Marks |
|------------------------|---------------------|-------|
| Internal Test I        | Written Examination | 10    |
| Internal Test II       | Written Examination | 10    |
| Internal Test III      | Written Examination | 10    |
| Assessment             | Assignment          | 05    |
| Attendance             | Performance         | 05    |
| Total                  |                     | 40    |

|                    |                      |                 |          |          |          |               |
|--------------------|----------------------|-----------------|----------|----------|----------|---------------|
| <i>PAI 26 1 04</i> | <i>Advanced DBMS</i> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                      | PCC             | 3        | 0        | 0        | 3             |

|                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                         |
| Database Management Systems (Basic Concepts) – Any stream can apply                                                                                                                                                                                                                                                                                                                                                           |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                       |
| <ul style="list-style-type: none"> <li>To understand advanced indexing and storage structures in databases.</li> <li>To analyze and optimize query processing techniques.</li> <li>To apply concurrency control and recovery mechanisms for data integrity.</li> <li>To evaluate transaction management and isolation levels.</li> <li>To design distributed database systems with appropriate consistency models.</li> </ul> |

|                       |                                                                            |    |
|-----------------------|----------------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                            |    |
| CO1                   | Explain advanced indexing and storage structures in databases.             | K2 |
| CO2                   | Analyze and optimize complex query processing techniques.                  | K4 |
| CO3                   | Apply concurrency control and recovery protocols to ensure data integrity. | K3 |
| CO4                   | Evaluate transaction management and isolation levels.                      | K5 |
| CO5                   | Design distributed database solutions with appropriate consistency models. | K6 |

|                                                                                                                                                                                                                 |                              |            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|------------|
| <b>Syllabus</b>                                                                                                                                                                                                 |                              |            |
| <b>Unit 1</b>                                                                                                                                                                                                   | <b>DISTRIBUTED DATABASES</b> | <b>(9)</b> |
| Distributed Systems – Introduction – Architecture; Distributed Database Concepts – Distributed Data Storage – Distributed Transactions – Commit Protocols – Concurrency Control – Distributed Query Processing. |                              |            |

|                                                                                                                                                                                                                                                                                                                                                                         |                                  |            |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|------------|
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                           | <b>NOSQL DATABASES</b>           | <b>(9)</b> |
| NoSQL – CAP Theorem – Sharding – Document based - MongoDB Operation – Using MongoDB with PHP / JAVA/ Python – Cassandra: Data Model – Key Space – Table Operations – CRUD Operations – CQL Types – HIVE: Data types – Database Operations – Partitioning – HiveQL.                                                                                                      |                                  |            |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                           | <b>ADVANCED DATABASE SYSTEMS</b> | <b>(9)</b> |
| Spatial Databases: Spatial Data Types – Spatial Relationships – Spatial Data Structures – Spatial Access Methods – Temporal Databases: Overview – Active Database – Deductive Databases – Recursive Queries in SQL – Mobile Databases: Location and Handoff Management – Mobile Transaction Models – Concurrency - Transaction Commit Protocols – Multimedia Databases. |                                  |            |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                           | <b>XML&amp; JSON</b>             | <b>(9)</b> |
| XML Database: XML – XML Schema – XML DOM – XSL – XSLT – XPath and XQuery – JSON Document Databases – Document (MongoDB) Data Model - JSON and BSON– Polymorphic Schemas – Using MongoDB Shell – Basic Querying – Create and Insert – Creating Collections – Update and Delete.                                                                                          |                                  |            |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                           | <b>GRAPH DATABASES</b>           | <b>(9)</b> |
| Introduction to Graph Databases – The Power of Graph Databases – Data Modeling with Graphs – Querying Graphs – Introduction to Cypher – CQL Clauses – Write Clause – Read Clause – General Clauses – CQL Functions – Building a Graph Database application.                                                                                                             |                                  |            |

|                                                                                                                                                                                                                                                                                                           |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                                                                                                                                                        |
| <ol style="list-style-type: none"> <li>1. Henry F. Korth, Abraham Silberschatz, S. Sudharshan, “Database System Concepts”, Sixth Edition, McGraw-Hill, 2011</li> <li>2. R. Elmasri, S. B. Navathe, “Fundamentals of Database Systems”, Seventh Edition, Pearson Education/Addison Wesley, 2017</li> </ol> |
| <b>Reference:</b>                                                                                                                                                                                                                                                                                         |
| <ol style="list-style-type: none"> <li>1. Shashank Tiwari, “Professional NoSQL”, O’Reilly Media, 2011.</li> <li>2. Shakuntala Gupta Edward (Author), Navin Sabharwal, “Practical MongoDB: Architecting, Developing, and Administering MongoDB”, APRESS, First Edition, 2018.</li> </ol>                   |
| <b>Web / NPTEL Resources:</b>                                                                                                                                                                                                                                                                             |
| <ol style="list-style-type: none"> <li>1. Data Base Management System, IIT Kharagpur: <a href="https://nptel.ac.in/courses/106105175">nptel.ac.in/courses/106105175</a></li> <li>2. Data Base Management System : <a href="#">Preview: Data Base Management System   SWAYAM</a></li> </ol>                |

| CO-PO Mapping |     |     |     |     |     |     |     |     |     |      |      |      |      |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| CO            | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
| CO1           | 3   | 2   | 2   | 2   | 3   | 2   | –   | –   | –   | 2    | 1    | 3    | 2    |
| CO2           | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO3           | 3   | 3   | 3   | 3   | 3   | 3   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO4           | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | 3    | 2    | 3    | 3    |
| CO5           | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 1   | 3    | 3    | 3    | 3    |

| Assessment Methodology |                     |       |
|------------------------|---------------------|-------|
| Assessment Methodology | Assessment Tools    | Marks |
| Internal Test I        | Written Examination | 10    |
| Internal Test II       | Written Examination | 10    |
| Internal Test III      | Written Examination | 10    |
| Assessment             | Assignment          | 05    |
| Attendance             | Performance         | 05    |
| Total                  |                     | 40    |

|                   |                                                            |                 |          |          |          |               |
|-------------------|------------------------------------------------------------|-----------------|----------|----------|----------|---------------|
| <b>PAIL 26 01</b> | <b>ADVANCED DATA<br/>STRUCTURES AND<br/>ALGORITHMS LAB</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                   |                                                            | PCC             | 0        | 0        | 2        | 2             |

#### Course Prerequisite / Preamble

Basic understanding of **data structures, algorithms, and programming concepts**, along with familiarity in **discrete mathematics and problem-solving skills**, to effectively learn and apply advanced algorithmic techniques covered in this course.

#### Course Objective

- To understand and implement advanced algorithmic strategies including dynamic programming, greedy, and graph algorithms.
- To solve complex computational problems involving optimization, string matching, and flow networks using efficient techniques.
- To develop analytical skills for comparing algorithm performance in terms of time and space complexity.
- To apply advanced design techniques for solving real-world computational problems.
- To gain hands-on experience in implementing classical algorithms for structured problem-solving.

#### Course Outcome

|      |                                                                                                                                |    |
|------|--------------------------------------------------------------------------------------------------------------------------------|----|
| LCO1 | To understand and implement advanced algorithmic strategies such as dynamic programming, greedy methods, and graph algorithms. | K3 |
| LCO2 | To solve complex computational problems involving optimization, string matching, and flow networks using efficient techniques. | K3 |
| LCO3 | To analyze and compare algorithmic performance using time and space complexity measures.                                       | K4 |
| LCO4 | To apply appropriate data structures and algorithmic paradigms for efficient problem-solving.                                  | K3 |
| LCO5 | To evaluate and optimize algorithms for real-world computational problems.                                                     | K5 |

| <b>LIST OF EXPERIMENTS</b> |                                                                                                                                                                      |
|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.                         | Implementation of Binary Search Tree: Insertion, deletion, searching, and tree traversals; analyze the time complexity of each operation.                            |
| 2.                         | Implementation of AVL Tree: Perform insertion and deletion with LL, RR, LR, and RL rotations and analyze the height of the tree.                                     |
| 3.                         | Implementation of Red-Black Tree: Implement insertion and search operations and study the balancing properties of the tree.                                          |
| 4.                         | Implementation of Hashing Techniques: Implement hash tables using different collision-resolution techniques such as linear probing, quadratic probing, and chaining. |
| 5.                         | Implementation of Heaps and Priority Queues: Construct min-heaps and max-heaps and implement insertion, deletion, heapify, and priority queue operations.            |
| 6.                         | Implementation of Binomial Heap: Perform insertion, union, minimum extraction, and key-decrease operations.                                                          |
| 7.                         | Implementation of Divide-and-Conquer Algorithms: Implement Merge Sort, Quick Sort, and Binary Search and compare their performance for different input sizes.        |
| 8.                         | Implementation of Randomized Algorithms: Implement Randomized Quick Sort and analyze its performance for different input distributions.                              |
| 9.                         | Greedy Algorithm Applications: Implement Activity Selection, Fractional Knapsack, and Minimum Spanning Tree algorithms using appropriate greedy strategies.          |
| 10.                        | Dynamic Programming Applications: Implement Matrix Chain Multiplication, Longest Common Subsequence, and 0/1 Knapsack using dynamic programming.                     |
| 11.                        | Graph Traversal Algorithms: Implement BFS and DFS using adjacency matrix/list representations and analyze their time and space complexity.                           |
| 12.                        | Shortest Path Algorithms: Implement Dijkstra's and Bellman-Ford algorithms and compare their applicability and complexity.                                           |
| 13.                        | Minimum Spanning Tree Algorithms: Implement Kruskal's and Prim's algorithms using appropriate data structures and compare their performance.                         |
| 14.                        | Network Flow and Matching: Implement the Ford-Fulkerson/Edmonds-Karp algorithm for maximum flow and solve a bipartite matching problem.                              |
| <b>Total: 45 Hours</b>     |                                                                                                                                                                      |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <ol style="list-style-type: none"> <li>1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, <i>Introduction to Algorithms</i>, MIT Press, 4th Edition, 2022.</li> <li>2. Ellis Horowitz, Sartaj Sahni and Sanguthevar Rajasekaran, <i>Computer Algorithms/C++</i>, Universities Press, 2nd Edition, 2008.</li> </ol>                                                                                                                  |
| <b>Reference</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <ol style="list-style-type: none"> <li>1. Jon Kleinberg and Éva Tardos, <i>Algorithm Design</i>, Pearson Education, 2005.</li> <li>2. Steven S. Skiena, <i>The Algorithm Design Manual</i>, 3rd Edition, Springer, 2020.</li> <li>3. Mark Allen Weiss, <i>Data Structures and Algorithm Analysis in C++</i>, 4th Edition, Pearson, 2014.</li> <li>4. Jeff Erickson, <i>Algorithms</i>, University of Illinois Urbana-Champaign, online lecture notes.</li> </ol> |
| <b>Web / NPTEL Resources</b>                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <ol style="list-style-type: none"> <li>1. Data Structures and Algorithms Design, IIT Kanpur : <a href="https://nptel.ac.in/courses/106104697">nptel.ac.in/courses/106104697</a></li> <li>2. Introduction to Data Structures and Algorithms : <a href="https://nptel.ac.in/courses/106102064">nptel.ac.in/courses/106102064</a></li> </ol>                                                                                                                        |

| <b>CO PO Mapping</b> |     |     |     |     |     |     |     |     |     |      |      |      |      |
|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| CO                   | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
| CO1                  | 3   | 3   | 2   | 2   | 2   | –   | –   | –   | –   | –    | –    | 3    | 2    |
| CO2                  | 3   | 3   | 3   | 2   | 3   | –   | –   | –   | 1   | –    | –    | 3    | 3    |
| CO3                  | 3   | 3   | 3   | 2   | 3   | –   | 1   | –   | 1   | –    | –    | 3    | 3    |
| CO4                  | 3   | 3   | 3   | 3   | 3   | –   | –   | –   | 1   | –    | –    | 3    | 3    |
| CO5                  | 3   | 3   | 3   | 2   | 3   | 1   | 1   | –   | 1   | 1    | 1    | 3    | 3    |

| Assessment Methodology                            | Assessment Tools | Marks |
|---------------------------------------------------|------------------|-------|
| Regular Laboratory Conduction                     | Observation      | 10    |
| Record Work                                       |                  | 10    |
| Model Exam                                        |                  | 15    |
| Virtual Lab Assignment / Online Coding Assessment | Review           | 10    |
| Model Creation                                    | Presentation     | 05    |
| Attendance                                        |                  | 10    |
| Total                                             |                  | 60    |

|                   |                                   |                 |          |          |          |               |
|-------------------|-----------------------------------|-----------------|----------|----------|----------|---------------|
| <b>PAIL 26 02</b> | <b>NEXT GENERATIVE AI<br/>LAB</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                   |                                   | PCC             | 0        | 0        | 2        | 2             |

### Course Prerequisite / Preamble

Basic knowledge of programming in Python, data structures, database concepts, probability and statistics, and fundamentals of machine learning/data mining, to effectively perform data analysis and implement machine learning algorithms using Weka and Python tools.

### Course Objective

- To provide hands-on experience in data analysis using Weka and Python tools.
- To apply data preprocessing techniques such as cleaning, transformation, and reduction on real datasets.
- To implement classification, clustering, and association rule mining algorithms.
- To evaluate and interpret machine learning model performance using appropriate metrics.
- To develop practical skills in handling real-world datasets using modern data science libraries.

### Course Outcome

|      |                                                                                                              |    |
|------|--------------------------------------------------------------------------------------------------------------|----|
| LCO1 | To gain hands-on experience in data analysis, preprocessing, and model implementation using Weka and Python. | K3 |
| LCO2 | To apply exploratory data analysis techniques on real-world datasets using appropriate tools.                | K3 |
| LCO3 | To implement data preprocessing techniques for cleaning, transformation, and reduction of data.              | K3 |
| LCO4 | To apply classification, clustering, and association rule mining algorithms using Python/Weka.               | K3 |
| LCO5 | To evaluate and interpret model performance and extract meaningful data patterns effectively.                | K4 |

### LIST OF EXPERIMENTS

1. Introduction to Generative AI and Foundation Models: Explore different types of generative models and compare their capabilities for text, image, audio and other AI tasks.

|                                                                                                                                                                                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 2. Prompt Engineering with Large Language Models: Implement zero-shot, one-shot and few-shot prompting and evaluate generated responses for different tasks.                    |
| 3. Text Generation using a Pre-trained Transformer: Use a pre-trained language model for text generation and compare greedy, top-k and nucleus sampling strategies.             |
| 4. Fine-Tuning a Pre-trained Language Model: Fine-tune a transformer-based model on a small domain-specific dataset and evaluate its performance.                               |
| 5. Parameter-Efficient Fine-Tuning using LoRA: Apply LoRA/PEFT techniques to adapt a pre-trained language model for a specific task.                                            |
| 6. Retrieval-Augmented Generation (RAG): Build a document question-answering system using document chunking, embeddings, vector retrieval and an LLM.                           |
| 7. RAG Evaluation and Optimization: Compare different chunking, embedding and retrieval strategies and evaluate answer relevance and faithfulness.                              |
| 8. Multimodal AI Application: Develop an application that accepts text and image inputs and generates descriptions, answers or captions.                                        |
| 9. Image Generation using Generative Models: Experiment with a pre-trained diffusion model and study the effect of different prompts on generated outputs.                      |
| 10. Build a Tool-Using AI Agent: Develop an AI agent capable of selecting and invoking predefined tools to perform multi-step tasks.                                            |
| 11. Reasoning and Planning Agent: Implement an agent using planning, reasoning and reflection mechanisms to solve a complex task.                                               |
| 12. Multi-Agent AI System: Design a multi-agent system with specialized agents such as planner, researcher and executor that collaborate to complete a task.                    |
| 13. Hallucination, Bias and Responsible AI Evaluation: Test an LLM for hallucination, bias and reliability using controlled prompts and evidence-based evaluation.              |
| 14. NextGen AI Mini Project: Design and implement an end-to-end intelligent application integrating an LLM/foundation model with RAG, tools, agents or multimodal capabilities. |
| <b>Total: 45 Hours</b>                                                                                                                                                          |

|                                                                                                    |
|----------------------------------------------------------------------------------------------------|
| <b>Text Books</b>                                                                                  |
| 1. Chip Huyen, AI Engineering: Building Applications with Foundation Models, O'Reilly Media, 2025. |
| 2. Sebastian Raschka, Build a Large Language Model (From Scratch), Manning Publications, 2024.     |

|                                                                                                                                                                                                                                                                                                                                       |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 3. Jay Alammam and Maarten Grootendorst, Hands-On Large Language Models: Language Understanding and Generation, O'Reilly Media, 2024.                                                                                                                                                                                                 |
| <b>Reference</b>                                                                                                                                                                                                                                                                                                                      |
| 1. Christopher M. Bishop and Hugh Bishop, Deep Learning: Foundations and Concepts, Springer, 2024.<br>2. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 3rd Edition, O'Reilly Media, 2022.<br>3. Rajeev Motwani and Prabhakar Raghavan, Randomized Algorithms, Cambridge University Press, 1995. |
| <b>Web / NPTEL Resources</b>                                                                                                                                                                                                                                                                                                          |
| 1. <a href="https://nptel.ac.in/courses/106102576">https://nptel.ac.in/courses/106102576</a><br>2. <a href="https://nptel.ac.in/courses/106108840">https://nptel.ac.in/courses/106108840</a>                                                                                                                                          |

| CO PO Mapping |     |     |     |     |     |     |     |     |     |      |      |      |      |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| CO            | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
| CO1           | 3   | 2   | 2   | 2   | 3   | –   | –   | 1   | –   | –    | –    | 3    | 3    |
| CO2           | 3   | 3   | 3   | 2   | 3   | –   | –   | 1   | 1   | –    | –    | 3    | 3    |
| CO3           | 3   | 3   | 3   | 3   | 3   | –   | –   | 1   | 1   | –    | –    | 3    | 3    |
| CO4           | 3   | 3   | 3   | 3   | 3   | 1   | –   | 1   | 2   | 1    | –    | 3    | 3    |
| CO5           | 3   | 3   | 2   | 3   | 3   | 2   | 1   | 3   | 1   | 1    | 1    | 3    | 3    |

| Assessment Methodology                            | Assessment Tools | Marks |
|---------------------------------------------------|------------------|-------|
| Regular Laboratory Conduction                     | Observation      | 10    |
| Record Work                                       |                  | 10    |
| Model Exam                                        |                  | 15    |
| Virtual Lab Assignment / Online Coding Assessment | Review           | 10    |
| Model Creation                                    | Presentation     | 05    |
| Attendance                                        |                  | 10    |
| Total                                             |                  | 60    |

|                    |                                                            |                 |          |          |          |               |
|--------------------|------------------------------------------------------------|-----------------|----------|----------|----------|---------------|
| <b>PCD 26 C 01</b> | <b>AUDITCOURSE-01 (ENGLISH FOR RESEARCH PAPER WRITING)</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                                                            | CDS             | 0        | 0        | 0        | 1             |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
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| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <ul style="list-style-type: none"> <li>• Foundational English Proficiency: Basic knowledge of English grammar, vocabulary, syntax, and sentence structure.</li> <li>• Basic Digital Literacy: Familiarity with word processing tools (e.g., MS Word) and slide software (e.g., PowerPoint).</li> </ul>                                                                                                                                                                                                                                                                                     |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <ul style="list-style-type: none"> <li>• Improve writing mechanics, structural syntax, and the overall readability level of complex technical claims.</li> <li>• Train students on the exact content requirements and rhetorical expectations for individual research manuscript subsections.</li> <li>• Develop the specialized skills needed to engineer attention-grabbing titles, concise abstracts, and high-impact introductions.</li> <li>• Inculcate robust academic honesty practices, focusing on appropriate paraphrasing, quote handling, and plagiarism avoidance.</li> </ul> |

|                       |                                                                                                                   |    |
|-----------------------|-------------------------------------------------------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                                                                   |    |
| <b>CO1</b>            | Draft grammatically precise, non-redundant, and coherent technical sentences by applying clean syntax structures. | K2 |
| <b>CO2</b>            | Formulate a compelling, relevant manuscript title and an objective, structured abstract for technical review.     | K3 |
| <b>CO3</b>            | Write structured introduction layouts and organize literature review parameters while eliminating ambiguity.      | K3 |
| <b>CO4</b>            | Articulate methodology steps, data validations, and discussion interpretations using standard academic styles.    | K4 |
| <b>CO5</b>            | Implement accurate citation mechanics, indexing techniques, and strict anti-plagiarism guardrails.                | K5 |

|                                                                                                                                                                                                            |                                                             |            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|------------|
| <b>Syllabus</b>                                                                                                                                                                                            |                                                             |            |
| <b>Unit 1</b>                                                                                                                                                                                              | <b>Architecture of Technical Sentences &amp; Paragraphs</b> | <b>(9)</b> |
| Planning and paper preparation steps; mastering structural word order; techniques for breaking up long sentences; building cohesive paragraph logic; writing with conciseness; removing active redundancy, |                                                             |            |

|                                                                                                                                                                                                                                                                                 |                                                                    |            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|------------|
| semantic ambiguity, and vagueness from engineering definitions.                                                                                                                                                                                                                 |                                                                    |            |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                   | <b>Academic Style, Hedging, and Plagiarism</b>                     | <b>(9)</b> |
| Clarifying complex findings; highlighting core innovative data contributions; the art of hedging (expressing caution/probability); objective critiquing of existing literature; active paraphrasing rules; understanding types of plagiarism and algorithmic similarity limits. |                                                                    |            |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                   | <b>Title Engineering, Abstract, and Introduction Layouts</b>       | <b>(9)</b> |
| Formulating precise, keyword-optimized titles; drafting structured abstracts (Background, Methods, Results, Conclusion segments); structural layers of the Introduction section; establishing the research problem; identifying gaps in state-of-the-art literature.            |                                                                    |            |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                   | <b>Documenting Methodology, Results, and Technical Discussions</b> | <b>(9)</b> |
| Describing research materials, digital frameworks, and experimental models; handling data visibility; highlighting specific numerical findings; writing standard technical discussion arguments; addressing system constraints or performance edge-cases.                       |                                                                    |            |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                   | <b>Conclusions, Referencing, and Publication Workflows</b>         | <b>(9)</b> |
| Drafting the final Conclusion block; suggesting concrete future extensions; standard reference tracking patterns (IEEE, APA styles); managing punctuation and mathematical notations; interacting with journal editors and navigating referee peer-review comments.             |                                                                    |            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <ul style="list-style-type: none"> <li>• Wallwork, A. (2016). English for Writing Research Papers (2nd ed.). Springer Science &amp; Business Media.</li> <li>• Dutta, S. K. (2018). Academic and Research Writing: Essential Skills and Styles. New Century Publications.</li> <li>• Jack, M. (2014). High Impact Research Writing and Scientific Communication. Cambridge University Press.</li> <li>• Ballou, S. V. (2008). Form and Style: Research Papers, Reports, Theses. Houghton Mifflin</li> </ul> |
| <b>Reference:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |

- National Institute of Technical Teachers Training and Research (NITTTR), Chennai. English for Research Paper Writing Video Stream.

### **CO-PO Mapping**

| <b>CO PO Mapping</b> |            |            |            |            |            |            |            |            |            |             |             |             |             |
|----------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
| <b>CO</b>            | <b>PO1</b> | <b>PO2</b> | <b>PO3</b> | <b>PO4</b> | <b>PO5</b> | <b>PO6</b> | <b>PO7</b> | <b>PO8</b> | <b>PO9</b> | <b>PO10</b> | <b>PO11</b> | <b>PSO1</b> | <b>PSO2</b> |
| CO1                  | 3          | 2          | 2          | 2          | 2          | –          | –          | 2          | 1          | 3           | 2           | 2           | 3           |
| CO2                  | 3          | 2          | 2          | 2          | 3          | –          | –          | 3          | 1          | 3           | 2           | 2           | 3           |
| CO3                  | 3          | 3          | 3          | 2          | 3          | –          | –          | 3          | 1          | 3           | 2           | 3           | 3           |
| CO4                  | 3          | 3          | 3          | 3          | 3          | –          | –          | 2          | 1          | 3           | 3           | 3           | 3           |
| CO5                  | 3          | 3          | 2          | 2          | 3          | 2          | –          | 3          | 2          | 3           | 3           | 3           | 3           |

| <b>Assessment Methodology</b> |                         |              |
|-------------------------------|-------------------------|--------------|
| <b>Assessment Methodology</b> | <b>Assessment Tools</b> | <b>Marks</b> |
| Internal Test I               | Written Examination     | 10           |
| Internal Test II              | Written Examination     | 10           |
| Internal Test III             | Written Examination     | 10           |
| Assessment                    | Assignment              | 05           |
| Attendance                    | Performance             | 05           |
| Total                         |                         | 40           |

|                 |                                       |                 |          |          |          |               |
|-----------------|---------------------------------------|-----------------|----------|----------|----------|---------------|
| <b>NIH26101</b> | <b>NPTEL / INTERNSHIP / HACKATHON</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                 |                                       | <b>PROJ</b>     | <b>0</b> | <b>0</b> | <b>0</b> | <b>1</b>      |

#### Course Prerequisite / Preamble

- This course provides experiential learning through NPTEL certification courses, industrial internships, innovation activities, and hackathon participation.
- Students gain practical exposure to industry practices, emerging technologies, teamwork, professional communication, and problem-solving through skill-oriented and application-based learning experiences.
- The course encourages self-learning, interdisciplinary collaboration, innovation, entrepreneurship, and industry interaction.

#### Course Objective

- To encourage self-learning through NPTEL and online certification courses.
- To provide industrial exposure through internships and training programs.
- To develop innovation, creativity, and teamwork through hackathons and competitions.
- To enhance technical, professional, and communication skills through practical experiences.
- To promote industry-oriented learning and problem-solving abilities.

#### Course Outcome

|            |                                                                                             |           |
|------------|---------------------------------------------------------------------------------------------|-----------|
| <b>CO1</b> | Apply domain knowledge gained through NPTEL courses, internships, and hackathon activities. | <b>K3</b> |
| <b>CO2</b> | Develop practical problem-solving skills using industry-oriented approaches.                | <b>K4</b> |
| <b>CO3</b> | Demonstrate teamwork, leadership, and communication skills in collaborative environments.   | <b>K3</b> |
| <b>CO4</b> | Analyze real-world engineering problems and propose innovative solutions.                   | <b>K4</b> |
| <b>CO5</b> | Prepare technical reports, presentations, and project documentation professionally          | <b>K3</b> |

#### Syllabus

|                                                                                                                                            |                   |
|--------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| <b>NPTEL / INTERNSHIP / HACKATHON ACTIVITIES</b>                                                                                           | <b>(60 Hours)</b> |
| Registration and successful completion of at least one approved NPTEL / SWAYAM / MOOC certification course relevant to the program domain. | <b>(20 Hours)</b> |

|                                                                                                                                             |                   |
|---------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| Participation in industrial internship / in-plant training / industrial skill development program in a recognized industry or organization. | <b>(20 Hours)</b> |
| Participation in internal or external hackathons, coding contests, design challenges, innovation contests, or technical competitions.       | <b>(20 Hours)</b> |
| Preparation and submission of internship report / NPTEL completion report / hackathon participation report with proper documentation.       | <b>(10 Hours)</b> |
| Technical presentation, viva voce, and demonstration of learning outcomes before department evaluation committee.                           | <b>(05 Hours)</b> |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>NPTEL / SWAYAM Guidelines</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <ol style="list-style-type: none"> <li>1. Students shall register for at least one NPTEL / SWAYAM / approved MOOC course relevant to their discipline.</li> <li>2. The minimum duration of the course shall be 4 weeks.</li> <li>3. Students must secure minimum 50% marks or successfully complete the certification requirements.</li> <li>4. Submission of course completion certificate is mandatory.</li> <li>5. Faculty coordinator approval is required before course registration.</li> </ol>                                                                                     |
| <b>Internship Guidelines</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <ol style="list-style-type: none"> <li>1. Students shall undergo internship / in-plant training in a registered industry, company, MSME, research organization, or startup.</li> <li>2. The internship duration shall not be less than 1 week or equivalent contact hours prescribed by the department.</li> <li>3. Students shall maintain a daily work diary and internship logbook.</li> <li>4. Internship completion certificate issued by the organization is mandatory.</li> <li>5. Students shall submit an internship report and give a presentation after completion.</li> </ol> |
| <b>Hackathon / Technical Competition Guidelines</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <ol style="list-style-type: none"> <li>1. Students may participate individually or as a team in approved hackathons or innovation contests.</li> <li>2. Participation may include coding competitions, hardware design contests, product development challenges, or startup idea competitions.</li> <li>3. Students shall submit proof of participation / certificates issued by organizers.</li> <li>4. Submission of problem statement, methodology, and outcome report is mandatory.</li> </ol>                                                                                        |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5. Innovative projects with prototypes or working models will receive additional weightage during evaluation.                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Evaluation Procedure</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <ol style="list-style-type: none"> <li>1. Continuous assessment shall be carried out by the faculty coordinator based on participation, learning outcomes, and documentation.</li> <li>2. Evaluation components include certificate verification, technical presentation, report quality, teamwork, innovation, and viva voce.</li> <li>3. Students failing to complete minimum requirements shall redo the activity as recommended by the department.</li> <li>4. Attendance and active participation are mandatory for internal evaluation.</li> </ol> |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                        |            |            |            |            |            |            |            |            |            |             |             |             |             |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
| <b>Web / NPTEL Resources</b>                                                                                                                                                                                                                                                                                                                                                                                                                           |            |            |            |            |            |            |            |            |            |             |             |             |             |
| <ol style="list-style-type: none"> <li>1. <a href="https://nptel.ac.in/">https://nptel.ac.in/</a></li> <li>2. <a href="https://swayam.gov.in/">https://swayam.gov.in/</a></li> <li>3. <a href="https://internship.aicte-india.org/">https://internship.aicte-india.org/</a></li> <li>4. <a href="https://www.hackathon.com/">https://www.hackathon.com/</a></li> <li>5. <a href="https://smartindia.gov.in/">https://smartindia.gov.in/</a></li> </ol> |            |            |            |            |            |            |            |            |            |             |             |             |             |
| <b>COPO Mapping</b>                                                                                                                                                                                                                                                                                                                                                                                                                                    |            |            |            |            |            |            |            |            |            |             |             |             |             |
| <b>COs</b>                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>PO1</b> | <b>PO2</b> | <b>PO3</b> | <b>PO4</b> | <b>PO5</b> | <b>PO6</b> | <b>PO7</b> | <b>PO8</b> | <b>PO9</b> | <b>PO10</b> | <b>PO11</b> | <b>PSO1</b> | <b>PSO2</b> |
| CO1                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 3          | 3          | 2          | 1          | 2          | -          | -          | -          | 1          | 2           | 1           | 3           | 3           |
| CO2                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 3          | 3          | 3          | 2          | 2          | -          | -          | -          | 2          | 2           | 1           | 3           | 3           |
| CO3                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 2          | 2          | 2          | 1          | 1          | 1          | -          | 1          | 3          | 3           | 1           | 2           | 2           |
| CO4                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 3          | 3          | 3          | 3          | 2          | 1          | 1          | -          | 2          | 2           | 2           | 3           | 3           |
| CO5                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 2          | 2          | 2          | 1          | 1          | 1          | -          | 1          | 3          | 3           | 1           | 2           | 2           |

|                                                              |                                                  |              |
|--------------------------------------------------------------|--------------------------------------------------|--------------|
| <b>Assessment Methodology</b>                                |                                                  |              |
| <b>Assessment Methodology</b>                                | <b>Assessment Tools</b>                          | <b>Marks</b> |
| <b>Assignments / Reviews</b>                                 | <b>Idea Presentation / Prototype / Viva Voce</b> | <b>50</b>    |
| <b>Hackathon Project / Internship Report / Demonstration</b> | <b>Model Evaluation and Presentation</b>         | <b>50</b>    |
| <b>Total</b>                                                 |                                                  | <b>100</b>   |

|                 |                                                                                        |                 |          |          |          |               |
|-----------------|----------------------------------------------------------------------------------------|-----------------|----------|----------|----------|---------------|
| <b>CDC26101</b> | <b>CAREER DEVELOPMENT SKILL-I</b><br><i>(Career Development / Professional Skills)</i> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                 |                                                                                        | CDS             | 0        | 0        | 2        | 1             |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Basic knowledge of Artificial Intelligence and Data Science concepts, programming fundamentals, and familiarity with computer-based productivity tools. Students should have basic proficiency in English communication and an understanding of academic and technical learning practices.                                                                                                                                                                                                           |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <ul style="list-style-type: none"> <li>• Develop effective professional, technical and interpersonal communication skills required for careers in Artificial Intelligence and Data Science.</li> <li>• Develop students' ability to prepare technical reports, research documents, presentations and professional correspondence.</li> <li>• Familiarize students with professional ethics, responsible AI, workplace practices and emerging career opportunities in AI and Data Science.</li> </ul> |

|                       |                                                                                                                                             |    |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                                                                                             |    |
| <b>CO1</b>            | Demonstrate effective professional and technical communication skills in AI and Data Science contexts.                                      | K2 |
| <b>CO2</b>            | Prepare structured technical reports, research documents, presentations and professional correspondence.                                    | K3 |
| <b>CO3</b>            | Develop and present a professional AI & Data Science portfolio using appropriate digital platforms and tools.                               | K3 |
| <b>CO4</b>            | Demonstrate career-readiness skills including resume preparation, professional networking, presentations, group discussions and interviews. | K4 |
| <b>CO5</b>            | Apply teamwork, leadership, problem-solving, project-management and professional-ethical practices in AI & Data Science environments.       | K5 |

|                                                                                                                                                                                                                                                               |                                   |            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|------------|
| <b>Syllabus</b>                                                                                                                                                                                                                                               |                                   |            |
| <b>Unit 1</b>                                                                                                                                                                                                                                                 | <b>Professional Communication</b> | <b>(9)</b> |
| Professional communication, effective listening and speaking, interpersonal communication, technical presentations, seminar skills, group discussions, professional email communication, workplace communication, and effective use of professional language. |                                   |            |

|                                                                                                                                                                                                                                                                                                                        |                                                               |            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|------------|
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                          | <b>Career Development Skills</b>                              | <b>(9)</b> |
| Career planning, identification of AI and Data Science career opportunities, preparation of professional resume/CV, LinkedIn profile development, personal branding, elevator pitch, professional networking, goal setting, and development of an individual career plan.                                              |                                                               |            |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                          | <b>Technical and Research Writing</b>                         | <b>(9)</b> |
| Technical documentation, report writing, research paper structure, abstract and problem statement preparation, literature review, technical proposal writing, citation and referencing, plagiarism awareness, research ethics, and preparation of project/thesis documentation.                                        |                                                               |            |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                          | <b>AI &amp; Data Science Professional Tools and Portfolio</b> | <b>(9)</b> |
| Git and GitHub, development of an AI/Data Science portfolio, project documentation, code presentation, data visualization for professional communication, AI-assisted productivity tools, project demonstration, and preparation of technical portfolios for industry and research opportunities.                      |                                                               |            |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                          | <b>Industry and Employability Skills</b>                      | <b>(9)</b> |
| Problem-solving and analytical thinking, teamwork, leadership, time and project management, Agile and Scrum fundamentals, technical and HR interview preparation, coding and aptitude skills, case-study discussions, mock interviews, entrepreneurship, professional ethics, responsible AI, and workplace readiness. |                                                               |            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <ul style="list-style-type: none"> <li>• M. Ashraf Rizvi, Effective Technical Communication, McGraw Hill Education.</li> <li>• Meenakshi Raman and Sangeeta Sharma, Technical Communication: Principles and Practice, Oxford University Press.</li> <li>• Mike Markel and Stuart A. Selber, Technical Communication, Bedford/St. Martin's.</li> <li>• John M. Lannon and Laura J. Gurak, Technical Communication, Pearson.</li> </ul>                                 |
| <b>Reference:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <ul style="list-style-type: none"> <li>• Sunita Mishra and C. Muralikrishna, Communication Skills for Engineers, Pearson.</li> <li>• K. R. Lakshminarayana, Technical Communication, SCITECH Publications.</li> <li>• Gerald J. Alred, Charles T. Brusaw and Walter E. Oliu, Handbook of Technical Writing, Bedford/St. Martin's.</li> <li>• Wayne C. Booth, Gregory G. Colomb and Joseph M. Williams, The Craft of Research, University of Chicago Press.</li> </ul> |

- Michael Alley, The Craft of Scientific Writing, Springer.
- Robert W. Bly, The Encyclopedia of Business Letters, Faxes and E-mail, Career Press.

### **CO-PO Mapping**

| <b>CO PO Mapping</b> |            |            |            |            |            |            |            |            |            |             |             |             |             |
|----------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
| <b>CO</b>            | <b>PO1</b> | <b>PO2</b> | <b>PO3</b> | <b>PO4</b> | <b>PO5</b> | <b>PO6</b> | <b>PO7</b> | <b>PO8</b> | <b>PO9</b> | <b>PO10</b> | <b>PO11</b> | <b>PSO1</b> | <b>PSO2</b> |
| CO1                  | 1          | 1          | –          | –          | 1          | 1          | –          | 1          | 2          | 3           | 1           | 2           | 2           |
| CO2                  | 2          | 2          | 1          | 2          | 1          | 1          | –          | 1          | 2          | 3           | 2           | 2           | 2           |
| CO3                  | 2          | 2          | 2          | 1          | 3          | 1          | –          | 1          | 2          | 3           | 2           | 3           | 3           |
| CO4                  | 1          | 2          | 2          | 1          | 2          | 1          | –          | 1          | 3          | 3           | 2           | 3           | 2           |
| CO5                  | 1          | 2          | 2          | 1          | 1          | 2          | 1          | 3          | 3          | 3           | 3           | 2           | 3           |

| <b>Assessment Methodology</b>      |                                       |       |
|------------------------------------|---------------------------------------|-------|
| Assessment Methodology             | Assessment Tools                      | Marks |
| Continuous Internal Assessment     | Observation / Record Work / Viva Voce | 30    |
| Internal Practical Examination     | Laboratory Performance                | 30    |
| End Semester Practical Examination | Experiment and Viva Voce              | 40    |
| Total                              |                                       | 100   |

# **SEMESTER - II**

|                    |                                               |                 |          |          |          |               |
|--------------------|-----------------------------------------------|-----------------|----------|----------|----------|---------------|
| <b>PAI 26 2 01</b> | <b>MACHINE LEARNING<br/>AND DEEP LEARNING</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                                               | PCC             | 3        | 0        | 0        | 3             |

### Course Prerequisite / Preamble

Basic knowledge of AI, linear algebra, probability and statistics

### Course Objective

- To understand the fundamental concepts and types of machine learning with real-world applications.
- To apply supervised and unsupervised learning algorithms for solving data-driven problems.
- To design and implement neural networks and deep learning models using backpropagation.
- To apply convolutional and sequence models for vision, speech, and NLP tasks.
- To use deep learning frameworks like TensorFlow and Keras for building and evaluating advanced models.

### Course Outcome

|     |                                                                         |    |
|-----|-------------------------------------------------------------------------|----|
| CO1 | Understand foundational machine learning concepts.                      | K2 |
| CO2 | Ability to implement decision tree algorithm and clustering techniques. | K3 |
| CO3 | Design and train neural networks for classification tasks.              | K3 |
| CO4 | Explore deep learning models like CNN and LSTM.                         | K3 |
| CO5 | Understand and implement various generative models.                     | K3 |

### Syllabus

|                                                                                                                                                                                                                                                                                                                                 |                                        |            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|------------|
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                   | <b>Foundations of Machine Learning</b> | <b>(9)</b> |
| Introduction to Machine Learning: Types of Learning – Training, Validation and Test Data – Feature Representation – Data Preprocessing – Feature Scaling – Bias and Variance – Overfitting and Underfitting – Model Selection – Cross Validation – Performance Evaluation – Loss Functions – Gradient Descent – Regularization. |                                        |            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                          |            |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|------------|
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Supervised and Unsupervised Learning</b>              | <b>(9)</b> |
| Machine Learning Algorithms: Linear Regression – Polynomial Regression – Logistic Regression – Naïve Bayes – K-Nearest Neighbour – Decision Trees – Random Forest – Support Vector Machine – Kernel Methods – Ensemble Learning – Bagging – Boosting – K-Means Clustering – Hierarchical Clustering – Gaussian Mixture Models                                                                                                                                     |                                                          |            |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Neural Networks and Fundamentals of Deep Learning</b> | <b>(9)</b> |
| Deep Learning Foundations: Artificial Neural Networks – Biological and Artificial Neurons – Multi-Layer Perceptron – Feedforward Neural Networks – Loss Functions – Gradient Descent – Backpropagation – Weight Initialization – Optimization Algorithms – Momentum – AdaGrad – RMSProp – Adam – Regularization – Dropout – Batch Normalization – Early Stopping – Vanishing and Exploding Gradients.                                                             |                                                          |            |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Deep Learning Architectures</b>                       | <b>(9)</b> |
| Deep Neural Networks: Convolutional Neural Networks – Convolution and Pooling – CNN Architectures – Recurrent Neural Networks – Backpropagation Through Time – Long Short-Term Memory – Gated Recurrent Units – Sequence Modelling – Attention Mechanism – Encoder-Decoder Architecture – Transformers – Applications in Computer Vision, Natural Language Processing and Speech Processing.                                                                      |                                                          |            |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Advanced Machine Learning and Deep Learning</b>       | <b>(9)</b> |
| Advanced Learning Techniques: Autoencoders – Variational Autoencoders – Generative Adversarial Networks – Diffusion Models – Self-Supervised Learning – Deep Reinforcement Learning – Graph Neural Networks – Explainable AI – Model Interpretability – Hyperparameter Optimization – Model Compression – Transfer Learning – Federated Learning – Applications of Machine Learning and Deep Learning – Recent Trends in Generative AI and Large Language Models. |                                                          |            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <ol style="list-style-type: none"> <li>1. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2nd edition, 2020.</li> <li>2. Stephen Marsland, Machine Learning: An Algorithmic Perspective, Chapman &amp; Hall/CRC, Second Edition, 2015.</li> <li>3. Ethem Alpaydin, Introduction to Machine Learning, Fourth Edition, MIT Press, 2020.</li> <li>4. Francois Chollet, Deep Learning with Python, Manning Publications, 2017.</li> </ol> |
| <b>Reference:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <ol style="list-style-type: none"> <li>1. Tom M. Mitchell, Machine Learning, First Edition, McGraw-Hill, 1997.</li> <li>2. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, The MIT Press, 2016.</li> </ol>                                                                                                                                                                                                                                     |

**Web / NPTEL Resources:**

1. Machine Learning and Deep learning - Fundamentals and Applications, IIT Guwahati: [nptel.ac.in/courses/108103192](https://nptel.ac.in/courses/108103192)
2. Deep Learning - IIT Ropar, IIT Ropar : [nptel.ac.in/courses/106106184](https://nptel.ac.in/courses/106106184)

**CO-PO Mapping**

| CO  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 2   | 1   | 3   | 2   | 2   | 3   | –   | –   | –   | 2    | 2    | 3    | 1    |
| CO2 | 3   | 2   | 3   | 3   | 3   | 3   | 1   | 1   | –   | 2    | 1    | 3    | 3    |
| CO3 | 3   | 2   | 3   | 3   | 3   | 3   | 1   | 1   | –   | 2    | 1    | 3    | 3    |
| CO4 | 2   | 1   | 3   | 3   | 2   | 3   | 1   | –   | –   | 2    | 2    | 3    | 2    |
| CO5 | 3   | 2   | 3   | 3   | 3   | 3   | 2   | 1   | 1   | 2    | 3    | 3    | 3    |

**Assessment Methodology**

| Assessment Methodology | Assessment Tools    | Marks |
|------------------------|---------------------|-------|
| Internal Test I        | Written Examination | 10    |
| Internal Test II       | Written Examination | 10    |
| Internal Test III      | Written Examination | 10    |
| Assessment             | Assignment          | 05    |
| Attendance             | Performance         | 05    |
| Total                  |                     | 40    |

|             |                                   |                 |          |          |          |               |
|-------------|-----------------------------------|-----------------|----------|----------|----------|---------------|
| PAI 26 2 02 | <b>EXPLORATORY DATA ANALYTICS</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|             |                                   | PCC             | 3        | 0        | 0        | 3             |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Basic programming knowledge (python) and basics of statistics.                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <ul style="list-style-type: none"> <li>To understand the fundamentals of Big Data and its real-world applications.</li> <li>To learn and apply MapReduce programming for distributed data processing.</li> <li>To develop Big Data solutions using Hadoop ecosystem tools.</li> <li>To apply techniques for handling and processing large-scale data efficiently.</li> <li>To design and evaluate stream data mining methods for real-time analytics.</li> </ul> |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

|                       |                                                                                           |    |
|-----------------------|-------------------------------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                                           |    |
| CO1                   | To understand Big Data concepts and apply analytics techniques for business applications. | K3 |
| CO2                   | To analyze and implement MapReduce programming model for distributed data processing.     | K4 |
| CO3                   | To develop Big Data solutions using Hadoop ecosystem tools.                               | K3 |
| CO4                   | To apply data processing techniques for large-scale and distributed datasets.             | K3 |
| CO5                   | To design and evaluate stream data mining algorithms for real-time Big Data applications. | K5 |

|                                                                                                                                                                                                                                                                                                                                                        |                                           |            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|------------|
| <b>Syllabus</b>                                                                                                                                                                                                                                                                                                                                        |                                           |            |
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                                          | <b>Introduction to Big Data Analytics</b> | <b>(9)</b> |
| Introduction to Big Data: Big Data – Characteristics of Big Data –Types of Big Data –Big Data Sources – Big Data Applications – Traditional Data Analytics vs Big Data Analytics – Big Data Analytics Lifecycle – Challenges in Big Data Analytics – Data Collection and Data Acquisition – Big Data Architecture – Distributed Computing and Storage. |                                           |            |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                          | <b>Exploratory Data Analytics</b>         | <b>(9)</b> |

|                                                                                                                                                                                                                                                                                                                                                                                           |                                                               |            |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|------------|
| Exploratory Data Analysis: Introduction to EDA –Data Types –Data Transformation – Data Integration – Data Reduction – Descriptive Statistics – Measures of Central Tendency – Measures of Dispersion – Correlation and Covariance – Distribution Analysis – Univariate, Bivariate and Multivariate Analysis – Exploratory Analysis of Large Datasets – Feature Exploration and Selection. |                                                               |            |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                             | <b>Big Data Visualization and Statistical Analytics</b>       | <b>(9)</b> |
| Big Data Visualization: Principles of Data Visualization –Charts and Graphs – Heat Maps – Multivariate Visualization – Interactive Visualization – Data Storytelling – Dashboard Design – Visualization using Python – NumPy – Pandas – Matplotlib – Seaborn – Introduction to Tableau/Power BI – Visual Analytics – Statistical Analysis of Big Data – Hypothesis Testing                |                                                               |            |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                             | <b>Big Data Processing and Analytics</b>                      | <b>(9)</b> |
| Big Data Processing: Hadoop Ecosystem – Hadoop Distributed File System (HDFS) – YARN – MapReduce Programming Model – NoSQL Databases – MongoDB – HBase Apache Spark – Spark Architecture – RDDs – Data Frames – Spark SQL – Spark Streaming – Distributed Data Processing – Batch Processing – Real-Time Data Processing – Scalable Analytics.                                            |                                                               |            |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                             | <b>Advanced Exploratory and Predictive Big Data Analytics</b> | <b>(9)</b> |
| Advanced Big Data Analytics: Classification – Regression – Clustering – K-Means – Hierarchical Clustering – DBSCAN – Anomaly Detection – Dimensionality Reduction – Principal Component Analysis – Time-Series Analysis – Text Mining – Sentiment Analysis – Recommender Systems – Graph Analytics – Machine Learning with Spark MLlib – Real-Time Analytics – Big Data Applications      |                                                               |            |

|                                                                                                                                                                              |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                           |
| 1. Raj Kamal and Preeti Saxena, Big Data Analytics: Introduction to Hadoop, Spark, and Machine Learning, MC Graw Hill, 2019.                                                 |
| <b>Reference:</b>                                                                                                                                                            |
| 1. Shilpi Saxena, Saurabh Gupta, Practical Real-time Data Processing and Analytics, Packt Publishing, 2017.                                                                  |
| 2. Gwen Shapira, Todd Palino, Rajini Sivaram, Krit Petty, Kafka – The Definitive Guide: Real-time data and stream processing at scale, Second Edition, O'Reilly Media, 2021. |
| 3. Ankit Jain, Mastering Apache Storm: Processing big data streams in real time, Packt Publishing, 2017.                                                                     |
| <b>Web / NPTEL Resources:</b>                                                                                                                                                |

1. Big Data Computing, IIT Patna : [nptel.ac.in/courses/106104189](https://nptel.ac.in/courses/106104189)
2. Big Data Computing: [Preview: Big Data Computing | SWAYAM](#)

| CO-PO Mapping |     |     |     |     |     |     |     |     |     |      |      |      |      |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| CO            | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
| CO1           | 2   | 1   | 3   | 2   | 2   | 1   | –   | –   | –   | 2    | 1    | 3    | 1    |
| CO2           | 2   | 1   | 3   | 3   | 3   | 1   | 1   | –   | –   | 2    | –    | 3    | 2    |
| CO3           | 3   | 2   | 3   | 3   | 3   | 1   | 1   | 1   | –   | 2    | –    | 3    | 3    |
| CO4           | 3   | 2   | 3   | 3   | 3   | 2   | 2   | 1   | 1   | 2    | 2    | 3    | 3    |
| CO5           | 3   | 2   | 3   | 3   | 3   | 1   | 2   | 1   | 1   | 2    | 1    | 3    | 3    |

| Assessment Methodology |                     |       |
|------------------------|---------------------|-------|
| Assessment Methodology | Assessment Tools    | Marks |
| Internal Test I        | Written Examination | 10    |
| Internal Test II       | Written Examination | 10    |
| Internal Test III      | Written Examination | 10    |
| Assessment             | Assignment          | 05    |
| Attendance             | Performance         | 05    |
| Total                  |                     | 40    |

|                    |                                      |                 |          |          |          |               |
|--------------------|--------------------------------------|-----------------|----------|----------|----------|---------------|
| <i>PAI 26 2 03</i> | <i>SECURITY FOR DATA<br/>SCIENCE</i> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                                      | PCC             | 3        | 0        | 0        | 3             |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Basic knowledge of data science and machine learning. Familiarity with cybersecurity concepts and Python programming.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <ul style="list-style-type: none"> <li>To understand fundamental concepts of data security, privacy, cyber threats, and their role in data science.</li> <li>To apply data science techniques for detecting malware and insider threats in real-world systems.</li> <li>To analyze adversarial attacks and develop defense mechanisms for machine learning models.</li> <li>To evaluate privacy-preserving techniques such as decision trees and secure data mining methods.</li> <li>To design secure and intelligent data science solutions for emerging applications like smart transportation systems.</li> </ul> |

|                       |                                                                                                                        |    |
|-----------------------|------------------------------------------------------------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                                                                        |    |
| CO1                   | To understand the basic concepts of data security, privacy, and cyber threats in data science systems.                 | K3 |
| CO2                   | To apply data science techniques for detecting malware and insider threats in real-world scenarios.                    | K3 |
| CO3                   | To analyze adversarial attacks on machine learning models and develop suitable defense mechanisms.                     | K3 |
| CO4                   | To evaluate privacy-preserving methods such as secure decision tree algorithms.                                        | K3 |
| CO5                   | To design and develop secure data science solutions for emerging applications like intelligent transportation systems. | K3 |

|                                                                                                                                                                                                                 |                     |            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>Syllabus</b>                                                                                                                                                                                                 |                     |            |
| <b>Unit 1</b>                                                                                                                                                                                                   | <b>Introduction</b> | <b>(9)</b> |
| Data Security and Privacy - Security Policies - Policy Enforcement and Related Issues - Data Privacy - Data Mining Techniques - Cyber Security Threats - Data Mining for Cyber Security - Security and Privacy- |                     |            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                      |            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|------------|
| Enhanced Data Mining - Semantic Web and Security - Big Data Security and Privacy - Issues and Research Challenges - Big Data Management and Analytics - Cyber Security for Big Data Analytics.                                                                                                                                                                                                                                                                                                                 |                                                      |            |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Data Science for Cyber Security</b>               | <b>(9)</b> |
| Data Science for Malicious Executables - Stream Analytics for Malware Detection: Stream Mining - Novel Class Detection - Evaluation - Security Applications and Malware Detection - Cloud-Based Data Science for Malware Detection - Stream Analytics for Insider Threat Detection: Big Data Techniques for Scalability - Ensemble Learning - Ensemble for Unsupervised Learning and Supervised Learning - Insider Threat Detection for Sequence Data - Classifying Sequence Data - USSSL - Anomaly Detection. |                                                      |            |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Security and Privacy Enhanced Data Science</b>    | <b>(9)</b> |
| Adversarial Learning: Adversarial Attack Models - Free-range Attack - Restrained Attack - Adversarial SVM Learning - AD-SVM against Free-range Attack Model - AD-SVM against Restrained Attack Model - Experiments on Artificial Dataset and Real Datasets. Adversarial Learning Using Relevance Vector Machine Ensembles: Relevance Vector Machine - Kernel Parameter Fitting - Experiments on Artificial Dataset and Real Datasets.                                                                          |                                                      |            |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Privacy Preserving Decision Trees</b>             | <b>(9)</b> |
| Privacy Metrics - Decision Tree Construction - Splitting Criterion - Discretizing Continuous Attributes - Stopping Criteria - Naive Bayes Classifier - Over Perturbed Numeric Data - PPDTC4.5 - Splitting Criterion - Splitting Training Data Set - Classifying the Perturbed Instance - Local vs. Global Data Mining - Reconstruction-Based Approaches Results - PPDTC4.5 Classifier Accuracy - Algorithm Complexity.                                                                                         |                                                      |            |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Emerging Applications for Secure Data Science</b> | <b>(9)</b> |
| Internet of Transportation Systems - Integration of Cyber Security and AI - Security and Privacy for the Internet of Transportation Systems - AI and Security for Cloud-based Internet of Transportation Systems - Directions for Secure Data Science.                                                                                                                                                                                                                                                         |                                                      |            |

|                                                                                                                                                                                            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                                         |
| 1. Bhavani Thuraishingham, Murat Kantarcioglu, and Latifur Khan, Secure Data Science: Integrating Cyber Security and Data Science, First Edition, CRC Press, Taylor & Francis Group, 2022. |
| <b>Reference:</b>                                                                                                                                                                          |
| 1. Joshua Saxe with Hillary Sanders, Malware Data Science: Attack Detection and Attribution, First Edition, No Starch Press, Inc., 2018.                                                   |
| 2. Cioffi-Revilla, Claudio, Data Driven Security: Analysis, Visualization and Dashboards, First                                                                                            |

Edition, John Wiley & Sons, Inc., 2014.

3. Clarence Chio and David Freeman, Machine Learning and Security: Protecting Systems with Data and Algorithms, First Edition, O'reilly Media, Inc., 2018.

**Web / NPTEL Resources:**

1. Cyber Security and Privacy, IIT Madras : [nptel.ac.in/courses/106106248](https://nptel.ac.in/courses/106106248)
2. Information Security - 5 - Secure Systems Engineering, IIT Madras : [nptel.ac.in/courses/106106199](https://nptel.ac.in/courses/106106199)

**CO-PO Mapping**

| CO  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 2   | 1   | 3   | 2   | 2   | 3   | –   | –   | –   | 2    | 2    | 3    | 1    |
| CO2 | 3   | 2   | 3   | 3   | 3   | 3   | 1   | 1   | –   | 2    | 1    | 3    | 3    |
| CO3 | 3   | 2   | 3   | 3   | 3   | 3   | 1   | 1   | –   | 2    | 1    | 3    | 3    |
| CO4 | 2   | 1   | 3   | 3   | 2   | 3   | 1   | –   | –   | 2    | 2    | 3    | 2    |
| CO5 | 3   | 2   | 3   | 3   | 3   | 3   | 2   | 1   | 1   | 2    | 3    | 3    | 3    |

**Assessment Methodology**

| Assessment Methodology | Assessment Tools    | Marks |
|------------------------|---------------------|-------|
| Internal Test I        | Written Examination | 10    |
| Internal Test II       | Written Examination | 10    |
| Internal Test III      | Written Examination | 10    |
| Assessment             | Assignment          | 05    |
| Attendance             | Performance         | 05    |
| Total                  |                     | 40    |

| <i>PAIL 26 03</i> | <i>ML AND DL LAB</i> | CATEGORY | L | T | P | CREDIT |
|-------------------|----------------------|----------|---|---|---|--------|
|                   |                      | PCC      | 0 | 0 | 2 | 2      |

### Course Prerequisite / Preamble

- Basic knowledge of Python programming.
- Understanding of fundamental statistics and probability concepts.
- Familiarity with linear algebra and data structures.
- Basic understanding of data analysis and visualization techniques.

### Course Objective

To comprehend the fundamental concepts of machine learning, implement various learning algorithms using Python, and develop the ability to evaluate, compare, and optimize predictive models for real-world applications.

### Course Outcome

|     |                                                                                                                  |    |
|-----|------------------------------------------------------------------------------------------------------------------|----|
| CO1 | Understand and implement core machine learning algorithms using Python from scratch and with libraries.          | K3 |
| CO2 | Explore various types of models including regression, classification, probabilistic models, and neural networks. | K3 |
| CO3 | Develop the ability to evaluate, compare, and optimize machine learning models for different problem types.      | K3 |

| Exp. No. | Title                          | Description / Problem Statements                                                                                                                             | CO  |
|----------|--------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| Ex.1     | Implement Linear Regression.   | Identification and solving of simple real-life or scientific or technical problems – Electricity Billing, Retail Shop Billing, Sin Series, etc.              | CO1 |
| Ex.2     | Implement Logistic Regression. | Python programming using simple statements and expressions – exchange values of two variables, circulate values of n variables, distance between two points. | CO2 |
| Ex.3     | Implement Naïve Bayes.         | Scientific problems using conditionals and iterative loops – Number Series, Number Patterns, Pyramid                                                         | CO2 |

|      |                                                                                            |                                                                                                                                                                                      |     |
|------|--------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
|      |                                                                                            | Pattern.                                                                                                                                                                             |     |
| Ex.4 | Implement Bayesian Belief Networks.                                                        | Implementing real-time / technical applications using Lists and Tuples.                                                                                                              | CO2 |
| Ex.5 | Implement the Expectation Maximization algorithm.                                          | Implementing real-time / technical applications using Sets and Dictionaries – language components, automobile elements, civil structure elements; operations of Sets & Dictionaries. | CO2 |
| Ex.6 | Implement Neural Network: a) Feedforward Neural Network (FNN) b) Backpropagation Algorithm | Implementing programs using Functions – Factorial, largest number in a list, area of shapes.                                                                                         | CO3 |
| Ex.7 | Implement Support Vector Machine (SVM).                                                    | Implementing programs using Strings – reverse, palindrome check, character count, replacing characters.                                                                              | CO3 |
| Ex.8 | Implement Ensemble Learning: a) Random Forest b) XGBoost                                   | Implementing programs using written modules and Python Standard Libraries – Pandas, NumPy, Matplotlib, SciPy.                                                                        | CO3 |

#### Text Books:

1. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, Aurélien Géron, 3rd Edition, O'Reilly Media, 2023.
2. Python Machine Learning, Sebastian Raschka and Vahid Mirjalili, 3rd Edition, Packt Publishing, 2019.
3. Deep Learning with Python, François Chollet, 2nd Edition, Manning Publications, 2021.

#### Reference:

1. Pattern Recognition and Machine Learning, Christopher M. Bishop, Springer, 2006.
2. Deep Learning, Ian Goodfellow, Yoshua Bengio, and Aaron Courville, MIT Press, 2016.

#### Web / NPTEL Resources:

1. [NPTEL – Machine Learning](#)
2. [TensorFlow Tutorials](#)

3. ☐ [Scikit-learn Documentation](#)

| <b>CO-PO Mapping</b> |            |            |            |            |            |            |            |            |            |             |             |             |             |
|----------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
| <b>Cos</b>           | <b>PO1</b> | <b>PO2</b> | <b>PO3</b> | <b>PO4</b> | <b>PO5</b> | <b>PO6</b> | <b>PO7</b> | <b>PO8</b> | <b>PO9</b> | <b>PO10</b> | <b>PO11</b> | <b>PSO1</b> | <b>PSO2</b> |
| CO1                  | 1          | 1          | 3          | 2          | 2          | –          | –          | –          | –          | 2           | –           | 3           | 1           |
| CO2                  | 2          | 1          | 3          | 3          | 3          | –          | 1          | –          | –          | 2           | –           | 3           | 2           |
| CO3                  | 3          | 2          | 3          | 3          | 3          | –          | 1          | 1          | –          | 2           | –           | 3           | 3           |

| <b>Assessment Methodology</b>                     | <b>Assessment Tools</b> | <b>Marks</b> |
|---------------------------------------------------|-------------------------|--------------|
| Regular Laboratory Conduction                     | Observation             | 10           |
| Record Work                                       |                         | 10           |
| Model Exam                                        |                         | 15           |
| Virtual Lab Assignment / Online Coding Assessment | Review                  | 10           |
| Model Creation                                    | Presentation            | 05           |
| Attendance                                        |                         | 10           |
| Total                                             |                         | 60           |

|                     |                                           |                 |          |          |          |               |
|---------------------|-------------------------------------------|-----------------|----------|----------|----------|---------------|
| <b>PAIL 26 2 04</b> | <b>EXPLORATORY DATA<br/>ANALYTICS LAB</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                     |                                           | PCC             | 0        | 0        | 2        | 2             |

|                                                                                                                                                                                                                                          |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                    |
| <ul style="list-style-type: none"> <li>• Basic knowledge of Python or Java programming.</li> <li>• Familiarity with database concepts and SQL.</li> <li>• Understanding of data structures and operating system fundamentals.</li> </ul> |
| <b>Course Objective</b>                                                                                                                                                                                                                  |
| To understand the fundamentals of Big Data processing, implement distributed data processing applications using MapReduce, Pig, Hive, and Apache Spark, and develop skills to analyze and manage large-scale datasets efficiently.       |

|                       |                                                                      |    |
|-----------------------|----------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                      |    |
| CO1                   | Implement various applications using Map Reduce programming          | K3 |
| CO2                   | Implement and evaluate the data manipulation procedures using pig.   | K3 |
| CO3                   | Implement and evaluate the data manipulation procedures using hive.  | K3 |
| CO4                   | Implement and evaluate the data manipulation procedures using spark. | K3 |

| Exp. No. | Title                                      | Description / Problem Statements                                                                                           | CO  |
|----------|--------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|-----|
| Ex.1     | Hadoop Installation and HDFS Commands      | Install and configure the Hadoop framework and perform file and directory operations using HDFS commands.                  | CO1 |
| Ex.2     | MapReduce using Combiner                   | Develop a MapReduce program to demonstrate the need and effectiveness of the Combiner in improving processing performance. | CO2 |
| Ex.3     | MapReduce I/O Formats – Text and Key-Value | Implement MapReduce applications using Text and Key-Value input/output formats for processing large datasets.              | CO2 |

|        |                                             |                                                                                                                                                                                                              |     |
|--------|---------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| Ex.4   | MapReduce I/O Formats – NLine and Multiline | Develop MapReduce applications using NLine and Multiline input/output formats for efficient data processing.                                                                                                 | CO2 |
| Ex.5   | Apache Pig and Hive                         | <b>5.1:</b> Install and configure Apache Pig and perform data manipulation using Pig Latin. <b>5.2:</b> Install and configure Apache Hive and execute DDL, DML, and analytical queries on large datasets.    | CO3 |
| Ex.6   | Sequence File Input/Output Formats          | Implement MapReduce applications using Sequence File input and output formats for efficient storage and processing of data.                                                                                  | CO2 |
| Ex.7   | Distributed Cache and Join Operations       | <b>7.1:</b> Implement Distributed Cache and Map-side Join. <b>7.2:</b> Implement Reduce-side Join for combining large datasets.                                                                              | CO2 |
| Ex.8   | Building and Running Spark Applications     | Build, configure, and execute Apache Spark applications using Spark Core.                                                                                                                                    | CO4 |
| Ex. 9  | Word Count using Hadoop and Spark           | Implement the Word Count application using Hadoop MapReduce and Apache Spark and compare the results.                                                                                                        | CO4 |
| Ex. 10 | Manipulating RDDs                           | Create and manipulate Resilient Distributed Datasets (RDDs) using Spark transformations and actions.                                                                                                         | CO4 |
| Ex. 11 | Spark SQL, Matrix Algorithms and Streaming  | <b>11.1:</b> Implement matrix algorithms using Spark. <b>11.2:</b> Develop Spark SQL programs for structured data processing. <b>11.3:</b> Build a Spark Streaming application for real-time data analytics. | CO4 |

#### Text Books:

1. Hadoop: The Definitive Guide, Tom White, 4th Edition, O'Reilly Media, 2015.
2. Learning Spark: Lightning-Fast Data Analytics, Jules S. Damji, Brooke Wenig, Tathagata Das, and Denny Lee, 2nd Edition, O'Reilly Media, 2020.
3. Programming Pig, Alan Gates, O'Reilly Media, 2011.

|                                                                                                                            |  |  |  |  |  |  |  |  |  |  |  |  |  |
|----------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|--|--|--|--|--|--|--|--|
| <b>Reference:</b>                                                                                                          |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. Data-Intensive Text Processing with MapReduce, Jimmy Lin and Chris Dyer, Morgan & Claypool Publishers, 2010.            |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2. Big Data Fundamentals: Concepts, Drivers & Techniques, Thomas Erl, Wajid Khattak, and Paul Buhler, Prentice Hall, 2015. |  |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>Web / NPTEL Resources:</b>                                                                                              |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. <a href="#">NPTEL – Big Data Computing</a>                                                                              |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2. <a href="#">Apache Hadoop Documentation</a>                                                                             |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3. <a href="#">Apache Spark Documentation</a>                                                                              |  |  |  |  |  |  |  |  |  |  |  |  |  |

| <b>CO-PO Mapping</b> |            |            |            |            |            |            |            |            |            |             |             |             |             |
|----------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
| <b>Cos</b>           | <b>PO1</b> | <b>PO2</b> | <b>PO3</b> | <b>PO4</b> | <b>PO5</b> | <b>PO6</b> | <b>PO7</b> | <b>PO8</b> | <b>PO9</b> | <b>PO10</b> | <b>PO11</b> | <b>PSO1</b> | <b>PSO2</b> |
| CO1                  | 1          | 1          | 3          | 2          | 3          | –          | –          | –          | –          | 2           | –           | 3           | 1           |
| CO2                  | 2          | 1          | 3          | 3          | 3          | –          | 1          | –          | –          | 2           | –           | 3           | 2           |
| CO3                  | 2          | 2          | 3          | 3          | 3          | –          | 1          | 1          | –          | 2           | –           | 3           | 2           |
| CO4                  | 3          | 2          | 3          | 3          | 3          | 1          | 2          | 1          | 1          | 2           | 1           | 3           | 3           |

| <b>Assessment Methodology</b>                     | <b>Assessment Tools</b> | <b>Marks</b> |
|---------------------------------------------------|-------------------------|--------------|
| Regular Laboratory Conduction                     | Observation             | 10           |
| Record Work                                       |                         | 10           |
| Model Exam                                        |                         | 15           |
| Virtual Lab Assignment / Online Coding Assessment | Review                  | 10           |
| Model Creation                                    | Presentation            | 05           |
| Attendance                                        |                         | 10           |
| Total                                             |                         | 60           |

|                    |                                                               |                 |          |          |          |               |
|--------------------|---------------------------------------------------------------|-----------------|----------|----------|----------|---------------|
| <b>PCD 26 C 02</b> | <b>AUDIT COURSE-02<br/>(ENTREPRENEURSHIP<br/>DEVELOPMENT)</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                                                               | CDS             | 0        | 0        | 0        | 0             |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <ul style="list-style-type: none"> <li>Basic Business &amp; Economics Awareness: Familiarity with elementary financial concepts (revenue, cost, profit) and market demand.</li> <li>Problem-Solving Skills: Ability to analyze case studies and identify real-world consumer or industrial pain points.</li> </ul>                                                                                                                                                                                                                   |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <ul style="list-style-type: none"> <li>Instil an entrepreneurial mindset and demystify the process of transforming innovative ideas into viable business ventures.</li> <li>Develop capabilities to perform systematic feasibility analyses, market research, and risk assessments.</li> <li>Train students in drafting comprehensive, investor-ready business models and financial plans.</li> <li>Familiarize students with statutory regulations, intellectual property protection, and government startup ecosystems.</li> </ul> |

|                       |                                                                                                                                         |    |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                                                                                         |    |
| <b>CO1</b>            | Analyze the entrepreneurial ecosystem, identifying traits of successful entrepreneurs and navigating corporate ethical landscapes       | K2 |
| <b>CO2</b>            | Conduct structured ideation sessions and evaluate market opportunities using feasibility frameworks and design thinking metrics.        | K3 |
| <b>CO3</b>            | Formulate a comprehensive business plan, including structural, operational, marketing, and scaling strategy configurations.             | K3 |
| <b>CO4</b>            | Construct foundational financial statements, project cash flows, and identify appropriate seed-funding or venture capital channels.     | K4 |
| <b>CO5</b>            | Evaluate intellectual property requirements (patents, copyrights) and comply with statutory legal frameworks for business registration. | K5 |

|                                                                                                                                                                                                                                                                      |                                        |            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|------------|
| <b>Syllabus</b>                                                                                                                                                                                                                                                      |                                        |            |
| <b>Unit 1</b>                                                                                                                                                                                                                                                        | <b>Foundations of Entrepreneurship</b> | <b>(9)</b> |
| Theory: Evolution of entrepreneurship; characteristics, mindsets, and functions of an entrepreneur; distinction between entrepreneur, intrapreneur, and manager; types of entrepreneurs; women entrepreneurship; entrepreneurial barriers and motivation frameworks. |                                        |            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                              |            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|------------|
| Practice: Case studies of disruptive global and regional startups; self-assessment profiling tests for entrepreneurial competencies                                                                                                                                                                                                                                                                                                                                          |                                                              |            |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Opportunity Identification &amp; Feasibility Analysis</b> | <b>(9)</b> |
| <p>Theory: Methods of generating business ideas; environmental scanning and market gap analysis; Design Thinking principles for problem-solving; Feasibility Study architecture: Technical, Economic, Operational, Financial, and Market feasibility; Minimum Viable Product (MVP) concept.</p> <p>Practice: Brainstorming and pitching early-stage concepts; conducting regional consumer pulse surveys to validate a specific problem statement.</p>                       |                                                              |            |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Business Model Development &amp; Planning</b>             | <b>(9)</b> |
| <p>Theory: The Business Model Canvas (BMC) framework (Value proposition, customer segments, channels); anatomy of a formal Business Plan; operational layouts and supply chain planning; marketing strategies (4 AS, digital positioning, customer acquisition cost).</p> <p>Practice: Drafting a detailed Business Model Canvas for a chosen tech or service startup idea; peer review of business strategy mock-up.</p>                                                    |                                                              |            |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Small Business Finance &amp; Funding Mechanisms</b>       | <b>(9)</b> |
| <p>Theory: Basics of startup accounting; understanding balance sheets, income statements, and cash flow projections; break-even analysis; working capital management; sources of finance: Bootstrapping, Angel Investors, Venture Capital, Crowdfunding, and Mudra/Government MSME schemes.</p> <p>Practice: Developing a 3-year financial estimation spreadsheet for a hypothetical venture; simulating an investor pitch deck QA.</p>                                      |                                                              |            |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Legal Frameworks, IPR &amp; Institutional Support</b>     | <b>(9)</b> |
| <p>Theory: Forms of business ownership (Sole Proprietorship, Partnership, LLP, Private Limited); statutory registrations and licensing requirements; Intellectual Property Rights (IPR): Patents, Trademarks, Copyrights, and Trade Secrets; Role of support institutions (DICs, SIDO, NSIC, EDI, Start-Up India initiatives).</p> <p>Practice: Simulating a patent filing process; exploring the online Startup India portal to map incubation and tax-exemption steps.</p> |                                                              |            |

|                                                                                                                                                                                                                                                                                                                                                    |  |  |  |  |  |  |  |  |  |  |  |  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|--|--|--|--|--|--|--|
| <b>Text Books:</b>                                                                                                                                                                                                                                                                                                                                 |  |  |  |  |  |  |  |  |  |  |  |  |
| <p>Entrepreneurship Development (5th Edition) by S.S. Khanka (S. Chand &amp; Company), which outlines essential MSME structural setup, women entrepreneur traits, and national institutional support arrays.</p> <p>Robert D. Hisrich, Michael P. Peters, and Dean A. Shepherd's Entrepreneurship (11th Edition, McGraw Hill).</p>                 |  |  |  |  |  |  |  |  |  |  |  |  |
| <b>Reference:</b>                                                                                                                                                                                                                                                                                                                                  |  |  |  |  |  |  |  |  |  |  |  |  |
| <ul style="list-style-type: none"> <li>Entrepreneurship (11th Edition) Authors: Robert D. Hisrich, Michael P. Peters, Dean A. Shepherd<br/>Publisher: McGraw Hill Education</li> <li>Entrepreneurship: Successfully Launching New Ventures (6th Edition) Authors: Bruce R. Barringer, R. Duane Ireland<br/>Publisher: Pearson Education</li> </ul> |  |  |  |  |  |  |  |  |  |  |  |  |

### **CO-PO Mapping**

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

| <b>Assessment Methodology</b>      |                                       |       |
|------------------------------------|---------------------------------------|-------|
| Assessment Methodology             | Assessment Tools                      | Marks |
| Continuous Internal Assessment     | Observation / Record Work / Viva Voce | 30    |
| Internal Practical Examination     | Laboratory Performance                | 30    |
| End Semester Practical Examination | Experiment and Viva Voce              | 40    |
| Total                              |                                       | 100   |

|                 |                                       |                 |          |          |          |               |
|-----------------|---------------------------------------|-----------------|----------|----------|----------|---------------|
| <b>NIH26201</b> | <b>NPTEL / INTERNSHIP / HACKATHON</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                 |                                       | <b>PROJ</b>     | <b>0</b> | <b>0</b> | <b>0</b> | <b>1</b>      |

#### Course Prerequisite / Preamble

- This course provides experiential learning through NPTEL certification courses, industrial internships, innovation activities, and hackathon participation.
- Students gain practical exposure to industry practices, emerging technologies, teamwork, professional communication, and problem-solving through skill-oriented and application-based learning experiences.
- The course encourages self-learning, interdisciplinary collaboration, innovation, entrepreneurship, and industry interaction.

#### Course Objective

- To encourage self-learning through NPTEL and online certification courses.
- To provide industrial exposure through internships and training programs.
- To develop innovation, creativity, and teamwork through hackathons and competitions.
- To enhance technical, professional, and communication skills through practical experiences.
- To promote industry-oriented learning and problem-solving abilities.

#### Course Outcome

|            |                                                                                             |           |
|------------|---------------------------------------------------------------------------------------------|-----------|
| <b>CO1</b> | Apply domain knowledge gained through NPTEL courses, internships, and hackathon activities. | <b>K3</b> |
| <b>CO2</b> | Develop practical problem-solving skills using industry-oriented approaches.                | <b>K4</b> |
| <b>CO3</b> | Demonstrate teamwork, leadership, and communication skills in collaborative environments.   | <b>K3</b> |
| <b>CO4</b> | Analyze real-world engineering problems and propose innovative solutions.                   | <b>K4</b> |
| <b>CO5</b> | Prepare technical reports, presentations, and project documentation professionally          | <b>K3</b> |

#### Syllabus

|                                                                                                                                            |                   |
|--------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| <b>NPTEL / INTERNSHIP / HACKATHON ACTIVITIES</b>                                                                                           | <b>(60 Hours)</b> |
| Registration and successful completion of at least one approved NPTEL / SWAYAM / MOOC certification course relevant to the program domain. | <b>(20 Hours)</b> |

|                                                                                                                                             |                   |
|---------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| Participation in industrial internship / in-plant training / industrial skill development program in a recognized industry or organization. | <b>(20 Hours)</b> |
| Participation in internal or external hackathons, coding contests, design challenges, innovation contests, or technical competitions.       | <b>(20 Hours)</b> |
| Preparation and submission of internship report / NPTEL completion report / hackathon participation report with proper documentation.       | <b>(10 Hours)</b> |
| Technical presentation, viva voce, and demonstration of learning outcomes before department evaluation committee.                           | <b>(05 Hours)</b> |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>NPTEL / SWAYAM Guidelines</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <ul style="list-style-type: none"> <li>6. Students shall register for at least one NPTEL / SWAYAM / approved MOOC course relevant to their discipline.</li> <li>7. The minimum duration of the course shall be 4 weeks.</li> <li>8. Students must secure minimum 50% marks or successfully complete the certification requirements.</li> <li>9. Submission of course completion certificate is mandatory.</li> <li>10. Faculty coordinator approval is required before course registration.</li> </ul>                                                                                     |
| <b>Internship Guidelines</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <ul style="list-style-type: none"> <li>6. Students shall undergo internship / in-plant training in a registered industry, company, MSME, research organization, or startup.</li> <li>7. The internship duration shall not be less than 1 week or equivalent contact hours prescribed by the department.</li> <li>8. Students shall maintain a daily work diary and internship logbook.</li> <li>9. Internship completion certificate issued by the organization is mandatory.</li> <li>10. Students shall submit an internship report and give a presentation after completion.</li> </ul> |
| <b>Hackathon / Technical Competition Guidelines</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <ul style="list-style-type: none"> <li>6. Students may participate individually or as a team in approved hackathons or innovation contests.</li> <li>7. Participation may include coding competitions, hardware design contests, product development challenges, or startup idea competitions.</li> <li>8. Students shall submit proof of participation / certificates issued by organizers.</li> <li>9. Submission of problem statement, methodology, and outcome report is mandatory.</li> </ul>                                                                                         |

|                                                                                                                                         |
|-----------------------------------------------------------------------------------------------------------------------------------------|
| 10. Innovative projects with prototypes or working models will receive additional weightage during evaluation.                          |
| <b>Evaluation Procedure</b>                                                                                                             |
| 5. Continuous assessment shall be carried out by the faculty coordinator based on participation, learning outcomes, and documentation.  |
| 6. Evaluation components include certificate verification, technical presentation, report quality, teamwork, innovation, and viva voce. |
| 7. Students failing to complete minimum requirements shall redo the activity as recommended by the department.                          |
| 8. Attendance and active participation are mandatory for internal evaluation.                                                           |

|                                                                                          |     |     |     |     |     |     |     |     |     |      |      |      |      |
|------------------------------------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| Web / NPTEL Resources                                                                    |     |     |     |     |     |     |     |     |     |      |      |      |      |
| 6. <a href="https://nptel.ac.in/">https://nptel.ac.in/</a>                               |     |     |     |     |     |     |     |     |     |      |      |      |      |
| 7. <a href="https://swayam.gov.in/">https://swayam.gov.in/</a>                           |     |     |     |     |     |     |     |     |     |      |      |      |      |
| 8. <a href="https://internship.aicte-india.org/">https://internship.aicte-india.org/</a> |     |     |     |     |     |     |     |     |     |      |      |      |      |
| 9. <a href="https://www.hackathon.com/">https://www.hackathon.com/</a>                   |     |     |     |     |     |     |     |     |     |      |      |      |      |
| 10. <a href="https://smartindia.gov.in/">https://smartindia.gov.in/</a>                  |     |     |     |     |     |     |     |     |     |      |      |      |      |
| CO/                                                                                      |     |     |     |     |     |     |     |     |     |      |      |      |      |
| PO Mapping                                                                               |     |     |     |     |     |     |     |     |     |      |      |      |      |
| COs                                                                                      | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
| CO1                                                                                      | 3   | 3   | 2   | 1   | 2   | -   | -   | -   | 1   | 2    | 1    | 3    | 3    |
| CO2                                                                                      | 3   | 3   | 3   | 2   | 2   | -   | -   | -   | 2   | 2    | 1    | 3    | 3    |
| CO3                                                                                      | 2   | 2   | 2   | 1   | 1   | 1   | -   | 1   | 3   | 3    | 1    | 2    | 2    |
| CO4                                                                                      | 3   | 3   | 3   | 3   | 2   | 1   | 1   | -   | 2   | 2    | 2    | 3    | 3    |
| CO5                                                                                      | 2   | 2   | 2   | 1   | 1   | 1   | -   | 1   | 3   | 3    | 1    | 2    | 2    |

|                                                              |                                                  |              |
|--------------------------------------------------------------|--------------------------------------------------|--------------|
| <b>Assessment Methodology</b>                                |                                                  |              |
| <b>Assessment Methodology</b>                                | <b>Assessment Tools</b>                          | <b>Marks</b> |
| <b>Assignments / Reviews</b>                                 | <b>Idea Presentation / Prototype / Viva Voce</b> | <b>50</b>    |
| <b>Hackathon Project / Internship Report / Demonstration</b> | <b>Model Evaluation and Presentation</b>         | <b>50</b>    |
| <b>Total</b>                                                 |                                                  | <b>100</b>   |

|                 |                                                             |                 |          |          |          |               |
|-----------------|-------------------------------------------------------------|-----------------|----------|----------|----------|---------------|
| <b>CDC26201</b> | <b>CAREER DEVELOPMENT SKILL-II (Applied Data Analytics)</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                 |                                                             | CDS             | 0        | 0        | 2        | 1             |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <ul style="list-style-type: none"> <li>• Basic knowledge of probability, statistics, and linear algebra.</li> <li>• Familiarity with Python programming and fundamental data structures.</li> <li>• Basic understanding of databases and machine learning concepts.</li> <li>• Foundation for advanced data-driven modelling and analytical applications..</li> </ul>                                                                                                                                                                                                  |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <ul style="list-style-type: none"> <li>• To introduce an end-to-end data science workflow for solving real-world problems.</li> <li>• To develop skills in data acquisition, preprocessing, exploration, visualization, and feature engineering.</li> <li>• To apply statistical and machine learning techniques for predictive and descriptive analytics.</li> <li>• To analyze structured, unstructured, temporal, and high-dimensional data.</li> <li>• To enable students to develop and communicate data-driven solutions for real-world applications.</li> </ul> |

|                       |                                                                                                                   |    |
|-----------------------|-------------------------------------------------------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                                                                   |    |
| CO1                   | Apply data acquisition, preprocessing, exploratory analysis, and visualization techniques to real-world datasets. | K3 |
| CO2                   | Apply statistical and machine learning techniques for descriptive and predictive analytics.                       | K4 |
| CO3                   | Develop analytical models using feature engineering, dimensionality reduction, clustering, and ensemble methods.  | K4 |
| CO4                   | Analyze temporal, textual, and other complex datasets using appropriate data science techniques.                  | K4 |
| CO5                   | Evaluate data science solutions and communicate analytical insights for effective decision-making.                | K5 |

|                                                                                                                                                                |                                             |            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|------------|
| <b>Syllabus</b>                                                                                                                                                |                                             |            |
| <b>Unit 1</b>                                                                                                                                                  | <b>Data Preparation and EDA</b>             | <b>(9)</b> |
| Data collection – SQL – Data cleaning – Missing values – Outliers – Data transformation – Feature engineering – Exploratory data analysis – Data visualization |                                             |            |
| <b>Unit 2</b>                                                                                                                                                  | <b>Statistical and Predictive Analytics</b> | <b>(9)</b> |

|                                                                                                                                                                                   |                                            |            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|------------|
|                                                                                                                                                                                   |                                            |            |
| Descriptive statistics – Hypothesis testing – Regression – Classification – Clustering – Feature selection – Model evaluation – Cross-validation.                                 |                                            |            |
| <b>Unit 3</b>                                                                                                                                                                     | <b>Advanced Machine Learning Analytics</b> | <b>(9)</b> |
| Ensemble methods – Random Forest – Gradient Boosting – Hyperparameter tuning – Imbalanced data – Explainable AI – Model interpretation – Performance optimization.                |                                            |            |
| <b>Unit 4</b>                                                                                                                                                                     | <b>Real-World Data Analytics</b>           | <b>(9)</b> |
| Time-series analytics – Forecasting – Anomaly detection – Text analytics – Sentiment analysis – Recommendation systems – Customer and operational analytics.                      |                                            |            |
| <b>Unit 5</b>                                                                                                                                                                     | <b>Production Data Science</b>             | <b>(9)</b> |
| Data pipelines – Model deployment – APIs – Dashboards – Model monitoring – Data and model drift – MLOps fundamentals – Business KPIs – Data storytelling – Industry case studies. |                                            |            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <ul style="list-style-type: none"> <li>• Alasdair Gilchrist, Industry 4.0: The Industrial Internet of Things, Apress.</li> <li>• Bartodziej, Christoph Jan, The Concept Industry 4.0: An Empirical Analysis of Technologies and Applications in Production Logistics, Springer.</li> <li>• William D. Cardwell et al., Industrial Internet of Things: Cybermanufacturing Systems, Springer.</li> <li>• Rajkumar Buyya and Amir Vahid Dastjerdi, Internet of Things: Principles and Paradigms, Morgan Kaufmann.</li> </ul>                                                                                                                          |
| <b>Reference:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <ul style="list-style-type: none"> <li>• Klaus Schwab, The Fourth Industrial Revolution, World Economic Forum.</li> <li>• Sudha Jamthe, IoT and Edge Computing for Architects, Packt.</li> <li>• Dirk Slama, Frank Puhlmann, Jim Morrish and Rishi Bhatnagar, Enterprise IoT: Strategies and Best Practices for Connected Product and Service Development, O'Reilly.</li> <li>• Fei Tao, Meng Zhang, A.Y.C. Nee, Digital Twin Driven Smart Manufacturing, Academic Press.</li> <li>• Selected recent research papers from IEEE, Springer, Elsevier and ACM on Industry 4.0, IIoT, Digital Twins, Edge AI and intelligent manufacturing.</li> </ul> |

**CO-PO Mapping**

| <b>CO PO Mapping</b> |            |            |            |            |            |            |            |            |            |             |             |             |             |
|----------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
| <b>CO</b>            | <b>PO1</b> | <b>PO2</b> | <b>PO3</b> | <b>PO4</b> | <b>PO5</b> | <b>PO6</b> | <b>PO7</b> | <b>PO8</b> | <b>PO9</b> | <b>PO10</b> | <b>PO11</b> | <b>PSO1</b> | <b>PSO2</b> |
| CO1                  | 3          | 2          | 1          | 1          | 2          | 1          | 1          | 1          | 1          | 1           | 1           | 2           | 2           |
| CO2                  | 3          | 3          | 2          | 2          | 3          | 2          | 1          | 1          | 2          | 2           | 1           | 3           | 3           |
| CO3                  | 3          | 3          | 3          | 2          | 3          | 2          | 1          | 1          | 2          | 2           | 2           | 3           | 3           |
| CO4                  | 2          | 3          | 3          | 3          | 3          | 2          | 2          | 2          | 2          | 2           | 2           | 3           | 3           |
| CO5                  | 3          | 3          | 3          | 2          | 3          | 2          | 2          | 2          | 3          | 3           | 2           | 3           | 3           |

| <b>Assessment Methodology</b>      |                                       |       |
|------------------------------------|---------------------------------------|-------|
| Assessment Methodology             | Assessment Tools                      | Marks |
| Continuous Internal Assessment     | Observation / Record Work / Viva Voce | 30    |
| Internal Practical Examination     | Laboratory Performance                | 30    |
| End Semester Practical Examination | Experiment and Viva Voce              | 40    |
| Total                              |                                       | 100   |

# **SEMESTER – III**

|                    |                                 |                 |          |          |          |               |
|--------------------|---------------------------------|-----------------|----------|----------|----------|---------------|
| <b>PAI 26 3 01</b> | <b>RESEARCH<br/>METHODOLOGY</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                                 | PCC             | 3        | 1        | 0        | 4             |

|                                                                                                                                                                                                                                                                                                                                 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                           |
| <ul style="list-style-type: none"> <li>• Basic understanding of engineering concepts and problem-solving.</li> <li>• Familiarity with technical writing and computer applications.</li> <li>• Basic knowledge of intellectual property rights and innovation is desirable.</li> </ul>                                           |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                         |
| To understand the principles of engineering research, develop skills in identifying research problems, conducting literature reviews with ethical practices, preparing technical research proposals, and applying intellectual property, copyright, licensing, and technology transfer concepts for research commercialization. |

|                       |                                                                                               |    |
|-----------------------|-----------------------------------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                                               |    |
| CO1                   | Identify and formulate the research problem for a given engineering domain.                   | K3 |
| CO2                   | Analyze the literature studies, plagiarism and ethics for the identified research problem.    | K3 |
| CO3                   | Develop the effective technical writing and presentation of a research proposal using a tool. | K3 |
| CO4                   | Design and file the copyright of research work for trade as a product in the market.          | K3 |
| CO5                   | Apply the research for licensing and technology transfer as a product in world market.        | K3 |

|                                                                                                                                                                                                                |                     |            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>Syllabus</b>                                                                                                                                                                                                |                     |            |
| <b>Unit 1</b>                                                                                                                                                                                                  | <b>Introduction</b> | <b>(9)</b> |
| Definition of research problem, sources of research problem, criteria characteristics of a good research problem, errors in selecting a research problem, scope and objectives of research problem. Approaches |                     |            |

|                                                                                                                                                                                                                                                                                                                                   |                                           |            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|------------|
| of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations. CO1 UNIT II                                                                                                                                                                                            |                                           |            |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                     | <b>Literature Review</b>                  | <b>(9)</b> |
| Effective literature review approaches, literature analysis, avoiding plagiarism, ethics in research, data collection, analysis, interpretation.                                                                                                                                                                                  |                                           |            |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                     | <b>Technical Writing and Presentation</b> | <b>(9)</b> |
| Effective technical writing, how to write report, paper developing a research proposal, format of research proposal, a presentation and assessment by a review committee.                                                                                                                                                         |                                           |            |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                     | <b>Communities and Interactions</b>       | <b>(9)</b> |
| Introduction: Protection for ideas, means for protecting ideas, sources of intellectual property law, basic format to intellectual property issues. Justifications: objections to exclusive rights                                                                                                                                |                                           |            |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                     | <b>Patent and Inventions</b>              | <b>(9)</b> |
| Patent: The structure of patent law, patent terminology, patents act 1977, application for a patent, ownership of the patent, the proprietary right, patent licenses. Patentable inventions: inventions, excluded categories, industrial application, novelty, inventive step, disclosure, genetic engineering and patentability. |                                           |            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <ol style="list-style-type: none"> <li>1. Research Methodology: Methods and Techniques, C. R. Kothari and Gaurav Garg, 4th Edition, New Age International Publishers, 2019.</li> <li>2. Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar, 5th Edition, Sage Publications, 2019.</li> <li>3. The Craft of Research, Wayne C. Booth, Gregory G. Colomb, Joseph M. Williams, 4th Edition, University of Chicago Press, 2016.</li> </ol> |
| <b>Reference:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <ol style="list-style-type: none"> <li>1. Practical Research: Planning and Design, Paul D. Leedy and Jeanne Ellis Ormrod, 12th Edition, Pearson, 2019.</li> <li>2. Intellectual Property Rights, Debirag E. Bouchoux, Cengage Learning, 2017.</li> </ol>                                                                                                                                                                                                   |
| <b>Web / NPTEL Resources:</b>                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <ol style="list-style-type: none"> <li>1. <a href="#"><u>NPTEL – Research Methodology</u></a></li> </ol>                                                                                                                                                                                                                                                                                                                                                   |

2. [NPTEL – Patent Drafting for Beginners](#)

3. [World Intellectual Property Organization \(WIPO\) Academy](#)

#### CO-PO Mapping

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3   | 2   | 2   | 3   | 2   | 2   | 1   | –   | –   | 2    | 1    | 2    | 3    |
| CO2 | 3   | 2   | 2   | 3   | 1   | 3   | 1   | –   | –   | 2    | 1    | 2    | 3    |
| CO3 | 2   | 3   | 2   | 2   | 2   | 2   | 2   | 1   | –   | 2    | –    | 2    | 2    |
| CO4 | 2   | 2   | 1   | 2   | 1   | 3   | 1   | –   | 1   | 2    | 2    | 1    | 2    |
| CO5 | 3   | 2   | 2   | 3   | 2   | 3   | 2   | 1   | 1   | 2    | 2    | 2    | 3    |

#### Assessment Methodology

| Assessment Methodology | Assessment Tools    | Marks |
|------------------------|---------------------|-------|
| Internal Test I        | Written Examination | 10    |
| Internal Test II       | Written Examination | 10    |
| Internal Test III      | Written Examination | 10    |
| Assessment             | Assignment          | 05    |
| Attendance             | Performance         | 05    |
| Total                  |                     | 40    |

|                    |                                 |                 |          |          |          |               |
|--------------------|---------------------------------|-----------------|----------|----------|----------|---------------|
| <b>PAI 26 3 02</b> | <b>DISSERTATION (PHASE - I)</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                                 | PROJ            | 0        | 0        | 0        | 6             |

#### Course Prerequisite / Preamble

- Basic knowledge of Python programming, Machine Learning, and Data Science concepts.
- Familiarity with databases, data preprocessing, and analytical techniques.
- Basic understanding of research methodology, technical documentation, and AI development tools.

#### Course Objective

To identify and analyze research problems in Artificial Intelligence and Data Science, perform comprehensive literature surveys, formulate innovative AI-based solutions, utilize appropriate development tools and datasets, and develop technical writing, communication, and project planning skills for successful research and product development.

#### Course Outcome

|     |                                                                                                                                                                                   |    |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| CO1 | Identify and formulate research problems in Artificial Intelligence and Data Science by considering societal and industrial needs, and perform a comprehensive literature survey. | K3 |
| CO2 | Analyze the identified problem, evaluate existing solutions, and propose innovative AI and Data Science-based approaches using appropriate tools and techniques.                  | K3 |
| CO3 | Select suitable datasets, algorithms, software tools, and methodologies for developing AI and Data Science solutions.                                                             | K3 |
| CO4 | Design and prepare a project proposal, system architecture, and implementation plan for an AI and Data Science application.                                                       | K3 |
| CO5 | Demonstrate effective technical writing, documentation, teamwork, communication, and presentation skills through project reviews and reports.                                     | K2 |

The Dissertation work maybe analytical, experimental, design or combination of both. Phase I the Dissertation work involves the implementation of the existing system. It includes:

- Identification of a suitable problem pertaining to recent issues/ challenges in information security.

- In depth literature study of the topic.
- Detailed requirement analysis and finalization of the software and hardware requirements.
- Preparing a detailed action plan for implementing the solution to the problem.
- Detailed Analysis/Modelling/Simulation of the solution to the problem.
- Final development of product/process and testing/validation of the results.
- Preparation of a report in the specified format for evaluation.

#### CO-PO Mapping

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3   | 2   | 2   | 3   | 2   | 1   | 1   | –   | –   | 2    | 1    | 2    | 3    |
| CO2 | 3   | 2   | 3   | 3   | 3   | 2   | 1   | 1   | 1   | 2    | 1    | 3    | 3    |
| CO3 | 2   | 2   | 3   | 3   | 3   | 1   | 1   | 1   | –   | 2    | –    | 3    | 2    |
| CO4 | 3   | 2   | 3   | 3   | 3   | 2   | 2   | 2   | 1   | 2    | 1    | 3    | 3    |
| CO5 | 2   | 3   | 2   | 2   | 2   | 2   | 2   | 3   | 1   | 3    | 1    | 2    | 2    |

| Assessment Methodology                       | Assessment Tools | Marks |
|----------------------------------------------|------------------|-------|
| Problem Identification and Literature Survey | Review           | 10    |
| Requirement Analysis and Project Proposal    | Evaluation       | 10    |
| Project Synopsis and Presentation            | Presentation     | 10    |
| Progress Review / Weekly Review              | Observation      | 10    |
| Report Preparation                           | Documentation    | 10    |
| Total                                        |                  | 50    |

|                 |                                       |                 |          |          |          |               |
|-----------------|---------------------------------------|-----------------|----------|----------|----------|---------------|
| <b>NIH26301</b> | <b>NPTEL / INTERNSHIP / HACKATHON</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                 |                                       | <b>PROJ</b>     | <b>0</b> | <b>0</b> | <b>0</b> | <b>1</b>      |

#### Course Prerequisite / Preamble

- This course provides experiential learning through NPTEL certification courses, industrial internships, innovation activities, and hackathon participation.
- Students gain practical exposure to industry practices, emerging technologies, teamwork, professional communication, and problem-solving through skill-oriented and application-based learning experiences.
- The course encourages self-learning, interdisciplinary collaboration, innovation, entrepreneurship, and industry interaction.

#### Course Objective

- To encourage self-learning through NPTEL and online certification courses.
- To provide industrial exposure through internships and training programs.
- To develop innovation, creativity, and teamwork through hackathons and competitions.
- To enhance technical, professional, and communication skills through practical experiences.
- To promote industry-oriented learning and problem-solving abilities.

#### Course Outcome

|            |                                                                                             |           |
|------------|---------------------------------------------------------------------------------------------|-----------|
| <b>CO1</b> | Apply domain knowledge gained through NPTEL courses, internships, and hackathon activities. | <b>K3</b> |
| <b>CO2</b> | Develop practical problem-solving skills using industry-oriented approaches.                | <b>K4</b> |
| <b>CO3</b> | Demonstrate teamwork, leadership, and communication skills in collaborative environments.   | <b>K3</b> |
| <b>CO4</b> | Analyze real-world engineering problems and propose innovative solutions.                   | <b>K4</b> |
| <b>CO5</b> | Prepare technical reports, presentations, and project documentation professionally          | <b>K3</b> |

#### Syllabus

|                                                                                                                                            |                   |
|--------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| <b>NPTEL / INTERNSHIP / HACKATHON ACTIVITIES</b>                                                                                           | <b>(60 Hours)</b> |
| Registration and successful completion of at least one approved NPTEL / SWAYAM / MOOC certification course relevant to the program domain. | <b>(20 Hours)</b> |

|                                                                                                                                             |                   |
|---------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| Participation in industrial internship / in-plant training / industrial skill development program in a recognized industry or organization. | <b>(20 Hours)</b> |
| Participation in internal or external hackathons, coding contests, design challenges, innovation contests, or technical competitions.       | <b>(20 Hours)</b> |
| Preparation and submission of internship report / NPTEL completion report / hackathon participation report with proper documentation.       | <b>(10 Hours)</b> |
| Technical presentation, viva voce, and demonstration of learning outcomes before department evaluation committee.                           | <b>(05 Hours)</b> |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>NPTEL / SWAYAM Guidelines</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <p>11. Students shall register for at least one NPTEL / SWAYAM / approved MOOC course relevant to their discipline.</p> <p>12. The minimum duration of the course shall be 4 weeks.</p> <p>13. Students must secure minimum 50% marks or successfully complete the certification requirements.</p> <p>14. Submission of course completion certificate is mandatory.</p> <p><b>15. Faculty coordinator approval is required before course registration.</b></p>                                                                              |
| <b>Internship Guidelines</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <p>11. Students shall undergo internship / in-plant training in a registered industry, company, MSME, research organization, or startup.</p> <p>12. The internship duration shall not be less than 1 week or equivalent contact hours prescribed by the department.</p> <p>13. Students shall maintain a daily work diary and internship logbook.</p> <p>14. Internship completion certificate issued by the organization is mandatory.</p> <p>15. Students shall submit an internship report and give a presentation after completion.</p> |
| <b>Hackathon / Technical Competition Guidelines</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <p>11. Students may participate individually or as a team in approved hackathons or innovation contests.</p> <p>12. Participation may include coding competitions, hardware design contests, product development challenges, or startup idea competitions.</p> <p>13. Students shall submit proof of participation / certificates issued by organizers.</p> <p>14. Submission of problem statement, methodology, and outcome report is mandatory.</p>                                                                                       |

|                                                                                                                                          |
|------------------------------------------------------------------------------------------------------------------------------------------|
| 15. Innovative projects with prototypes or working models will receive additional weightage during evaluation.                           |
| <b>Evaluation Procedure</b>                                                                                                              |
| 9. Continuous assessment shall be carried out by the faculty coordinator based on participation, learning outcomes, and documentation.   |
| 10. Evaluation components include certificate verification, technical presentation, report quality, teamwork, innovation, and viva voce. |
| 11. Students failing to complete minimum requirements shall redo the activity as recommended by the department.                          |
| 12. Attendance and active participation are mandatory for internal evaluation.                                                           |

|                                                                                           |            |            |            |            |            |            |            |            |            |             |             |             |             |
|-------------------------------------------------------------------------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
| <b>Web / NPTEL Resources</b>                                                              |            |            |            |            |            |            |            |            |            |             |             |             |             |
| 11. <a href="https://nptel.ac.in/">https://nptel.ac.in/</a>                               |            |            |            |            |            |            |            |            |            |             |             |             |             |
| 12. <a href="https://swayam.gov.in/">https://swayam.gov.in/</a>                           |            |            |            |            |            |            |            |            |            |             |             |             |             |
| 13. <a href="https://internship.aicte-india.org/">https://internship.aicte-india.org/</a> |            |            |            |            |            |            |            |            |            |             |             |             |             |
| 14. <a href="https://www.hackathon.com/">https://www.hackathon.com/</a>                   |            |            |            |            |            |            |            |            |            |             |             |             |             |
| 15. <a href="https://smartindia.gov.in/">https://smartindia.gov.in/</a>                   |            |            |            |            |            |            |            |            |            |             |             |             |             |
| <b>COPO Mapping</b>                                                                       |            |            |            |            |            |            |            |            |            |             |             |             |             |
| <b>COs</b>                                                                                | <b>PO1</b> | <b>PO2</b> | <b>PO3</b> | <b>PO4</b> | <b>PO5</b> | <b>PO6</b> | <b>PO7</b> | <b>PO8</b> | <b>PO9</b> | <b>PO10</b> | <b>PO11</b> | <b>PSO1</b> | <b>PSO2</b> |
| CO1                                                                                       | 3          | 3          | 2          | 1          | 2          | -          | -          | -          | 1          | 2           | 1           | 3           | 3           |
| CO2                                                                                       | 3          | 3          | 3          | 2          | 2          | -          | -          | -          | 2          | 2           | 1           | 3           | 3           |
| CO3                                                                                       | 2          | 2          | 2          | 1          | 1          | 1          | -          | 1          | 3          | 3           | 1           | 2           | 2           |
| CO4                                                                                       | 3          | 3          | 3          | 3          | 2          | 1          | 1          | -          | 2          | 2           | 2           | 3           | 3           |
| CO5                                                                                       | 2          | 2          | 2          | 1          | 1          | 1          | -          | 1          | 3          | 3           | 1           | 2           | 2           |

|                                                              |                                                  |              |
|--------------------------------------------------------------|--------------------------------------------------|--------------|
| <b>Assessment Methodology</b>                                |                                                  |              |
| <b>Assessment Methodology</b>                                | <b>Assessment Tools</b>                          | <b>Marks</b> |
| <b>Assignments / Reviews</b>                                 | <b>Idea Presentation / Prototype / Viva Voce</b> | <b>50</b>    |
| <b>Hackathon Project / Internship Report / Demonstration</b> | <b>Model Evaluation and Presentation</b>         | <b>50</b>    |
| <b>Total</b>                                                 |                                                  | <b>100</b>   |

|                 |                                                          |                 |          |          |          |               |
|-----------------|----------------------------------------------------------|-----------------|----------|----------|----------|---------------|
| <b>CDC26301</b> | <b>CAREER DEVELOPMENT SKILL-III (Applied AI Systems)</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                 |                                                          | CDS             | 0        | 0        | 2        | 1             |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <ul style="list-style-type: none"> <li>• Basic knowledge of artificial intelligence and machine learning.</li> <li>• Familiarity with Python programming, databases, and APIs</li> <li>• Basic understanding of neural networks and data processing pipelines.</li> <li>• Foundation for designing and deploying intelligent, enterprise-oriented AI system</li> </ul>                                                                                                                                                                                                                            |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <ul style="list-style-type: none"> <li>• To develop the ability to identify and formulate real-world AI system requirements.</li> <li>• To introduce architectures involving automation, RAG, AI agents, APIs, and enterprise tools.</li> <li>• To develop skills for integrating data pipelines, APIs, queues, connectors, and tool-calling mechanisms.</li> <li>• To introduce agent orchestration, state management, evaluation, guardrails, security, and observability.</li> <li>• To enable students to design, pilot, deploy, monitor, and operationalize reliable AI systems..</li> </ul> |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

|                       |                                                                                                                                     |    |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                                                                                     |    |
| CO1                   | Analyze customer workflows, stakeholder requirements, constraints, and success metrics for AI system development.                   | K4 |
| CO2                   | Design AI system architectures using rules, automation, RAG, and agent-based approaches with appropriate boundaries.                | K5 |
| CO3                   | Integrate APIs, ingestion pipelines, queues, enterprise connectors, and tool-calling mechanisms into AI applications.               | K4 |
| CO4                   | Implement orchestration, state management, evaluation, guardrails, RBAC, audit trails, and observability for AI systems.            | K5 |
| CO5                   | Develop deployment, pilot rollout, rollback, incident management, documentation, and operational handoff strategies for AI systems. | K5 |

| <b>Syllabus</b>                                                                                                                                                                                                                                                                                                                       |                                                        |            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|------------|
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                         | <b>AI Problem Discovery and System Requirements</b>    | <b>(9)</b> |
| Customer workflows and stakeholder discovery – Stakeholder mapping – User journeys – Business problem identification – AI opportunity assessment – Requirement elicitation – Constraints and scope – Functional and non-functional requirements – Success metrics and KPIs -AI system specification.                                  |                                                        |            |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                         | <b>AI Architecture, Automation, RAG and Agents</b>     | <b>(9)</b> |
| AI APIs – RESTful services – API authentication – Data ingestion pipelines – Data preprocessing and transformation – Batch and real-time processing – Event-driven architectures – Queues and asynchronous workflows – Enterprise connectors – Databases and external services                                                        |                                                        |            |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                         | <b>APIs, Data Pipelines and Enterprise Integration</b> | <b>(9)</b> |
| AI APIs – RESTful services – API authentication – Data ingestion pipelines – Data preprocessing and transformation – Batch and real-time processing – Event-driven architectures – Queues and asynchronous workflows – Enterprise connectors – Databases and external services                                                        |                                                        |            |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                         | <b>Agent Orchestration, Evaluation and Governance</b>  | <b>(9)</b> |
| Agent orchestration patterns – Multi-step workflows – Multi-agent systems – State and context management – Memory mechanisms – Checkpoints and approvals – Human-in-the-loop approval – AI evaluation frameworks – Evaluation datasets – Accuracy, relevance, robustness, and reliability – Guardrails – Prompt and output validation |                                                        |            |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                         | <b>Deployment, Operations and AI System Lifecycle</b>  | <b>(9)</b> |
| AI system deployment strategies – Production readiness – Pilot rollout – Controlled deployment – User adoption – Monitoring and performance management – Model and application versioning – Rollback strategies – Incident response – Failure recovery – Business continuity – Cost monitoring – Security monitoring                  |                                                        |            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <ul style="list-style-type: none"> <li>• Chip Huyen, <i>Designing Machine Learning Systems</i>, O'Reilly Media.</li> <li>• David Hand, <i>The Impossibility of Automated Data Science</i>, Springer.</li> <li>• David De Cremer, Garry Kasparov and others, <i>AI and the Future of Work</i>, selected industry resources.</li> <li>• James G. Shanahan, <i>Talking Machines: An Introduction to Neural Language Processing</i>, MIT Pres</li> </ul> |
| <b>Reference:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                    |

- hip Huyen, *AI Engineering: Building Applications with Foundation Models*, O'Reilly Media.
- Eugene Yan, *Building Machine Learning Powered Applications*, Manning.
- Martin Kleppmann, *Designing Data-Intensive Applications*, O'Reilly Media.
- Ian Goodfellow, Yoshua Bengio and Aaron Courville, *Deep Learning*, MIT Press.

### **CO-PO Mapping**

| <b>CO PO Mapping</b> |            |            |            |            |            |            |            |            |            |             |             |             |             |
|----------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
| <b>CO</b>            | <b>PO1</b> | <b>PO2</b> | <b>PO3</b> | <b>PO4</b> | <b>PO5</b> | <b>PO6</b> | <b>PO7</b> | <b>PO8</b> | <b>PO9</b> | <b>PO10</b> | <b>PO11</b> | <b>PSO1</b> | <b>PSO2</b> |
| <b>CO1</b>           | 3          | 3          | 3          | 2          | 1          | 2          | -          | 1          | 2          | 2           | 1           | 3           | 3           |
| <b>CO2</b>           | 3          | 3          | 3          | 3          | 3          | 1          | -          | 1          | 1          | 1           | 2           | 3           | 3           |
| <b>CO3</b>           | 3          | 3          | 3          | 2          | 3          | 1          | -          | 1          | 2          | 1           | 2           | 3           | 3           |
| <b>CO4</b>           | 3          | 3          | 3          | 3          | 3          | 1          | -          | 3          | 2          | 2           | 2           | 3           | 3           |
| <b>CO5</b>           | 3          | 3          | 3          | 3          | 3          | 2          | 1          | 3          | 2          | 3           | 3           | 3           | 3           |

| <b>Assessment Methodology</b>      |                                       |       |
|------------------------------------|---------------------------------------|-------|
| Assessment Methodology             | Assessment Tools                      | Marks |
| Continuous Internal Assessment     | Observation / Record Work / Viva Voce | 30    |
| Internal Practical Examination     | Laboratory Performance                | 30    |
| End Semester Practical Examination | Experiment and Viva Voce              | 40    |
| Total                              |                                       | 100   |

# **SEMESTER - IV**

|                    |                                     |                 |          |          |          |               |
|--------------------|-------------------------------------|-----------------|----------|----------|----------|---------------|
| <b>PAI 26 4 01</b> | <b>DISSERTATION (PHASE – 2)</b>     | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    | <b>PROJECT REPORT AND VIVA VOCE</b> | PROJ            | 0        | 0        | 0        | 10            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <ul style="list-style-type: none"> <li>• Basic knowledge of Python programming, Machine Learning, and Data Science concepts.</li> <li>• Familiarity with databases, data preprocessing, and analytical techniques.</li> <li>• Basic understanding of research methodology, technical documentation, and AI development tools.</li> </ul>                                                                                                                                                                                                                                                |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| To identify and analyze research problems in Artificial Intelligence and Data Science, perform comprehensive literature surveys, formulate innovative AI-based solutions, utilize appropriate development tools and datasets, and develop technical writing, communication, and project planning skills for successful research and product development. Students are expected to have completed their project work and be capable of independently conducting literature review, system design, implementation, experimentation, documentation, and presentation of research findings. |

|                       |                                                                                                                                                                                   |    |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                                                                                                                                   |    |
| CO1                   | Identify and formulate research problems in Artificial Intelligence and Data Science by considering societal and industrial needs, and perform a comprehensive literature survey. | K3 |
| CO2                   | Analyze the identified problem, evaluate existing solutions, and propose innovative AI and Data Science-based approaches using appropriate tools and techniques.                  | K3 |
| CO3                   | Select suitable datasets, algorithms, software tools, and methodologies for developing AI and Data Science solutions.                                                             | K3 |
| CO4                   | Design and prepare a project proposal, system architecture, and implementation plan for an AI and Data Science application.                                                       | K3 |
| CO5                   | Demonstrate effective technical writing, documentation, teamwork, communication, and presentation skills through project reviews and reports.                                     | K2 |

The Dissertation work maybe analytical, experimental, design or combination of both. Phase I the Dissertation work involves the implementation of the existing system. It includes:

- Identification of a suitable problem pertaining to recent issues/ challenges in information security.
- In depth literature study of the topic.
- Detailed requirement analysis and finalization of the software and hardware requirements.
- Preparing a detailed action plan for implementing the solution to the problem.
- Detailed Analysis/Modelling/Simulation of the solution to the problem.
- Final development of product/process and testing/validation of the results.
- Preparation of a report in the specified format for evaluation.

#### CO-PO Mapping

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3   | 3   | 2   | 2   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO2 | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO3 | 3   | 3   | 3   | 3   | 3   | 2   | –   | –   | –   | 2    | 2    | 3    | 3    |
| CO4 | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 3    | 2    | 3    | 3    |
| CO5 | 2   | 2   | 2   | 2   | 3   | 2   | 2   | 3   | 3   | 3    | 3    | 3    | 3    |

| Assessment Methodology                       | Assessment Tools | Marks |
|----------------------------------------------|------------------|-------|
| Problem Identification and Literature Survey | Review           | 10    |
| Requirement Analysis and Project Proposal    | Evaluation       | 10    |
| Project Synopsis and Presentation            | Presentation     | 10    |
| Progress Review / Weekly Review              | Observation      | 10    |
| Report Preparation                           | Documentation    | 10    |
| Total                                        |                  | 50    |
|                                              |                  |       |

# **SEMESTER – I**

# **ELECTIVES**

| PEL 26 1 01 | BUSINESS ANALYTICS | CATEGORY | L | T | P | CREDIT |
|-------------|--------------------|----------|---|---|---|--------|
|             |                    | PE       | 3 | 0 | 0 | 3      |

|                                                                                                                                                                                                                                                                                                                                                 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                           |
| Students should have completed prior coursework or demonstrated proficiency in the following areas: fundamentals of computer science, basic mathematics and statistics.                                                                                                                                                                         |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                         |
| To understand the principles and methodologies of business analytics, develop skills in data preprocessing and exploratory analysis using Python and R, build predictive models for business decision-making, collaborate effectively using version control tools, and evaluate and communicate analytics outcomes for real-world applications. |

|                       |                                                                                                          |    |
|-----------------------|----------------------------------------------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                                                          |    |
| CO1                   | Understand and apply business analytics methodologies to derive actionable insights.                     | K3 |
| CO2                   | Develop proficiency in data cleansing, transformation, and exploratory data analysis using Python and R. | K3 |
| CO3                   | Build predictive models to solve real-world business problems.                                           | K3 |
| CO4                   | Collaborate effectively using version control systems like GitHub.                                       | K3 |
| CO5                   | Measure and communicate the success of analytics projects.                                               | K3 |

|                                                                                                                                                                                                        |                                            |            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|------------|
| <b>Syllabus</b>                                                                                                                                                                                        |                                            |            |
| <b>Unit 1</b>                                                                                                                                                                                          | <b>Introduction</b>                        | <b>(9)</b> |
| Overview and its significance in modern enterprises- Role of a Business Analyst - Bridging technical and business domains-analytics tools and technologies - data types and sources                    |                                            |            |
| <b>Unit 2</b>                                                                                                                                                                                          | <b>Data Preparation and Transformation</b> | <b>(9)</b> |
| Data cleansing techniques: Handling missing values-outliers-and inconsistencies - Data transformation: Normalization, encoding, and feature engineering - Utilizing Python and R for data preparation. |                                            |            |

|                                                                                                                                                                                                                        |                                            |            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|------------|
| <b>Unit 3</b>                                                                                                                                                                                                          | <b>Exploratory Data Analysis (EDA)</b>     | <b>(9)</b> |
| Techniques for summarizing and visualizing data-Identifying patterns, trends, and anomalies-Using visualization libraries:<br>Matplotlib, Seaborn, ggplot2                                                             |                                            |            |
| <b>Unit 4</b>                                                                                                                                                                                                          | <b>Predictive Modelling</b>                | <b>(9)</b> |
| Introduction and machine learning concepts-Building models: Regression, classification, clustering-Model evaluation and validation techniques-Implementing models using scikit-learn and caret.                        |                                            |            |
| <b>Unit 5</b>                                                                                                                                                                                                          | <b>Collaboration and Measuring Success</b> | <b>(9)</b> |
| Version control and collaboration using GitHub-Best practices for documenting and sharing analytics projects-Defining and tracking Key Performance Indicators (KPIs)-Communicating results to stakeholders effectively |                                            |            |

|                                                                                                                                                                                                         |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                                                      |
| 1. Deanne Larson, <i>Modern Business Analytics</i> , O'Reilly Media, December 2024.                                                                                                                     |
| <b>Reference:</b>                                                                                                                                                                                       |
| 1. H.K. Dangi & Gurveen Kaur, <i>Business Analytics</i> , Taxmann, 2024.<br>2. Ali Emrouznejad, <i>Business Analytics and Decision Making in Practice</i> , Springer, 2024.                             |
| <b>Web / NPTEL Resources:</b>                                                                                                                                                                           |
| 1. <a href="#"><u>NPTEL – Data Analytics with Python</u></a><br>2. <a href="#"><u>NPTEL – Business Analytics and Data Mining Modeling Using R</u></a><br>3. <a href="#"><u>GitHub Documentation</u></a> |

| <b>CO-PO Mapping</b> |            |            |            |            |            |            |            |            |            |             |             |             |             |
|----------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
| <b>Cos</b>           | <b>PO1</b> | <b>PO2</b> | <b>PO3</b> | <b>PO4</b> | <b>PO5</b> | <b>PO6</b> | <b>PO7</b> | <b>PO8</b> | <b>PO9</b> | <b>PO10</b> | <b>PO11</b> | <b>PSO1</b> | <b>PSO2</b> |
| CO1                  | 2          | 2          | 2          | 2          | 2          | 2          | –          | –          | –          | 2           | 1           | 3           | 2           |
| CO2                  | 3          | 3          | 2          | 3          | 3          | 2          | –          | –          | –          | 2           | 1           | 3           | 3           |
| CO3                  | 3          | 3          | 3          | 3          | 3          | 2          | 1          | –          | –          | 2           | 2           | 3           | 3           |
| CO4                  | 3          | 2          | 3          | 3          | 3          | 2          | 1          | –          | –          | 2           | 2           | 3           | 3           |
| CO5                  | 2          | 2          | 2          | 2          | 2          | 3          | 1          | 1          | 1          | 3           | 3           | 2           | 3           |

| <b>Assessment Methodology</b> |                         |              |
|-------------------------------|-------------------------|--------------|
| <b>Assessment Methodology</b> | <b>Assessment Tools</b> | <b>Marks</b> |
| Internal Test I               | Written Examination     | 10           |
| Internal Test II              | Written Examination     | 10           |
| Internal Test III             | Written Examination     | 10           |
| Assessment                    | Assignment              | 05           |
| Attendance                    | Performance             | 05           |
| Total                         |                         | 40           |

| PEL 26 1 02 | WEB ANALYTICS | CATEGORY | L | T | P | CREDIT |
|-------------|---------------|----------|---|---|---|--------|
|             |               | PE       | 3 | 0 | 0 | 3      |

### Course Prerequisite / Preamble

Students should have basic knowledge of digital marketing, statistics, and data visualization tools.

### Course Objective

To understand the fundamentals of web analytics, develop proficiency in using modern analytics tools for measuring website and application performance, apply data-driven decision-making techniques, ensure ethical and privacy-compliant analytics practices, and analyze real-world business cases across different industries.

### Course Outcome

|     |                                                                       |    |
|-----|-----------------------------------------------------------------------|----|
| CO1 | Understand web analytics fundamentals and their applications.         | K3 |
| CO2 | Master tools like Google Analytics 4, Tag Manager, and Looker Studio. | K3 |
| CO3 | Develop skills in data-driven decision-making for websites and apps.  | K3 |
| CO4 | Apply ethical, privacy-compliant analytics.                           | K3 |
| CO5 | Perform case-based analysis for different industries.                 | K3 |

### Syllabus

|                                                                                                                                                                                                                                    |                              |     |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|-----|
| Unit 1                                                                                                                                                                                                                             | Foundations of Web Analytics | (9) |
| Introduction-Digital Marketing Ecosystem: Channels & Traffic Sources-Understanding Data Types: Clickstream, Behavioural, Transactional-Foundational Metrics: Traffic, Engagement, Conversion, Retention-KPI Development Frameworks |                              |     |

|                                                                                                                                                                                                                                                                  |                                                   |            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|------------|
| <b>Unit 2</b>                                                                                                                                                                                                                                                    | <b>Tools &amp; Techniques for Data Collection</b> | <b>(9)</b> |
| Clickstream Analysis: Data Collection & Reporting - Google Analytics 4 Essentials: Properties, Events, Goals - Google Tag Manager: Variables, Triggers, Tags - Behaviour Analysis: User Journeys, Flow Visualization, Heatmaps - App and Mobile Analytics Basics |                                                   |            |
| <b>Unit 3</b>                                                                                                                                                                                                                                                    | <b>Testing, Attribution &amp; Optimization</b>    | <b>(9)</b> |
| Experimentation Techniques: A/B Testing, Multivariate Testing - Attribution Models: Last Click, Linear, Time Decay, Data-Driven Models - Multi-Channel Funnels - Conversion Rate Optimization                                                                    |                                                   |            |
| <b>Unit 4</b>                                                                                                                                                                                                                                                    | <b>Privacy, Governance &amp; Reporting</b>        | <b>(9)</b> |
| Data Privacy Regulations: GDPR, CCPA, Data Governance - Ethical Data Collection & Usage - Dashboards and Reporting: Data Storytelling Techniques - Google Looker Studio - Dashboard Creation & Visualization                                                     |                                                   |            |
| <b>Unit 5</b>                                                                                                                                                                                                                                                    | <b>Applications, Case Studies &amp; Careers</b>   | <b>(9)</b> |
| Case Studies: eCommerce, SaaS, Media Analytics - Cross-Platform Analytics - Web + Mobile Integration - Career Paths in Web Analytics: Roles & Certifications - Future Trends: AI in Analytics, Predictive Web Analytics                                          |                                                   |            |

|                                                                                                                                |
|--------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                             |
| 1. Avinash Kaushik, Web Analytics 2.0: The Art of Online Accountability & Science of Customer Centricity, 1st ed, Wiley, 2009. |
| 2. Clifton B., Advanced Web Metrics with Google Analytics, 2nd ed, Wiley Publishing, Inc. 2010.                                |
| <b>Reference:</b>                                                                                                              |
| 1. A. Karim Feroz, Gohar F. Khan, Marshall Sponder, Digital Analytics for Marketing, 2nd Edition, Routledge, January 2024.     |
| <b>Web / NPTEL Resources:</b>                                                                                                  |
| 1. <a href="#"><u>NPTEL – Data Analytics with Python</u></a>                                                                   |
| 2. <a href="#"><u>Google Analytics Academy (Google Skillshop)</u></a>                                                          |
| 3. <a href="#"><u>Google Analytics Help Center</u></a>                                                                         |

| <b>CO-PO Mapping</b> |            |            |            |            |            |            |            |            |            |             |             |             |             |
|----------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
| <b>Cos</b>           | <b>PO1</b> | <b>PO2</b> | <b>PO3</b> | <b>PO4</b> | <b>PO5</b> | <b>PO6</b> | <b>PO7</b> | <b>PO8</b> | <b>PO9</b> | <b>PO10</b> | <b>PO11</b> | <b>PSO1</b> | <b>PSO2</b> |
| CO1                  | 2          | 2          | 2          | 2          | 3          | 2          | –          | –          | –          | 2           | 1           | 3           | 2           |
| CO2                  | 3          | 3          | 2          | 3          | 3          | 2          | –          | –          | –          | 2           | 1           | 3           | 3           |
| CO3                  | 3          | 3          | 3          | 3          | 3          | 2          | 1          | –          | –          | 2           | 2           | 3           | 3           |
| CO4                  | 2          | 3          | 2          | 3          | 3          | 3          | 2          | 2          | 1          | 3           | 2           | 3           | 2           |
| CO5                  | 2          | 2          | 2          | 2          | 2          | 3          | 2          | 2          | 2          | 3           | 3           | 2           | 3           |

| <b>Assessment Methodology</b> |                         |              |
|-------------------------------|-------------------------|--------------|
| <b>Assessment Methodology</b> | <b>Assessment Tools</b> | <b>Marks</b> |
| Internal Test I               | Written Examination     | 10           |
| Internal Test II              | Written Examination     | 10           |
| Internal Test III             | Written Examination     | 10           |
| Assessment                    | Assignment              | 05           |
| Attendance                    | Performance             | 05           |
| Total                         |                         | 40           |

|                    |                                               |                 |          |          |          |               |
|--------------------|-----------------------------------------------|-----------------|----------|----------|----------|---------------|
| <b>PEL 26 1 03</b> | <b><i>SOCIAL NETWORKING<br/>ANALYTICS</i></b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                                               | PE              | 3        | 0        | 0        | 3             |

|                                                                                                                                                                                                                                                                                                                                                 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                           |
| <ul style="list-style-type: none"> <li>• Basic understanding of graphs, linear algebra, probability, and algorithms.</li> <li>• Basic programming knowledge, preferably in Python, for implementing network analysis techniques.</li> </ul>                                                                                                     |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                         |
| To understand the principles and methodologies of business analytics, develop skills in data preprocessing and exploratory analysis using Python and R, build predictive models for business decision-making, collaborate effectively using version control tools, and evaluate and communicate analytics outcomes for real-world applications. |

|                       |                                                                                       |    |
|-----------------------|---------------------------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                                       |    |
| CO1                   | Understand social media mining concepts and apply graph basics to represent networks. | K3 |
| CO2                   | Analyze network measures like centrality, similarity, and transitivity.               | K3 |
| CO3                   | Evaluate network models to explain real-world network structures.                     | K3 |
| CO4                   | Apply methods to detect communities and understand information diffusion.             | K3 |
| CO5                   | Analyze influence, homophily, and apply recommendation techniques.                    | K3 |

|                                                                                                                                                                                         |                         |            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|------------|
| <b>Syllabus</b>                                                                                                                                                                         |                         |            |
| <b>Unit 1</b>                                                                                                                                                                           | <b>Introduction</b>     | <b>(9)</b> |
| Social Media Mining - New Challenges for Mining - Graph Essentials: Graph basics - Graph Representation - Types of Graphs - Connectivity in Graphs - Special Graphs - Graph Algorithms. |                         |            |
| <b>Unit 2</b>                                                                                                                                                                           | <b>Network Measures</b> | <b>(9)</b> |

|                                                                                                                                                                                                                                                                                                                                                                |                                     |            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|------------|
| Centrality - Degree Centrality - Eigenvector Centrality - Katz Centrality – PageRank - Betweenness Centrality - Closeness Centrality - Group Centrality - Transitivity and Reciprocity - Balance and Status – Similarity - Structural Equivalence - Regular Equivalence.                                                                                       |                                     |            |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                  | <b>Network Models</b>               | <b>(9)</b> |
| Properties of Real-World Networks - Degree Distribution - Clustering Coefficient - Average Path Length - Random Graphs - Evolution - Properties - Small-World Model - Preferential Attachment Model.                                                                                                                                                           |                                     |            |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                  | <b>Communities and Interactions</b> | <b>(9)</b> |
| Community Analysis: Community Detection - Community Evolution - Community Evaluation. Information Diffusion in social media: Herd Behaviour - Information Cascades - Diffusion of Innovations - Epidemics.                                                                                                                                                     |                                     |            |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                  | <b>Applications</b>                 | <b>(9)</b> |
| Influence and Homophily - Measuring Assortativity - Measuring and Modelling Influence - Measuring and Modelling Homophily - Distinguishing Influence and Homophily - Shuffle Test - Edge-Reversal Test - Randomization Test - Recommendation in Social Media. Case study: Classification and Analysis of Facebook Metrics Dataset Using Supervised Classifiers |                                     |            |

|                                                                                                                                                                                                                                                                                        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                                                                                                                                     |
| 1. Zafarani, Reza, Mohammad Ali Abbasi, and Huan Liu, Social Media Mining: An Introduction, First Edition, Cambridge University Press, 2014.                                                                                                                                           |
| <b>Reference:</b>                                                                                                                                                                                                                                                                      |
| 1. Nilanjan Dey Samarjeet Borah Rosalina Babo Amira Ashour, Social Network Analytics – Computational Research Methods and Techniques, First Edition, Academic Press, 2018.<br>2. Cioffi-Revilla, Claudio, Introduction to Computational Social Science, First Edition, Springer, 2014. |
| <b>Web / NPTEL Resources:</b>                                                                                                                                                                                                                                                          |
| 1. <a href="#"><u>NPTEL – Social Networks</u></a><br>2. <a href="#"><u>NPTEL – Data Analytics with Python</u></a><br>3. <a href="#"><u>NetworkX Documentation</u></a><br>4. <a href="#"><u>SNAP (Stanford Network Analysis Platform)</u></a>                                           |

| <b>CO-PO Mapping</b> |            |            |            |            |            |            |            |            |            |             |             |             |             |
|----------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
| <b>Cos</b>           | <b>PO1</b> | <b>PO2</b> | <b>PO3</b> | <b>PO4</b> | <b>PO5</b> | <b>PO6</b> | <b>PO7</b> | <b>PO8</b> | <b>PO9</b> | <b>PO10</b> | <b>PO11</b> | <b>PSO1</b> | <b>PSO2</b> |
| CO1                  | 2          | 2          | 3          | 2          | 3          | 2          | –          | –          | –          | 2           | 1           | 3           | 2           |
| CO2                  | 3          | 3          | 3          | 3          | 3          | 2          | 1          | –          | –          | 2           | 2           | 3           | 3           |
| CO3                  | 3          | 3          | 3          | 3          | 3          | 2          | 1          | –          | –          | 2           | 2           | 3           | 3           |
| CO4                  | 3          | 2          | 3          | 3          | 3          | 3          | 2          | 1          | –          | 3           | 2           | 3           | 3           |
| CO5                  | 3          | 3          | 3          | 3          | 3          | 3          | 2          | 2          | 1          | 3           | 3           | 3           | 3           |

| <b>Assessment Methodology</b> |                         |              |
|-------------------------------|-------------------------|--------------|
| <b>Assessment Methodology</b> | <b>Assessment Tools</b> | <b>Marks</b> |
| Internal Test I               | Written Examination     | 10           |
| Internal Test II              | Written Examination     | 10           |
| Internal Test III             | Written Examination     | 10           |
| Assessment                    | Assignment              | 05           |
| Attendance                    | Performance             | 05           |
| Total                         |                         | 40           |

|                    |                                                  |                 |          |          |          |               |
|--------------------|--------------------------------------------------|-----------------|----------|----------|----------|---------------|
| <b>PEL 26 1 04</b> | <b>DATA VISUALISATION<br/>AND INTERPRETATION</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                                                  | PE              | 3        | 0        | 0        | 3             |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Knowledge on basics of Data Analytics and Python coding.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <ul style="list-style-type: none"> <li>• To introduce the fundamentals of data visualization and statistical charting techniques.</li> <li>• To impart skills in selecting visualization types appropriate to data and problem context.</li> <li>• To enable design of interactive dashboards for decision support on large-scale data.</li> <li>• To develop proficiency in multivariate and spatio-temporal visualization techniques.</li> <li>• To provide hands-on exposure to industry-standard visualization tools such as Tableau.</li> </ul> |

|                       |                                                                                                                               |    |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                                                                               |    |
| CO1                   | Analyze the different data types and visualization types to bring out the insight.                                            | K4 |
| CO2                   | Relate the visualization towards the problem based on the dataset to analyze and bring out valuable insight on large dataset. | K4 |
| CO3                   | Design visualization dashboard to support the decision making on large scale data.                                            | K6 |
| CO4                   | Demonstrate the analysis of large dataset using various visualization techniques and tools.                                   | K3 |
| CO5                   | Evaluate the effectiveness of different visualization approaches for a given analytical problem.                              | K5 |

|                                                                                                                                                                                                                                                                                                                                                                                                   |                                           |            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|------------|
| <b>Syllabus</b>                                                                                                                                                                                                                                                                                                                                                                                   |                                           |            |
| <b>Unit I</b>                                                                                                                                                                                                                                                                                                                                                                                     | <b>Introduction to Data Visualization</b> | <b>(9)</b> |
| Overview of data visualization – data abstraction – Task abstraction – Dimensions and measures – Analysis: Four Levels for validation. Statistical Charts (Bar Chart – stacked bar chart – Line chart – Histogram – Pie Chart – Frequency Polygon – Box Plot – Scatter Plot – Regression Curves.)                                                                                                 |                                           |            |
| <b>Unit II</b>                                                                                                                                                                                                                                                                                                                                                                                    | <b>Visualization Techniques</b>           | <b>(9)</b> |
| Introduction to various data visualization tools – scalar and point techniques – vector visualization techniques – multidimensional Techniques – Visualizing cluster analysis – Means and Hierarchical Cluster Techniques.                                                                                                                                                                        |                                           |            |
| <b>Unit III</b>                                                                                                                                                                                                                                                                                                                                                                                   | <b>Spatio-Temporal Data Visualization</b> | <b>(9)</b> |
| Time series data visualization – text data visualization – spatial data visualization – Visual Analytics: Networks and Trees – Heat Map – Tree Map – Map Color and other Channels Manipulate View – Visual Attributes.                                                                                                                                                                            |                                           |            |
| <b>Unit IV</b>                                                                                                                                                                                                                                                                                                                                                                                    | <b>Multivariate Data Visualization</b>    | <b>(9)</b> |
| Multivariate data visualization – Geometric Projection techniques – Icon-Based techniques – Pixel-Oriented techniques – hierarchical techniques – scatter plot Matrix – Hyper Box – Trellis display – parallel coordinates.                                                                                                                                                                       |                                           |            |
| <b>Unit V</b>                                                                                                                                                                                                                                                                                                                                                                                     | <b>Data Visualization Tools</b>           | <b>(9)</b> |
| Tableau Functions and logics: Marks and Channels – Arrange Tables – arrange spatial data – Facets into multiple views. Data Dashboard – Taxonomies – User interaction – Organizational Functions – Dashboard Design – worksheets – workbook optimization – Protection and common mistakes. Dashboard Creation using Visualization tools – Use case: Financial Marketing – Insurance – Healthcare. |                                           |            |

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|---------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                |
| 1. Tamara Munzer, Visualization Analysis and Design, 1st Edition, CRC Press, United States, 2015. |
| 2. Michael Fry, Jeffrey Ohlmann, Jeffrey Camm, James Cochran, Data Visualization: Exploring and   |

|                                                                                                                                    |
|------------------------------------------------------------------------------------------------------------------------------------|
| Explaining with Data, South-Western College Publishing, 2021.                                                                      |
| <b>Reference:</b>                                                                                                                  |
| 1. Dr. Chun-hauh Chen, W. K. Hardle, A. Unwin, Handbook of Data Visualization, 1st Edition, Springer Publication, Germany, 2008.   |
| 2. Ben Fry, Visualizing Data, 1st Edition, O'Reilly Media, United States, 2008.                                                    |
| 3. Avril Coghlan, A little book of R for multivariate analysis, 1st Edition, Welcome Trust Sanger Institute, United Kingdom, 2013. |
| <b>Web / NPTEL Resources:</b>                                                                                                      |
| <a href="http://nptel.ac.in/courses/106106179">http://nptel.ac.in/courses/106106179</a>                                            |
| <a href="http://www.tableau.com/learn/training">http://www.tableau.com/learn/training</a>                                          |

| CO-PO Mapping |     |     |     |     |     |     |     |     |     |      |      |      |      |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| Cos           | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
| CO1           | 2   | 2   | 2   | 2   | 3   | 2   | –   | –   | –   | 2    | 1    | 3    | 2    |
| CO2           | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO3           | 3   | 3   | 3   | 3   | 3   | 3   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO4           | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 1   | –   | 3    | 2    | 3    | 3    |
| CO5           | 3   | 2   | 3   | 3   | 3   | 3   | 2   | 2   | 1   | 3    | 3    | 3    | 3    |

| Assessment Methodology |                     |       |
|------------------------|---------------------|-------|
| Assessment Methodology | Assessment Tools    | Marks |
| Internal Test I        | Written Examination | 10    |
| Internal Test II       | Written Examination | 10    |
| Internal Test III      | Written Examination | 10    |
| Assessment             | Assignment          | 05    |
| Attendance             | Performance         | 05    |
| Total                  |                     | 40    |

|             |                        |          |   |   |   |        |
|-------------|------------------------|----------|---|---|---|--------|
| PEL 26 1 05 | RECOMMENDER<br>SYSTEMS | CATEGORY | L | T | P | CREDIT |
|             |                        | PE       | 3 | 0 | 0 | 3      |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Basic knowledge of data structures, statistics, linear algebra, machine learning, and Python programming.                                                                                                                                                                                                                                                                                                                                                              |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <ul style="list-style-type: none"> <li>• To introduce the fundamentals and challenges of recommender systems.</li> <li>• To impart skills in content-based and collaborative filtering techniques.</li> <li>• To enable development of hybrid recommendation models.</li> <li>• To familiarize students with matrix factorization and model-based approaches.</li> <li>• To develop the ability to design and evaluate domain-specific recommender systems.</li> </ul> |

|                       |                                                                  |    |
|-----------------------|------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                  |    |
| CO1                   | Understand the importance and challenges of recommender systems. | K2 |
| CO2                   | Apply content-based filtering techniques.                        | K3 |
| CO3                   | Implement collaborative filtering methods.                       | K3 |
| CO4                   | Develop hybrid recommendation models.                            | K6 |
| CO5                   | Design and evaluate a domain-specific recommender system.        | K6 |

|                                                                                                                                                                                                                                                                                                                   |                                |            |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|------------|
| <b>Syllabus</b>                                                                                                                                                                                                                                                                                                   |                                |            |
| <b>Unit I</b>                                                                                                                                                                                                                                                                                                     | <b>Introduction</b>            | <b>(9)</b> |
| Introduction, Recommender Systems Function, Data and Knowledge Sources, Recommendation Techniques, Application and Evaluation, Recommender Systems and Human Computer Interaction, Recommender Systems as a Multi-Disciplinary Field, Recommender Systems Challenges.                                             |                                |            |
| <b>Unit II</b>                                                                                                                                                                                                                                                                                                    | <b>Content-based Filtering</b> | <b>(9)</b> |
| High level architecture of content-based systems, Advantages and drawbacks of content-based filtering, Item profiles, discovering features of documents, pre-processing and feature extraction, obtaining item features from tags, Methods for learning user profiles, Similarity based retrieval, Classification |                                |            |

|                                                                                                                                                                                                                                                                                  |                                      |            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|------------|
| algorithms.                                                                                                                                                                                                                                                                      |                                      |            |
| <b>Unit III</b>                                                                                                                                                                                                                                                                  | <b>Collaborative Filtering</b>       | <b>(9)</b> |
| User-based recommendation, Item-based recommendation, Model based approaches, Matrix factorization, Attacks on Collaborative recommender systems.                                                                                                                                |                                      |            |
| <b>Unit IV</b>                                                                                                                                                                                                                                                                   | <b>Hybrid Approaches</b>             | <b>(9)</b> |
| Opportunities for hybridization, Monolithic hybridization design: Feature combination, Feature augmentation, Parallelized hybridization design: Weighted, Switching, Mixed, Pipelined hybridization design: Cascade Meta-level, Limitations of hybridization strategies.         |                                      |            |
| <b>Unit V</b>                                                                                                                                                                                                                                                                    | <b>Evaluating Recommender System</b> | <b>(9)</b> |
| Recommendation System Properties: Accuracy, Coverage, confidence, Trust, novelty, serendipity, diversity, Experimental Settings: Offline Experiments and Online Evaluation. Case Studies: Recommender systems in personalized web search and knowledge-based recommender system. |                                      |            |

|                                                                                                                                                                                                                                         |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                                                                                      |
| 1. Ricci F., Rokach L., Shapira D., Kantor B.P., Recommender Systems Handbook, Springer, First Edition, 2011.                                                                                                                           |
| 2. Jannach D., Zanker M. and Felfering A., Recommender Systems: An Introduction, Cambridge University Press, First Edition, 2011.                                                                                                       |
| 3. Charu C. Aggarwal, Recommender Systems: The Textbook, Springer, First Edition, 2016.                                                                                                                                                 |
| <b>Reference:</b>                                                                                                                                                                                                                       |
| 1. Manouselis N., Drachsler H., Verbert K., Duval E., Recommender Systems For Learning, Springer, First Edition, 2013.                                                                                                                  |
| <b>Web / NPTEL Resources:</b>                                                                                                                                                                                                           |
| <a href="https://www.tensorflow.org/recommenders">https://www.tensorflow.org/recommenders</a><br><a href="https://surpriselib.com">https://surpriselib.com</a><br><a href="https://nptel.ac.in/courses">https://nptel.ac.in/courses</a> |

|                      |
|----------------------|
| <b>CO-PO Mapping</b> |
|----------------------|

| <b>Cos</b> | <b>PO1</b> | <b>PO2</b> | <b>PO3</b> | <b>PO4</b> | <b>PO5</b> | <b>PO6</b> | <b>PO7</b> | <b>PO8</b> | <b>PO9</b> | <b>PO10</b> | <b>PO11</b> | <b>PSO1</b> | <b>PSO2</b> |
|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
| CO1        | 2          | 2          | 2          | 2          | 2          | 2          | –          | –          | –          | 2           | 1           | 3           | 2           |
| CO2        | 3          | 3          | 3          | 3          | 3          | 2          | 1          | –          | –          | 2           | 2           | 3           | 3           |
| CO3        | 3          | 3          | 3          | 3          | 3          | 3          | 1          | –          | –          | 2           | 2           | 3           | 3           |
| CO4        | 3          | 2          | 3          | 3          | 3          | 3          | 2          | 1          | –          | 3           | 2           | 3           | 3           |
| CO5        | 3          | 3          | 3          | 3          | 3          | 3          | 2          | 2          | 1          | 3           | 3           | 3           | 3           |

| <b>Assessment Methodology</b> |                         |              |
|-------------------------------|-------------------------|--------------|
| <b>Assessment Methodology</b> | <b>Assessment Tools</b> | <b>Marks</b> |
| Internal Test I               | Written Examination     | 10           |
| Internal Test II              | Written Examination     | 10           |
| Internal Test III             | Written Examination     | 10           |
| Assessment                    | Assignment              | 05           |
| Attendance                    | Performance             | 05           |
| Total                         |                         | 40           |

| PEL 26 1 06 | RESPONSIBLE AI | CATEGORY | L | T | P | CREDIT |
|-------------|----------------|----------|---|---|---|--------|
|             |                | PE       | 3 | 0 | 0 | 3      |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Basic knowledge of machine learning and data analysis.                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <ul style="list-style-type: none"> <li>• To introduce the principles of fairness, accountability, bias, and privacy in AI.</li> <li>• To enable assessment of fairness and ethics in AI models.</li> <li>• To impart methods for reducing bias and ensuring fairness in data and models.</li> <li>• To familiarize students with privacy-preserving techniques in AI.</li> <li>• To develop the ability to design responsible AI solutions with awareness of accuracy trade-offs.</li> </ul> |

|                       |                                                                           |    |
|-----------------------|---------------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                           |    |
| CO1                   | Understand concepts of fairness, accountability, bias, and privacy in AI. | K2 |
| CO2                   | Assess fairness and ethics in AI models.                                  | K5 |
| CO3                   | Apply methods to reduce bias and ensure fairness in data and models.      | K3 |
| CO4                   | Implement privacy-preserving techniques in AI.                            | K3 |
| CO5                   | Develop responsible AI solutions with awareness of accuracy trade-offs.   | K6 |

|                                                                                                                                                                                                                                                                                                                 |                                            |            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|------------|
| <b>Syllabus</b>                                                                                                                                                                                                                                                                                                 |                                            |            |
| <b>Unit I</b>                                                                                                                                                                                                                                                                                                   | <b>Introduction</b>                        | <b>(9)</b> |
| Introduction to responsible AI: Need for ethics in AI, AI for Society and Humanity. Fairness and Bias: Sources of Biases, Exploratory data analysis, limitation of a dataset, Preprocessing, in-processing and post-processing to remove bias, Group fairness and Individual fairness, Counterfactual fairness. |                                            |            |
| <b>Unit II</b>                                                                                                                                                                                                                                                                                                  | <b>Interpretability and Explainability</b> | <b>(9)</b> |

|                                                                                                                                                                                                                 |                                  |            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|------------|
| Interpretability through simplification and visualization, Intrinsic interpretable methods, Post Hoc interpretability, Explainability through causality, Model agnostic interpretation.                         |                                  |            |
| <b>Unit III</b>                                                                                                                                                                                                 | <b>Ethics and Accountability</b> | <b>(9)</b> |
| Auditing AI models, fairness assessment, Principles for ethical practices. Accountability: Black-box problem, Algorithmic accountability, responsibility in decision-making by AI, case studies of AI failures. |                                  |            |
| <b>Unit IV</b>                                                                                                                                                                                                  | <b>Privacy Preservation</b>      | <b>(9)</b> |
| Attack models, Privacy-preserving Learning, Differential privacy, Federated learning – concepts, significance and applications.                                                                                 |                                  |            |
| <b>Unit V</b>                                                                                                                                                                                                   | <b>Case Study</b>                | <b>(9)</b> |
| Recommendation systems, Medical diagnosis, Hiring/Education, Computer Vision, Natural Language Processing, smart cities.                                                                                        |                                  |            |

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|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 1. Virginia Dignum, Responsible Artificial Intelligence: How to Develop and Use AI in a Responsible Way, Springer Nature, 2019.                                                                                                                                                                                                                                                                                                                      |
| 2. Christoph Molnar, Interpretable Machine Learning, Lulu, 1st Edition, 2019.                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Reference:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <ul style="list-style-type: none"> <li>Responsible AI: Implement an Ethical Approach in Your Organization – Adnan Masood and Adenrele Awotunde, Packt Publishing, 2024.</li> <li>Responsible Artificial Intelligence: How to Develop and Use AI in a Responsible Way – Virginia Dignum, Springer, 2019.</li> <li>Ethics of Artificial Intelligence and Robotics – Vincent C. Müller (Ed.), Springer Handbook of Robotics, Springer, 2021.</li> </ul> |
| <b>Web / NPTEL Resources:</b>                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <a href="http://nptel.ac.in/courses">http://nptel.ac.in/courses</a><br><a href="http://ai.google/responsibility">http://ai.google/responsibility</a>                                                                                                                                                                                                                                                                                                 |

| <b>CO-PO Mapping</b> |            |            |            |            |            |            |            |            |            |             |             |             |             |
|----------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
| <b>Cos</b>           | <b>PO1</b> | <b>PO2</b> | <b>PO3</b> | <b>PO4</b> | <b>PO5</b> | <b>PO6</b> | <b>PO7</b> | <b>PO8</b> | <b>PO9</b> | <b>PO10</b> | <b>PO11</b> | <b>PSO1</b> | <b>PSO2</b> |
| CO1                  | 2          | 2          | 2          | 2          | 2          | 3          | 2          | 2          | 1          | 2           | 2           | 3           | 2           |
| CO2                  | 3          | 3          | 3          | 3          | 3          | 2          | 1          | 1          | –          | 2           | 2           | 3           | 3           |
| CO3                  | 3          | 3          | 2          | 3          | 2          | 3          | 3          | 3          | 2          | 3           | 3           | 2           | 3           |
| CO4                  | 3          | 2          | 3          | 3          | 3          | 3          | 2          | 2          | 1          | 2           | 2           | 3           | 3           |
| CO5                  | 3          | 3          | 3          | 3          | 3          | 3          | 2          | 2          | 2          | 3           | 3           | 3           | 3           |

| <b>Assessment Methodology</b> |                         |              |
|-------------------------------|-------------------------|--------------|
| <b>Assessment Methodology</b> | <b>Assessment Tools</b> | <b>Marks</b> |
| Internal Test I               | Written Examination     | 10           |
| Internal Test II              | Written Examination     | 10           |
| Internal Test III             | Written Examination     | 10           |
| Assessment                    | Assignment              | 05           |
| Attendance                    | Performance             | 05           |
| Total                         |                         | 40           |

# **SEMESTER – II**

# **ELECTIVES**

|             |                                   |                 |          |          |          |               |
|-------------|-----------------------------------|-----------------|----------|----------|----------|---------------|
| PEL 26 2 01 | <b>PARALLEL AND GPU COMPUTING</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|             |                                   | PE              | 3        | 0        | 0        | 3             |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Basic knowledge of computer architecture, programming and data structures.                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <ul style="list-style-type: none"> <li>• To introduce parallel computing concepts, architectures, and performance metrics.</li> <li>• To enable application of parallel programming models for concurrent execution.</li> <li>• To develop GPU-based programs using the CUDA programming model.</li> <li>• To implement parallel algorithms and analyze their efficiency.</li> <li>• To explore real-world applications of GPU computing in data analytics.</li> </ul> |

|                       |                                                                        |    |
|-----------------------|------------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                        |    |
| CO1                   | Understand parallel computing, architectures, and performance metrics. | K2 |
| CO2                   | Apply parallel programming models for concurrent execution.            | K3 |
| CO3                   | Develop GPU-based programs using the CUDA programming model.           | K6 |
| CO4                   | Implement parallel algorithms and analyze their efficiency.            | K4 |
| CO5                   | Explore real-world applications of GPU computing.                      | K3 |

|                                                                                                                                                                                                                       |                                              |            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|------------|
| <b>Syllabus</b>                                                                                                                                                                                                       |                                              |            |
| <b>Unit I</b>                                                                                                                                                                                                         | <b>Introduction to Parallel Computing</b>    | <b>(9)</b> |
| Overview of Parallel Computing – Need and Scope – Flynn’s Taxonomy – Types of Parallelism – Shared Memory and Distributed Memory Architectures – Amdahl’s Law – Performance Metrics – Applications in Data Analytics. |                                              |            |
| <b>Unit II</b>                                                                                                                                                                                                        | <b>Parallel Programming Models and Tools</b> | <b>(9)</b> |
| Message Passing Interface (MPI) – Concepts of Communication and Synchronization – Point-to-Point and Collective Communication – OpenMP Programming Model – Fork-Join Model – Parallel Directives                      |                                              |            |

|                                                                                                                                                                                                                                                                             |                                                          |            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|------------|
| and Synchronization Constructs – Parallel Debugging and Profiling Tools.                                                                                                                                                                                                    |                                                          |            |
| <b>Unit III</b>                                                                                                                                                                                                                                                             | <b>GPU Architecture and Programming Basics</b>           | <b>(9)</b> |
| Introduction to GPUs – Differences Between CPU and GPU Architectures – CUDA Programming Model – Threads, Blocks, and Grids – Memory Hierarchy in CUDA – Writing and Launching CUDA Kernels – CUDA Memory Management – Synchronization and Thread Divergence.                |                                                          |            |
| <b>Unit IV</b>                                                                                                                                                                                                                                                              | <b>Parallel Algorithms and Data Structures</b>           | <b>(9)</b> |
| Parallel Algorithms for Matrix Operations – Reduction – Scan – Sorting – Searching – MapReduce Model – Load Balancing and Scalability Issues – Data Parallelism in Data Analytics Workflows.                                                                                |                                                          |            |
| <b>Unit V</b>                                                                                                                                                                                                                                                               | <b>Applications and Advanced Topics in GPU Computing</b> | <b>(9)</b> |
| High-Performance Computing (HPC) for Data Analytics – Use Cases: Deep Learning, Image Processing, Real-Time Analytics – GPU Libraries (cuBLAS, cuDNN, Thrust) – Introduction to TensorFlow and PyTorch with GPU Acceleration – Future Trends in Parallel and GPU Computing. |                                                          |            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 1. Michael J. Quinn, Parallel Programming in C with MPI and OpenMP, McGraw Hill Education India, 2017.                                                                                                                                                                                                                                                                                                                                                                                                      |
| 2. Jason Sanders and Edward Kandrot, CUDA by Example: An Introduction to General-Purpose GPU Programming, Addison-Wesley, 2010.                                                                                                                                                                                                                                                                                                                                                                             |
| 3. Brian Tuomanen, Hands-On GPU Programming with Python and CUDA, Packt Publishing, 2018.                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Reference:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <ul style="list-style-type: none"> <li>• Programming Massively Parallel Processors: A Hands-on Approach – David B. Kirk and Wen-mei W. Hwu, 4th Edition, Morgan Kaufmann (Elsevier), 2022.</li> <li>• CUDA by Example: An Introduction to General-Purpose GPU Programming – Jason Sanders and Edward Kandrot, Addison-Wesley Professional, 2010.</li> <li>• Introduction to Parallel Computing – Ananth Grama, Anshul Gupta, George Karypis, and Vipin Kumar, 2nd Edition, Addison-Wesley, 2003.</li> </ul> |
| <b>Web / NPTEL Resources:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <a href="https://developer.nvidia.com/cuda-zone">https://developer.nvidia.com/cuda-zone</a><br><a href="https://nptel.ac.in/courses">https://nptel.ac.in/courses</a>                                                                                                                                                                                                                                                                                                                                        |

| <b>CO-PO Mapping</b> |            |            |            |            |            |            |            |            |            |             |             |             |             |
|----------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
| <b>Cos</b>           | <b>PO1</b> | <b>PO2</b> | <b>PO3</b> | <b>PO4</b> | <b>PO5</b> | <b>PO6</b> | <b>PO7</b> | <b>PO8</b> | <b>PO9</b> | <b>PO10</b> | <b>PO11</b> | <b>PSO1</b> | <b>PSO2</b> |
| CO1                  | 2          | 2          | 2          | 2          | 3          | 2          | –          | –          | –          | 2           | 1           | 3           | 2           |
| CO2                  | 3          | 3          | 3          | 3          | 3          | 2          | 1          | –          | –          | 2           | 2           | 3           | 3           |
| CO3                  | 3          | 3          | 3          | 3          | 3          | 3          | 1          | –          | –          | 2           | 2           | 3           | 3           |
| CO4                  | 3          | 3          | 3          | 3          | 3          | 3          | 2          | 1          | –          | 3           | 2           | 3           | 3           |
| CO5                  | 3          | 3          | 3          | 3          | 3          | 3          | 2          | 2          | 1          | 3           | 3           | 3           | 3           |

| <b>Assessment Methodology</b> |                         |              |
|-------------------------------|-------------------------|--------------|
| <b>Assessment Methodology</b> | <b>Assessment Tools</b> | <b>Marks</b> |
| Internal Test I               | Written Examination     | 10           |
| Internal Test II              | Written Examination     | 10           |
| Internal Test III             | Written Examination     | 10           |
| Assessment                    | Assignment              | 05           |
| Attendance                    | Performance             | 05           |
| Total                         |                         | 40           |

| <b>PEL 26 2 02</b> | <b>CLOUD COMPUTING</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|--------------------|------------------------|-----------------|----------|----------|----------|---------------|
|                    |                        | PE              | 3        | 0        | 0        | 3             |

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| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Basic understanding of networking, operating systems, databases, and programming.                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <ul style="list-style-type: none"> <li>• To introduce core concepts, models, and technologies in cloud computing.</li> <li>• To analyse cloud infrastructure for scalable data analytics solutions.</li> <li>• To enable use of cloud platforms and services for big data and real-time analytics.</li> <li>• To implement secure and efficient data processing using cloud-based tools.</li> <li>• To apply cloud AI/ML services for advanced analytics applications.</li> </ul> |

|                       |                                                                         |    |
|-----------------------|-------------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                         |    |
| CO1                   | Understand core concepts, models, and technologies in cloud computing.  | K2 |
| CO2                   | Analyse cloud infrastructure for scalable data analytics solutions.     | K4 |
| CO3                   | Use cloud platforms and services for big data and real-time analytics.  | K3 |
| CO4                   | Implement secure and efficient data processing using cloud-based tools. | K3 |
| CO5                   | Apply cloud AI/ML services for advanced analytics applications.         | K3 |

|                                                                                                                                                                                           |                                          |            |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|------------|
| <b>Syllabus</b>                                                                                                                                                                           |                                          |            |
| <b>Unit I</b>                                                                                                                                                                             | <b>Fundamentals of Cloud Computing</b>   | <b>(9)</b> |
| Definition and characteristics – Service models: IaaS, PaaS, SaaS – Deployment models: public, private, hybrid – Virtualization technologies – Benefits and challenges in data analytics. |                                          |            |
| <b>Unit II</b>                                                                                                                                                                            | <b>Cloud Infrastructure and Services</b> | <b>(9)</b> |

|                                                                                                                                                                                         |                                                |            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|------------|
| Compute and storage services – Elasticity and scalability – Cloud networking basics – Load balancing – Introduction to containerization (Docker, Kubernetes) for analytics workloads.   |                                                |            |
| <b>Unit III</b>                                                                                                                                                                         | <b>Cloud Platforms for Data Analytics</b>      | <b>(9)</b> |
| AWS, Azure, Google Cloud overview – Cloud-native analytics tools (Amazon Redshift, BigQuery, Azure Synapse) – Data lakes vs data warehouses – Serverless computing for ETL.             |                                                |            |
| <b>Unit IV</b>                                                                                                                                                                          | <b>Data Management and Processing on Cloud</b> | <b>(9)</b> |
| Big data processing frameworks: Hadoop, Spark – Cloud storage options: S3, Blob storage – Stream data processing with cloud services – Data security and compliance in cloud analytics. |                                                |            |
| <b>Unit V</b>                                                                                                                                                                           | <b>Advanced Topics and Applications</b>        | <b>(9)</b> |
| Cloud-based ML and AI services – AutoML tools – Edge and fog computing – Cost optimization strategies – Case studies: real-time analytics, predictive analytics in the cloud.           |                                                |            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 1. Rajkumar Buyya, Christian Vecchiola, and Thamarai Selvi, Mastering Cloud Computing: Foundations and Applications Programming, McGraw Hill Education, 2022.                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| 2. Gautam Shroff, Enterprise Cloud Computing: Technology, Architecture, Applications, Cambridge University Press, Reprint Edition, 2021.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Reference:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <ul style="list-style-type: none"> <li>• Cloud Computing: Concepts, Technology &amp; Architecture – Thomas Erl, Ricardo Puttini, and Zaigham Mahmood, Pearson Education, 2013.</li> <li>• Cloud Computing: Theory and Practice – Dan C. Marinescu, 2nd Edition, Morgan Kaufmann (Elsevier), 2017.</li> <li>• Mastering Cloud Computing: Foundations and Applications Programming – Rajkumar Buyya, Christian Vecchiola, and S. Thamarai Selvi, Morgan Kaufmann (Elsevier), 2013.</li> <li>• Cloud Computing: Principles and Paradigms – Rajkumar Buyya, James Broberg, and Andrzej Goscinski (Eds.), Wiley, 2011.</li> </ul> |
| <b>Web / NPTEL Resources:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <a href="https://nptel.ac.in/courses/106105167">https://nptel.ac.in/courses/106105167</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

| <b>CO-PO Mapping</b> |            |            |            |            |            |            |            |            |            |             |             |             |             |
|----------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|-------------|-------------|-------------|-------------|
| <b>Cos</b>           | <b>PO1</b> | <b>PO2</b> | <b>PO3</b> | <b>PO4</b> | <b>PO5</b> | <b>PO6</b> | <b>PO7</b> | <b>PO8</b> | <b>PO9</b> | <b>PO10</b> | <b>PO11</b> | <b>PSO1</b> | <b>PSO2</b> |
| CO1                  | 2          | 2          | 2          | 2          | 3          | 2          | –          | –          | –          | 2           | 1           | 3           | 2           |
| CO2                  | 3          | 3          | 3          | 3          | 3          | 2          | 1          | –          | –          | 2           | 2           | 3           | 3           |
| CO3                  | 3          | 3          | 3          | 3          | 3          | 3          | 1          | –          | –          | 2           | 2           | 3           | 3           |
| CO4                  | 3          | 3          | 3          | 3          | 3          | 3          | 2          | 1          | –          | 3           | 2           | 3           | 3           |
| CO5                  | 3          | 3          | 3          | 3          | 3          | 3          | 2          | 2          | 1          | 3           | 3           | 3           | 3           |

| <b>Assessment Methodology</b> |                         |              |
|-------------------------------|-------------------------|--------------|
| <b>Assessment Methodology</b> | <b>Assessment Tools</b> | <b>Marks</b> |
| Internal Test I               | Written Examination     | 10           |
| Internal Test II              | Written Examination     | 10           |
| Internal Test III             | Written Examination     | 10           |
| Assessment                    | Assignment              | 05           |
| Attendance                    | Performance             | 05           |
| Total                         |                         | 40           |

|             |                         |          |   |   |   |        |
|-------------|-------------------------|----------|---|---|---|--------|
| PEL 26 2 03 | MULTIMODAL<br>ANALYTICS | CATEGORY | L | T | P | CREDIT |
|             |                         | PE       | 3 | 0 | 0 | 3      |

|                                                                                                                                                                                                                                                                                                                                                                                                                       |
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| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                 |
| Basic Programming, Mathematics, Machine Learning, Data Analysis, and understanding of Data Types.                                                                                                                                                                                                                                                                                                                     |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                               |
| <ul style="list-style-type: none"> <li>• To understand the principles of multimodal data integration.</li> <li>• To learn representation and fusion techniques for multimodal data.</li> <li>• To apply multimodal analytics in real-world scenarios.</li> <li>• To develop skills for ethical data handling and decision-making.</li> <li>• To explore emerging trends and career paths in multimodal AI.</li> </ul> |

|                       |                                                                     |    |
|-----------------------|---------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                     |    |
| CO1                   | Understand the principles of multimodal data integration.           | K2 |
| CO2                   | Learn representation and fusion techniques.                         | K3 |
| CO3                   | Apply multimodal analytics in real-world scenarios.                 | K3 |
| CO4                   | Develop skills for ethical data handling and decision-making.       | K6 |
| CO5                   | Evaluate multimodal models for interpretability and explainability. | K5 |

|                                                                                                                                                                                                                                    |                                                    |            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|------------|
| <b>Syllabus</b>                                                                                                                                                                                                                    |                                                    |            |
| <b>Unit I</b>                                                                                                                                                                                                                      | <b>Introduction to Multimodal Analytics</b>        | <b>(9)</b> |
| Definitions & Scope – Importance and Challenges – Types of Modalities – Overview of Use-Cases: Healthcare, Autonomous Vehicles, Retail, Security – Tools & Libraries: Python, TensorFlow, PyTorch, HuggingFace Multimodal toolkit. |                                                    |            |
| <b>Unit II</b>                                                                                                                                                                                                                     | <b>Representation Learning for Multimodal Data</b> | <b>(9)</b> |
| Data Preprocessing Techniques – Feature Extraction: Text, Image, Audio – Representation Models:                                                                                                                                    |                                                    |            |

|                                                                                                                                                                                                                     |                                                    |            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|------------|
| Autoencoders, Word2Vec, CNN, Transformers – Data Alignment Techniques – Temporal & Spatial.                                                                                                                         |                                                    |            |
| <b>Unit III</b>                                                                                                                                                                                                     | <b>Fusion Techniques for Multimodal Data</b>       | <b>(9)</b> |
| Early Fusion, Late Fusion, and Hybrid Fusion – Tensor Fusion Networks – Attention Mechanisms – Architectures: Multimodal Transformers, Multimodal Variational Autoencoders.                                         |                                                    |            |
| <b>Unit IV</b>                                                                                                                                                                                                      | <b>Applications of Multimodal Analytics</b>        | <b>(9)</b> |
| Sentiment Analysis across modalities – Multimodal Healthcare Analytics – Recommendation Systems using multimodal data – Human Activity Recognition using video and sensor fusion – Robotics and Autonomous Systems. |                                                    |            |
| <b>Unit V</b>                                                                                                                                                                                                       | <b>Case Studies, Ethics, and Future Directions</b> | <b>(9)</b> |
| Multimodal Analytics for Smart Cities – Privacy, Security, and Ethical Challenges – Interpretability and Explainability in Multimodal Models – Career Paths and Industry Trends – Future of Multimodal AI.          |                                                    |            |

|                                                                                                                  |
|------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                               |
| 1. Susan Shu Chang et al., AI Superstream: Multimodal Generative AI, O'Reilly Media, 2024.                       |
| <b>Reference:</b>                                                                                                |
| 1. Santosh Kumar & Sanjay Kumar Singh, Multimodal Machine Learning: Techniques and Applications, Elsevier, 2021. |
| <b>Web / NPTEL Resources:</b>                                                                                    |
| <a href="https://nptel.ac.in/courses">https://nptel.ac.in/courses</a>                                            |

| CO-PO Mapping |     |     |     |     |     |     |     |     |     |      |      |      |      |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| Cos           | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
| CO1           | 2   | 2   | 2   | 2   | 3   | 2   | –   | –   | –   | 2    | 1    | 3    | 2    |
| CO2           | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO3           | 3   | 3   | 3   | 3   | 3   | 3   | 1   | 1   | –   | 2    | 2    | 3    | 3    |
| CO4           | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 1   | 1   | 3    | 2    | 3    | 3    |
| CO5           | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 2   | 3    | 3    | 3    | 3    |

| <b>Assessment Methodology</b> |                         |              |
|-------------------------------|-------------------------|--------------|
| <b>Assessment Methodology</b> | <b>Assessment Tools</b> | <b>Marks</b> |
| Internal Test I               | Written Examination     | 10           |
| Internal Test II              | Written Examination     | 10           |
| Internal Test III             | Written Examination     | 10           |
| Assessment                    | Assignment              | 05           |
| Attendance                    | Performance             | 05           |
| Total                         |                         | 40           |

|                    |                                            |                 |          |          |          |               |
|--------------------|--------------------------------------------|-----------------|----------|----------|----------|---------------|
| <b>PEL 26 2 04</b> | <b><i>IOT AND PREDICTIVE ANALYTICS</i></b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                                            | PE              | 3        | 0        | 0        | 3             |

|                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                                  |
| Basic knowledge of programming, statistics, machine learning, databases, and computer networks.                                                                                                                                                                                                                                                                                                                                        |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                |
| <ul style="list-style-type: none"> <li>• To describe IoT architecture, components, and communication protocols.</li> <li>• To enable collection, storage, and preprocessing of IoT data for analytics.</li> <li>• To apply predictive models for analysis and forecasting.</li> <li>• To perform predictive analytics on IoT data for real-world use cases.</li> <li>• To evaluate IoT platforms and explore future trends.</li> </ul> |

|                       |                                                                     |    |
|-----------------------|---------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                     |    |
| CO1                   | Describe IoT architecture, components, and communication protocols. | K2 |
| CO2                   | Collect, store, and preprocess IoT data for analytics.              | K3 |
| CO3                   | Apply predictive models for analysis and forecasting.               | K3 |
| CO4                   | Perform predictive analytics on IoT data for real-world use cases.  | K4 |
| CO5                   | Evaluate IoT platforms and explore future trends.                   | K5 |

|                                                                                                    |                            |            |
|----------------------------------------------------------------------------------------------------|----------------------------|------------|
| <b>Syllabus</b>                                                                                    |                            |            |
| <b>Unit I</b>                                                                                      | <b>Introduction to IoT</b> | <b>(9)</b> |
| Definition and Evolution of IoT – IoT Ecosystem – IoT Architecture – Physical and Logical Design – |                            |            |

|                                                                                                                                                                                                                                                                          |                                             |            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|------------|
| IoT Enabling Technologies – Sensors and Actuators – Communication Protocols (Zigbee – Bluetooth – MQTT – HTTP – CoAP) – IoT Applications in Data Analytics.                                                                                                              |                                             |            |
| <b>Unit II</b>                                                                                                                                                                                                                                                           | <b>IoT Data Acquisition and Management</b>  | <b>(9)</b> |
| Data Collection from IoT Devices – Streaming Data and Time-Series – Edge vs. Cloud Computing – Data Storage Solutions (InfluxDB – MongoDB – AWS IoT Core) – Real-Time Data Processing – Sensor Data Characteristics – Preprocessing IoT Data for Analytics.              |                                             |            |
| <b>Unit III</b>                                                                                                                                                                                                                                                          | <b>Introduction to Predictive Analytics</b> | <b>(9)</b> |
| Definition and Importance – Types of Predictive Models – Supervised Learning Techniques – Linear and Logistic Regression – Decision Trees – Random Forests – Time Series Forecasting – Model Evaluation: MAE – RMSE – $R^2$ – Cross-Validation.                          |                                             |            |
| <b>Unit IV</b>                                                                                                                                                                                                                                                           | <b>Predictive Analytics on IoT Data</b>     | <b>(9)</b> |
| Data Integration from IoT Sources – Feature Engineering for Sensor Data – Predictive Maintenance – Anomaly Detection – Forecasting with IoT Data (ARIMA – LSTM – Prophet) – Visualization and Dashboarding – Case Studies in Smart Cities, Healthcare, and Industry 4.0. |                                             |            |
| <b>Unit V</b>                                                                                                                                                                                                                                                            | <b>IoT Platforms and Future Trends</b>      | <b>(9)</b> |
| Overview of IoT Platforms (ThingSpeak – AWS IoT – Google Cloud IoT – Azure IoT Hub) – Security and Privacy in IoT Data – Ethics in Predictive Analytics – Federated Learning for IoT – Edge AI – Role of AI/ML in Future IoT Systems – Research Directions.              |                                             |            |

|                                                                                                                                                                                                                                                                                                 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                                                                                                                                              |
| 1. Arshdeep Bahga & Vijay Madisetti, Internet of Things: A Hands-On Approach, Orient Blackswan, 1st Edition, 2015.                                                                                                                                                                              |
| 2. Eric Siegel, Predictive Analytics: The Power to Predict Who Will Click, Buy, Lie, or Die, John Wiley & Sons Inc, 2016.                                                                                                                                                                       |
| <b>Reference:</b>                                                                                                                                                                                                                                                                               |
| <ul style="list-style-type: none"> <li>Internet of Things: A Hands-On Approach – Arshdeep Bahga and Vijay Madisetti, Universities Press, 2015.</li> <li>The Internet of Things: Enabling Technologies, Platforms, and Use Cases – Pethuru Raj and Anupama C. Raman, CRC Press, 2017.</li> </ul> |

**Web / NPTEL Resources:**<http://nptel.ac.in/courses>**CO-PO Mapping**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 2   | 2   | 2   | 2   | 3   | 2   | –   | –   | –   | 2    | 1    | 3    | 2    |
| CO2 | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO3 | 3   | 3   | 3   | 3   | 3   | 3   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO4 | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 1   | 1   | 3    | 2    | 3    | 3    |
| CO5 | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 2   | 3    | 3    | 3    | 3    |

**Assessment Methodology**

| Assessment Methodology | Assessment Tools    | Marks |
|------------------------|---------------------|-------|
| Internal Test I        | Written Examination | 10    |
| Internal Test II       | Written Examination | 10    |
| Internal Test III      | Written Examination | 10    |
| Assessment             | Assignment          | 05    |
| Attendance             | Performance         | 05    |
| Total                  |                     | 40    |

|             |                                                      |                 |          |          |          |               |
|-------------|------------------------------------------------------|-----------------|----------|----------|----------|---------------|
| PEL 26 2 05 | <b>OPTIMISATION<br/>TECHNIQUES FOR<br/>ANALYTICS</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|             |                                                      | PE              | 3        | 0        | 0        | 3             |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Basic knowledge of linear algebra, calculus, and probability. Familiarity with Python programming and data analysis techniques.                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <ul style="list-style-type: none"> <li>• To describe basic optimization concepts and methods like least squares, SVM, and convex functions.</li> <li>• To enable use of descent methods to solve convex and smooth optimization problems.</li> <li>• To analyze momentum and stochastic gradient methods in machine learning.</li> <li>• To apply first-order methods to constrained and non-smooth optimization.</li> <li>• To develop dual optimization algorithms and apply them to real-world problems.</li> </ul> |

|                       |                                                                                                 |    |
|-----------------------|-------------------------------------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                                                 |    |
| CO1                   | Describe basic optimization concepts and methods like least squares, SVM, and convex functions. | K2 |
| CO2                   | Use descent methods to solve convex and smooth optimization problems.                           | K3 |
| CO3                   | Analyze momentum and stochastic gradient methods in machine learning.                           | K4 |
| CO4                   | Apply first-order methods to constrained and non-smooth optimization.                           | K3 |
| CO5                   | Develop dual optimization algorithms and apply them to real-world problems.                     | K6 |

|                                                                                                                                                                                                   |                     |            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>Syllabus</b>                                                                                                                                                                                   |                     |            |
| <b>Unit I</b>                                                                                                                                                                                     | <b>Introduction</b> | <b>(9)</b> |
| Data Analysis and Optimization – Least Squares – Matrix Factorization Problems – SVM – LR – Deep Learning – Foundations of Smooth Optimization – A Taxonomy of Solutions to Optimization Problems |                     |            |

|                                                                                                                                                                                                                                                                                                                                        |                                                             |            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|------------|
| – Taylor’s Theorem – Characterizing Minima of Smooth Functions – Convex Sets and Functions – Strongly Convex Functions.                                                                                                                                                                                                                |                                                             |            |
| <b>Unit II</b>                                                                                                                                                                                                                                                                                                                         | <b>Descent Methods</b>                                      | <b>(9)</b> |
| Descent Directions – Steepest-Descent Method – General Case – Convex Case – Strongly Convex Case – Comparison between Rates – Descent Methods: Convergence – Line-Search Methods – Convergence to Approximate Second-Order Necessary Points – Mirror Descent – The KL and PL Properties.                                               |                                                             |            |
| <b>Unit III</b>                                                                                                                                                                                                                                                                                                                        | <b>Gradient Methods Using Momentum / Coordinate Descent</b> | <b>(9)</b> |
| Differential Equations – Nesterov’s Method: Convex Quadratics – Convergence for Strongly Convex and Weakly Convex Functions – Conjugate Gradient Methods – Lower Bounds on Convergence Rates – Stochastic Gradient: Noisy Gradients – Incremental Gradient Method – Coordinate Descent in Machine Learning – Block-Coordinate Descent. |                                                             |            |
| <b>Unit IV</b>                                                                                                                                                                                                                                                                                                                         | <b>First-Order Methods for Constrained Optimization</b>     | <b>(9)</b> |
| Optimality Conditions – Euclidean Projection – Projected Gradient Algorithm – Conditional Gradient (Frank–Wolfe) Method – Sub-gradients and Subdifferentials – Calculus of Subdifferentials – Convex Sets and Convex Constrained Optimization – Optimality Conditions for Composite Non-smooth Functions.                              |                                                             |            |
| <b>Unit V</b>                                                                                                                                                                                                                                                                                                                          | <b>Duality and Algorithms</b>                               | <b>(9)</b> |
| Quadratic Penalty Function – Lagrangians and Duality – First-Order Optimality Conditions – Strong Duality – Dual Algorithms – Applications of Dual Algorithms: Consensus Optimization – Utility Maximization – Linear and Quadratic Programming – Automatic Differentiation.                                                           |                                                             |            |

|                                                                                                                           |
|---------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                        |
| 1. Stephen J. Wright, Benjamin Recht, Optimization for Data Analysis, Cambridge University Press, First Published 2022.   |
| <b>Reference:</b>                                                                                                         |
| 1. Richard W. Cole and Mukund N. Thapa, Linear and Nonlinear Optimization, First Edition, Springer New York, 2017.        |
| 2. Gerard Cornuejols and Reha Tutuncu, Optimization Methods in Finance, Fourth Edition, Cambridge University Press, 2013. |

**Web / NPTEL Resources:**

<http://nptel.ac.in/courses/106106179>

**CO-PO Mapping**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3   | 3   | 2   | 2   | 3   | 2   | –   | –   | –   | 2    | 1    | 3    | 2    |
| CO2 | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO3 | 3   | 3   | 3   | 3   | 3   | 3   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO4 | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | 3    | 2    | 3    | 3    |
| CO5 | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 1   | 3    | 3    | 3    | 3    |

**Assessment Methodology**

| Assessment Methodology | Assessment Tools    | Marks |
|------------------------|---------------------|-------|
| Internal Test I        | Written Examination | 10    |
| Internal Test II       | Written Examination | 10    |
| Internal Test III      | Written Examination | 10    |
| Assessment             | Assignment          | 05    |
| Attendance             | Performance         | 05    |
| Total                  |                     | 40    |

|             |                                     |                 |          |          |          |               |
|-------------|-------------------------------------|-----------------|----------|----------|----------|---------------|
| PEL 26 2 06 | <b>FINANCIAL AND RISK ANALYTICS</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|             |                                     | PE              | 3        | 0        | 0        | 3             |

### Course Prerequisite / Preamble

Student should have basic knowledge of Programming, Mathematics, Machine Learning, Data Analysis, and understanding of Data Types.

### Course Objective

- To introduce the fundamentals of financial risk and the structure of financial institutions.
- To equip students with quantitative techniques for measuring market, credit, and liquidity risk.
- To create awareness of operational, cyber, and climate-related risks in the financial sector.
- To familiarize students with regulatory compliance and enterprise risk management practices.
- To explore the role of AI/ML and RegTech in modern risk analytics.

### Course Outcome

|     |                                                                           |    |
|-----|---------------------------------------------------------------------------|----|
| CO1 | Understand and classify major types of financial risks.                   | K2 |
| CO2 | Apply quantitative risk measurement techniques.                           | K3 |
| CO3 | Analyze the structure and functions of financial institutions.            | K4 |
| CO4 | Evaluate the impact of modern challenges such as cyber and climate risks. | K5 |
| CO5 | Design integrated risk management strategies.                             | K6 |

### Syllabus

|                                                                                                                                                                                                 |                                                       |            |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|------------|
| <b>Unit 1</b>                                                                                                                                                                                   | <b>Foundations of Financial Risk and Institutions</b> | <b>(9)</b> |
| Introduction – Importance and Objectives – Types of Financial Risks – Risk vs. Uncertainty – Financial Institutions Overview – Regulatory Environment – Risk Management by Central Authorities. |                                                       |            |
| <b>Unit 2</b>                                                                                                                                                                                   | <b>Market Risk and Measurement Techniques</b>         | <b>(9)</b> |

|                                                                                                                                                                                                                                                           |                                                                   |            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|------------|
| Fundamentals – Value at Risk – Stress Testing and Scenario Analysis – Measuring Volatility – Historical Simulation, Delta-Normal Method – Model Risk Management – Governance Frameworks for Models.                                                       |                                                                   |            |
| <b>Unit 3</b>                                                                                                                                                                                                                                             | <b>Credit Risk and Liquidity Risk</b>                             | <b>(9)</b> |
| Credit Risk Management – Credit Scoring and Rating Systems – Credit Derivatives and Credit Default Swaps – Counterparty Risk – Liquidity Risk – Types: Funding vs. Market Liquidity Risk – Measuring and Managing Liquidity Risk – Collateral Management. |                                                                   |            |
| <b>Unit 4</b>                                                                                                                                                                                                                                             | <b>Operational, Cyber, and Climate Risks</b>                      | <b>(9)</b> |
| Definition, Framework, and Mitigation – Cyber Risk – Risks from Digital Transformation – Cyber Risk Regulations – Climate Risk – ESG Risk Management – Integrating Climate Risk in Financial Models.                                                      |                                                                   |            |
| <b>Unit 5</b>                                                                                                                                                                                                                                             | <b>Risk Management Best Practices &amp; Regulatory Compliance</b> | <b>(9)</b> |
| Enterprise Risk Management – Integrating Risks Across the Enterprise – Financial Regulation Overview – Stress Tests and Reporting Requirements – Future Trends in Risk Management – AI & Machine Learning in Risk Analytics – RegTech Innovations.        |                                                                   |            |

|                                                                                                    |
|----------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                 |
| 1. John C. Hull, Risk Management and Financial Institutions, 6th Edition, Wiley, 2023.             |
| <b>Reference:</b>                                                                                  |
| 1. Angelo Corelli, Understanding Financial Risk Management, 3rd Edition, Emerald Publishing, 2024. |
| <b>Web / NPTEL Resources:</b>                                                                      |
| <a href="http://nptel.ac.in/courses/110106072">http://nptel.ac.in/courses/110106072</a>            |

| CO-PO Mapping |     |     |     |     |     |     |     |     |     |      |      |      |      |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| Cos           | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
| CO1           | 2   | 2   | 2   | 2   | 2   | 3   | –   | –   | –   | 2    | 1    | 3    | 2    |
| CO2           | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO3           | 3   | 3   | 3   | 3   | 3   | 3   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO4           | 3   | 2   | 3   | 3   | 3   | 3   | 2   | 2   | 1   | 3    | 2    | 3    | 3    |

|     |   |   |   |   |   |   |   |   |   |   |   |   |   |
|-----|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
|-----|---|---|---|---|---|---|---|---|---|---|---|---|---|

| <b>Assessment Methodology</b> |                         |              |
|-------------------------------|-------------------------|--------------|
| <b>Assessment Methodology</b> | <b>Assessment Tools</b> | <b>Marks</b> |
| Internal Test I               | Written Examination     | 10           |
| Internal Test II              | Written Examination     | 10           |
| Internal Test III             | Written Examination     | 10           |
| Assessment                    | Assignment              | 05           |
| Attendance                    | Performance             | 05           |
| Total                         |                         | 40           |

|                    |                                   |                 |          |          |          |               |
|--------------------|-----------------------------------|-----------------|----------|----------|----------|---------------|
| <b>PEL 26 2 07</b> | <b>COMPUTATIONAL INTELLIGENCE</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                                   | PE              | 3        | 0        | 0        | 3             |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <ul style="list-style-type: none"> <li>• Basic knowledge of Programming (preferably Python/C++/Java)</li> <li>• Fundamentals of Data Structures and Algorithms</li> <li>• Basic Linear Algebra, Calculus, and Probability &amp; Statistics</li> <li>• Introductory knowledge of Machine Learning and Artificial Intelligence concepts (desirable but not mandatory)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <ul style="list-style-type: none"> <li>• Understand the fundamental concepts, principles, and applications of Computational Intelligence (CI).</li> <li>• Learn intelligent problem-solving techniques based on Artificial Neural Networks, Fuzzy Logic, Evolutionary Computation, and Swarm Intelligence.</li> <li>• Design and implement computational intelligence algorithms for optimization, classification, prediction, and decision-making problems.</li> <li>• Analyze and compare various computational intelligence techniques to select appropriate methods for real-world applications.</li> <li>• Develop practical skills in applying computational intelligence methods to domains such as data analytics, robotics, healthcare, finance, and intelligent automation</li> </ul> |

|                       |                                                                              |    |
|-----------------------|------------------------------------------------------------------------------|----|
| <b>Course Outcome</b> |                                                                              |    |
| CO1                   | Understand the fundamentals and techniques of Computational Intelligence.    | K3 |
| CO2                   | Implement basic neural networks for problem-solving.                         | K3 |
| CO3                   | Apply Evolutionary Computation and genetic algorithms to optimization tasks. | K3 |
| CO4                   | Use swarm intelligence to enhance problem-solving skills.                    | K3 |
| CO5                   | Develop fuzzy logic systems to handle uncertainty in engineering problems.   | K3 |

| <b>Syllabus</b>                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                     |            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|------------|
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Introduction</b>                                 | <b>(9)</b> |
| Background and history of evolutionary computation - Behavioural Motivations for Fuzzy Logic, Myths and Applications Areas of Computational Intelligence – Adaptation, Self-Organization and Evolution – Historical Views of Computational Intelligence – Adaptation and Self-Organization for Computational Intelligence – Ability to Generalize – Computational Intelligence and Soft Computing vs. Artificial Intelligence and Hard Computing. |                                                     |            |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Neural Network Concepts and Paradigms</b>        | <b>(9)</b> |
| Neural Networks – History – What Neural Networks Are and Why They Are Useful – Neural Network Components and Terminology – Neural Network Topology – Neural Network Adaptation – Comparing Neural Networks with Other Information Processing Methods – Preprocessing and Post-Processing.                                                                                                                                                         |                                                     |            |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Evolutionary Computation Theory And Concepts</b> | <b>(9)</b> |
| History of Evolutionary Computation – Overview of Evolutionary Computation – Genetic Algorithms – Evolutionary Programming – Evolution Strategies – Genetic Programming – Particle Swarm Optimization.                                                                                                                                                                                                                                            |                                                     |            |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Swarm Intelligence</b>                           | <b>(9)</b> |
| Particle Swarm Optimization – Particle Swarm Optimization Algorithm – PSO System Parameters – Modifications to PSO – Cooperative PSO – Particle Swarm Optimization versus Evolutionary Computing and Cultural Evolution – Applications of Particle Swarm Optimization – Ant Colony Optimization.                                                                                                                                                  |                                                     |            |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Fuzzy Systems</b>                                | <b>(9)</b> |
| Fuzzy Systems: Fuzzy Sets – Membership Functions – Fuzzy Operators – Characteristics of Fuzzy Sets – Linguistic Variables and Hedges – Fuzziness and Probability – Fuzzy Inference Systems: Fuzzification – Inference – Defuzzification – Fuzzy Controllers: Components of Fuzzy Controllers – Types of Fuzzy Controllers.                                                                                                                        |                                                     |            |

|                                                                                                                                                                         |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                      |
| <ul style="list-style-type: none"> <li>Eberhart, E. and Shi, Y., Computational Intelligence: Concepts and Implementations, Morgan Kaufmann, San Diego, 2007.</li> </ul> |

- Engelbrecht, A. P., Computational Intelligence: An Introduction, 2nd Edition, John Wiley & Sons, 2007.

#### Reference:

1. Rajasekaran, S. and Vijayalakshmi Pai, G. A., Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis and Applications, PHI Learning, 2003.
2. Marsland, S., Machine Learning: An Algorithmic Perspective, CRC Press, 2009.
3. Jang, J.-S. R., Sun, C.-T. and Mizutani, E., Neuro-Fuzzy and Soft Computing, PHI/Pearson Education, 2004.

#### Web / NPTEL Resources:

#### CO-PO Mapping

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 2   | 2   | 2   | 2   | 2   | 2   | –   | –   | –   | 2    | 1    | 3    | 2    |
| CO2 | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO3 | 3   | 3   | 3   | 3   | 3   | 3   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO4 | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | 3    | 2    | 3    | 3    |
| CO5 | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 1   | 3    | 3    | 3    | 3    |

#### Assessment Methodology

| Assessment Methodology | Assessment Tools    | Marks |
|------------------------|---------------------|-------|
| Internal Test I        | Written Examination | 10    |
| Internal Test II       | Written Examination | 10    |
| Internal Test III      | Written Examination | 10    |
| Assessment             | Assignment          | 05    |
| Attendance             | Performance         | 05    |
| Total                  |                     | 40    |

|                    |                                      |                 |          |          |          |               |
|--------------------|--------------------------------------|-----------------|----------|----------|----------|---------------|
| <b>PEL 26 2 08</b> | <b>BLOCKCHAIN AND CRYPTOCURRENCY</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                                      | PE              | 3        | 0        | 0        | 3             |

### Course Prerequisite / Preamble

- Basic knowledge of Computer Networks and Distributed Systems
- Fundamentals of Data Structures and Algorithms
- Basic understanding of Cryptography and Information Security concepts
- Programming proficiency in Python, Java, or Solidity (basic level)
- Familiarity with Database Management Systems and Web Technologies (desirable)

### Course Objective

- Understand the fundamental concepts, architecture, and working principles of blockchain technology and cryptocurrencies.
- Analyze distributed ledger technologies, consensus mechanisms, and cryptographic techniques used in blockchain systems.
- Design, develop, and deploy smart contracts and decentralized applications (DAppAS) using blockchain platforms.
- Evaluate blockchain applications in domains such as finance, supply chain, healthcare, digital identity, and governance.
- Assess the security, privacy, scalability, legal, and regulatory challenges associated with blockchain-based systems and cryptocurrency ecosystems.

### Course Outcome

|     |                                                                                      |    |
|-----|--------------------------------------------------------------------------------------|----|
| CO1 | Explain the core technology components of Blockchain and decentralized applications. | K3 |
| CO2 | Describe distributed ledger technologies and consensus mechanisms.                   | K3 |
| CO3 | Develop smart contracts on Ethereum and understand its architecture.                 | K3 |
| CO4 | Analyze the working of Bitcoin and identify its limitations.                         | K3 |
| CO5 | Utilize various blockchain development frameworks effectively.                       | K3 |

| <b>Syllabus</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                        |            |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|------------|
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Introduction to Blockchain</b>      | <b>(9)</b> |
| History of Blockchain and Bitcoin – Electronic Cash – Peer-to-Peer Structure – Genesis Block – Distributed Ledger – Cryptographically Secure and Append-Only Ledger – Updatable Through Consensus – Generic Elements of a Blockchain – How Blockchain Works – How Blockchain Accumulates Blocks – Benefits and Limitations – Tiers of Blockchain Technology – Features of Blockchain – Types of Blockchain.                                                                                                                   |                                        |            |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Distributed Ledgers</b>             | <b>(9)</b> |
| Distributed Ledger Technology – Public Blockchains – Private Blockchains – Semi-Private Blockchains – Sidechains – Permissioned Ledgers – Shared Ledgers – Fully Private and Proprietary Blockchains – Tokenized Blockchains – Tokenless Blockchains – Consensus – Consensus Mechanisms – Types of Consensus Mechanisms – Consensus in Blockchain.                                                                                                                                                                            |                                        |            |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Decentralization</b>                | <b>(9)</b> |
| Methods of decentralization – Disintermediation -Contest-driven decentralization - Routes to decentralization - The decentralization framework example - Blockchain and full ecosystem decentralization -Storage – Communication -Computing power and decentralization - Smart contracts Decentralized Organizations - Decentralized Autonomous Corporations - Decentralized Application - DApp examples -Open Bazaar - Platforms for decentralization -Ethereum -Maid Safe – Lisk.                                           |                                        |            |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Bitcoin – Cryptocurrency</b>        | <b>(9)</b> |
| Bitcoin definition - Digital keys and addresses - Private keys in Bitcoin - Public keys in Bitcoin - Addresses in Bitcoin - Transactions - The transaction life cycle - Transaction fee - Transaction pools - The transaction data structure - Metadata - Inputs - Outputs - Verification - The script language - Types of transactions - Coinbase transactions - Contracts - Tasks of the miners - Mining rewards - Proof of Work (PoW).                                                                                     |                                        |            |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>Development Tools and Framework</b> | <b>(9)</b> |
| Ethereum Network – Mainnet – Testnet – Private Network – Ether Cryptocurrency/Tokens (ETC and ETH) – Ethereum Virtual Machine (EVM) – Solidity Language: Data Types – Function Types – Reference Types – Control Structures – Introduction to Web3 – Contract Deployment – POST Requests – Truffle – Interaction with Smart Contracts – Oracles – Deployment on Decentralized Storage Using IPFS – Hyperledger: Reference Architecture – Hyperledger Fabric – Membership Services – Blockchain Services – Consensus Services. |                                        |            |

|                                                                                                                                                                                                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                                               |
| 1. Bashir, I., Mastering Blockchain: Distributed Ledger Technology, Decentralization, and Smart Contracts Explained, 3rd Edition, Packt Publishing, 2020.                                        |
| <b>Reference:</b>                                                                                                                                                                                |
| 1. Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction. Princeton University Press ,2016. |
| 2. Antonopoulos, Mastering Bitcoin, Second Edition, O'Reilly Publishers, 2017.                                                                                                                   |
| 3. D. Drescher, 'Blockchain Basics' First Edition, Apress, 2017.                                                                                                                                 |
| 4. Antonopoulos and G. Wood, Mastering Ethereum, First Edition, O'Reilly Publishers, 2018.                                                                                                       |
| <b>Web / NPTEL Resources:</b>                                                                                                                                                                    |
| <a href="https://nptel.ac.in/courses/106105235">https://nptel.ac.in/courses/106105235</a>                                                                                                        |

| CO-PO Mapping |     |     |     |     |     |     |     |     |     |      |      |      |      |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| Cos           | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
| CO1           | 2   | 2   | 2   | 2   | 2   | 2   | –   | –   | –   | 2    | 1    | 3    | 2    |
| CO2           | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO3           | 3   | 3   | 3   | 3   | 3   | 3   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO4           | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | 3    | 2    | 3    | 3    |
| CO5           | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 1   | 3    | 3    | 3    | 3    |

| Assessment Methodology |                     |       |
|------------------------|---------------------|-------|
| Assessment Methodology | Assessment Tools    | Marks |
| Internal Test I        | Written Examination | 10    |
| Internal Test II       | Written Examination | 10    |
| Internal Test III      | Written Examination | 10    |
| Assessment             | Assignment          | 05    |
| Attendance             | Performance         | 05    |
| Total                  |                     | 40    |

# **SEMESTER – III**

# **ELECTIVES**

|                    |                          |                 |          |          |          |               |
|--------------------|--------------------------|-----------------|----------|----------|----------|---------------|
| <b>PEL 26 3 01</b> | <b>BIG DATA SECURITY</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                          | PE              | 3        | 0        | 0        | 3             |

### Course Prerequisite / Preamble

- Fundamentals of Computer Networks
- Database Management Systems
- Basics of Big Data Technologies (Hadoop/Spark)
- Fundamentals of Information Security and Cryptography
- Programming knowledge in Python/Java

### Course Objective

- Understand the security challenges associated with Big Data platforms and distributed computing environments.
- Apply cryptographic techniques, authentication, and access control mechanisms to protect big data systems.
- Design secure architectures for Hadoop, Spark, cloud, and NoSQL environments.
- Analyze privacy-preserving techniques and regulatory frameworks for big data applications.
- Evaluate emerging technologies and best practices for securing large-scale data processing systems.

### Course Outcome

|     |                                                                                                                        |    |
|-----|------------------------------------------------------------------------------------------------------------------------|----|
| CO1 | Explain the security architecture, threats, and vulnerabilities in Big Data ecosystems.                                | K3 |
| CO2 | Implement authentication, authorization, encryption, and secure communication mechanisms for distributed data systems. | K3 |
| CO3 | Apply privacy-preserving data analytics and access control techniques in Big Data applications.                        | K3 |
| CO4 | Analyze and mitigate security risks in Hadoop, Spark, NoSQL databases, and cloud-based data platforms.                 | K3 |
| CO5 | Design secure Big Data solutions that comply with organizational security policies and data protection regulations.    | K3 |

| <b>Syllabus</b>                                                                                                                                                                                                                                                                                                                                                     |                                          |            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|------------|
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                                                                                       | <b>Introduction to Big Data Security</b> | <b>(9)</b> |
| Big Data ecosystem and architecture, characteristics of Big Data, distributed computing environments, Hadoop ecosystem overview, Spark architecture, security challenges in Big Data, threat models, vulnerabilities and attack vectors, confidentiality, integrity and availability (CIA) principles, security requirements, risk assessment, and data governance. |                                          |            |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                       | <b>Authentication and Access Control</b> | <b>(9)</b> |
| Authentication mechanisms, Kerberos authentication, Identity and Access Management (IAM), authorization models, Role-Based Access Control (RBAC), Attribute-Based Access Control (ABAC), Hadoop security architecture, Apache Ranger, Apache Knox, Apache Sentry, secure cluster configuration, user privilege management, and audit logging.                       |                                          |            |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                       | <b>Data Protection and Privacy</b>       | <b>(9)</b> |
| Data encryption at rest and in transit, key management, secure HDFS, secure communication protocols, data masking, tokenization, anonymization techniques, privacy-preserving data publishing, differential privacy, homomorphic encryption, secure multi-party computation, and privacy regulations.                                                               |                                          |            |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                       | <b>Cloud and NoSQL Security</b>          | <b>(9)</b> |
| Cloud security architecture, virtualization security, Big Data security in cloud environments, NoSQL database security, MongoDB security, Cassandra security, secure APIs, container security, Kubernetes security fundamentals, security monitoring, logging, intrusion detection, and vulnerability assessment.                                                   |                                          |            |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                       | <b>Emerging Trends and Case Studies</b>  | <b>(9)</b> |
| Artificial intelligence for cybersecurity, machine learning-based intrusion detection, blockchain for Big Data security, security analytics, data governance frameworks, GDPR, Digital Personal Data Protection (DPDP) Act, security auditing, incident response, digital forensics, and industrial case studies on Big Data security.                              |                                          |            |

|                                                                                                                                                                                                                                                                                                                                                                                                   |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                                                                                                                                                                                                                                                |
| <ul style="list-style-type: none"> <li>Ben Spivey, Hadoop Security: Protecting Your Big Data Platform, O'Reilly Media, 2015.</li> <li>Nina Godbole and Sunit Belapure, Cyber Security: Understanding Cyber Crimes, Computer Forensics and Legal Perspectives, Wiley India, 2021.</li> <li>Judith Hurwitz, Alan Nugent, Fern Halper, Marcia Kaufman, Big Data for Dummies, Wiley, 2016.</li> </ul> |

**Reference:**

- Donald Miner and Adam Shook, MapReduce Design Patterns, O'Reilly, 2013.
- Tom White, Hadoop: The Definitive Guide (4th Edition), O'Reilly, 2015.
- Bill Franks, Taming the Big Data Tidal Wave, Wiley, 2012.
- M. Tim Jones, Artificial Intelligence and Machine Learning for Cybersecurity, Packt Publishing, 2020.
- William Stallings, Cryptography and Network Security, Pearson, 8th Edition.

**Web / NPTEL Resources:**

<https://nptel.ac.in/courses/106104189>

<https://nptel.ac.in/courses/106106248>

<https://archive.nptel.ac.in/courses/106/106/106106157/>

**CO-PO Mapping**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 2   | 2   | 2   | 2   | 3   | 3   | —   | —   | —   | 2    | 1    | 3    | 2    |
| CO2 | 3   | 3   | 3   | 3   | 3   | 3   | 1   | —   | —   | 2    | 2    | 3    | 3    |
| CO3 | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 1   | —   | 2    | 2    | 3    | 3    |
| CO4 | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 1   | 3    | 2    | 3    | 3    |
| CO5 | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 2   | 3    | 3    | 3    | 3    |

**Assessment Methodology**

| Assessment Methodology | Assessment Tools    | Marks |
|------------------------|---------------------|-------|
| Internal Test I        | Written Examination | 10    |
| Internal Test II       | Written Examination | 10    |
| Internal Test III      | Written Examination | 10    |
| Assessment             | Assignment          | 05    |
| Attendance             | Performance         | 05    |
| Total                  |                     | 40    |

|                    |                       |                 |          |          |          |               |
|--------------------|-----------------------|-----------------|----------|----------|----------|---------------|
| <b>PEL 26 3 02</b> | <b>EXPLAINABLE AI</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                       | PE              | 3        | 0        | 0        | 3             |

### Course Prerequisite / Preamble

To learn Explainable AI (XAI), students should have a basic knowledge of Python programming, mathematics, and machine learning concepts. They should understand how AI models are trained and how data is prepared before training. Basic knowledge of deep learning is also helpful. Familiarity with simple model evaluation methods and AI ethics, such as fairness and transparency, will make it easier to understand how Explainable AI helps users trust and interpret AI models.

### Course Objective

1. To Understand the concepts within Explainable AI and interpretable machine learning
2. To Summarize, visualize, and explore the data using graphical and non-graphical techniques
3. To know the Importance of XAI in modern world
4. To Categorize XAI on the basis of their scope, agnosticity, data types and explanation techniques
5. To know the working principles and mathematical modelling of XAI techniques

### Course Outcome

|     |                                                                                                                                       |    |
|-----|---------------------------------------------------------------------------------------------------------------------------------------|----|
| CO1 | Describe the machine learning application's context and why explainability might help.                                                | K2 |
| CO2 | Understand the concepts of model validation, evaluation, and performance visualization for both supervised and unsupervised learning. | K3 |
| CO3 | Demonstrate post hoc explainability techniques through a self-chosen set of programming platforms.                                    | K2 |
| CO4 | Illustrate the results from Explainable deep learning techniques and suggest how it helps the problem context.                        | K2 |
| CO5 | Describe the comprehension of challenges and future related to Explainable AI                                                         | K2 |

### Syllabus

|                                                                                                       |                     |          |
|-------------------------------------------------------------------------------------------------------|---------------------|----------|
| <b>Unit 1</b>                                                                                         | <b>INTRODUCTION</b> | <b>9</b> |
| Black-Box problem, Goals, Brief History, Purpose, Societal Impact, Types of Explanations, Trade-offs, |                     |          |

|                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                |          |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|----------|
| Taxonomy, Flowchart for Interpretable and Explainable Techniques Pre-model Interpretability and Explainability: Data Science Process and EDA, Exploratory Data Analysis, Feature Engineering                                                                                                                                                                                                                                              |                                                                                |          |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>MODEL VISUALIZATION TECHNIQUES AND TRADITIONAL INTERPRETABLE ALGORITHMS</b> | <b>9</b> |
| Model Validation, Evaluation, and Hyperparameters, Model Selection and Visualization, Classification Model Visualization, Regression Model Visualization, Clustering Model Visualization, Interpretable Machine Learning Properties, Traditional Interpretable Algorithms                                                                                                                                                                 |                                                                                |          |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>MODEL INTERPRETABILITY</b>                                                  | <b>9</b> |
| Advances in Interpretable Machine Learning: Interpretable vs. Explainable Algorithms, Tools and Libraries, Ensemble-Based, Decision Tree-Based, Rule-Based Techniques, Scoring System Post-Hoc Interpretability and Explanations: Tools and Libraries, Visual Explanation, Feature Importance, Example-Based                                                                                                                              |                                                                                |          |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>EXPLAINABLE DEEP LEARNING</b>                                               | <b>9</b> |
| Applications, Tools and Libraries, Intrinsic, Perturbation, Gradient / Backpropagation                                                                                                                                                                                                                                                                                                                                                    |                                                                                |          |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>EXPLAINABILITY</b>                                                          | <b>9</b> |
| Time Series Forecasting, Natural Language Processing, and Computer Vision XAI: Challenges: Properties of Explanation, Categories of Explanation, Taxonomy of Explanation Evaluation XAI: Future: Formalization of Explanation Techniques and Evaluations, Adoption of Interpretable Techniques, Human-Machine Collaboration, Collective Intelligence from Multiple Disciplines, Responsible AI (RAI), XAI and Security, Causality and XAI |                                                                                |          |

|                                                                                                                                                                                                                                                                                            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books</b>                                                                                                                                                                                                                                                                          |
| <ul style="list-style-type: none"> <li>Uday Kamath and John Liu “Explainable Artificial Intelligence: An Introduction to Interpretable Machine Learning”, Springer Cham, First Edition, 2021.</li> </ul>                                                                                   |
| <b>Reference Books</b>                                                                                                                                                                                                                                                                     |
| <ul style="list-style-type: none"> <li>Leonida Gianfagna and Antonio Di Cecco, “Explainable AI with Python”, Springer International Publishing, First Edition, 2021.</li> <li>Denis Rothman, “Hands-On Explainable AI (XAI) with Python”, Packt Publishing, First Edition, 2020</li> </ul> |
| <b>Web / NPTEL Resources</b>                                                                                                                                                                                                                                                               |

- <http://www.ibm.com/in-en/watson/explainable-ai>
- <http://sites.google.com/view/explainable-ai-tutorial>
- <http://cloud.google.com/explainable-ai>

#### CO- PO Mapping

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 2   | 2   | 2   | 2   | 3   | 2   | –   | –   | –   | 2    | 1    | 3    | 2    |
| CO2 | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO3 | 3   | 3   | 3   | 3   | 3   | 3   | 1   | 1   | –   | 2    | 2    | 3    | 3    |
| CO4 | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 1   | 3    | 2    | 3    | 3    |
| CO5 | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 2   | 3    | 3    | 3    | 3    |

#### Assessment Methodology

| Assessment Methodology | Assessment Tools    | Marks |
|------------------------|---------------------|-------|
| Internal Test I        | Written Examination | 10    |
| Internal Test II       | Written Examination | 10    |
| Internal Test III      | Written Examination | 10    |
| Assessment             | Assignment          | 05    |
| Attendance             | Performance         | 05    |
| Total                  |                     | 40    |

|                    |                                        |                 |          |          |          |               |
|--------------------|----------------------------------------|-----------------|----------|----------|----------|---------------|
| <b>PEL 26 3 03</b> | <b>NATURAL LANGUAGE<br/>PROCESSING</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                                        | PE              | 3        | 0        | 0        | 3             |

#### Course Prerequisite / Preamble

To learn Natural Language Processing (NLP), students should have a basic understanding of Python programming, data structures, and mathematics, especially probability and statistics. They should also be familiar with machine learning concepts and basic data preprocessing techniques. A basic knowledge of linguistics, such as grammar, sentence structure, and vocabulary, is helpful for understanding how computers process and analyze human language.

#### Course Objective

- Provide theoretical concepts of language processing that shows how to explore interesting bodies of text.
- Familiarize with fundamental topics in language processing that include tagging, classification, and information extraction using tiny Python programs.
- Facilitate understanding of formal grammar to describe the structure of an unlimited set of sentences.
- Acquaint with methods to parse a sentence, recognize its syntactic structure and construct representations of meaning.
- 5. Familiarize with design of existing corpora, the typical workflow for creating a corpus and the life cycle of a corpus.

#### Course Outcome

|            |                                                                                          |    |
|------------|------------------------------------------------------------------------------------------|----|
| <b>CO1</b> | Comprehend the concept of natural language processing, its challenges and applications.  | K3 |
| <b>CO2</b> | Demonstrate skills in natural language processing using Natural Language Toolkit (NLTK). | K3 |
| <b>CO3</b> | Build and evaluate classifiers for textual data.                                         | K4 |
| <b>CO4</b> | Analyse linguistic structure of text and build feature-based grammar.                    | K3 |
| <b>CO5</b> | Determine the semantics of sentences using WordNet and Treebank.                         | K3 |

#### Syllabus

|                                                                                                                                                                                              |                            |            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|------------|
| <b>Unit 1</b>                                                                                                                                                                                | <b>Language Processing</b> | <b>(9)</b> |
| Computing with Language- Texts and Words, A Closer Look at Python-: Texts as Lists of Words, Computing with Language- Simple Statistics, Automatic Natural Language Understanding, Accessing |                            |            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                           |            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|------------|
| Text Corpora and Lexical Resources: Accessing Text Corpora, Conditional Frequency Distributions, Lexical Resources, WordNet.                                                                                                                                                                                                                                                                                                                 |                                           |            |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Processing Raw Text</b>                | <b>(9)</b> |
| Strings- Text Processing at the Lowest Level, Text Processing with Unicode, Regular Expressions for Detecting Word Patterns, Useful Applications of Regular Expressions, Normalizing Text, Regular Expressions for Tokenizing Text, Segmentation, Formatting: From Lists to Strings. Categorizing and Tagging Words: Mapping Words to Properties Using Python Dictionaries, Automatic Tagging, N-Gram Tagging, Transformation-Based Tagging. |                                           |            |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Learning to Classify Text</b>          | <b>(9)</b> |
| Supervised Classification, Evaluation, Modelling Linguistic Patterns Extracting Information from Text: Information, Chunking, Developing and Evaluating Chunkers, Recursion in Linguistic Structure.                                                                                                                                                                                                                                         |                                           |            |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Analyzing Sentence Structure</b>       | <b>(9)</b> |
| Context-Free Grammar, Parsing with Context-Free Grammar, Dependencies and Dependency Grammar, Grammar Development. Building Feature-Based Grammars: Grammatical Features, Processing Feature Structures, Extending a Feature Based Grammar.                                                                                                                                                                                                  |                                           |            |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Analyzing the Meaning of Sentences</b> | <b>(9)</b> |
| Natural Language Understanding, Propositional Logic, First-Order Logic, The Semantics of English Sentences. Managing Linguistic Data: Corpus Structure: A Case Study, The Life Cycle of a Corpus, Acquiring Data.                                                                                                                                                                                                                            |                                           |            |

|                                                                                                                                                                                                                                                                                                   |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books:</b>                                                                                                                                                                                                                                                                                |
| <ul style="list-style-type: none"> <li>Steven Bird, Evan Klein and Edward Loper, “Natural Language Processing with Python”, O'Reilly Media, Inc., 2009.</li> </ul>                                                                                                                                |
| <b>Reference:</b>                                                                                                                                                                                                                                                                                 |
| <ul style="list-style-type: none"> <li>Daniel Jurafsky and James H Martin. Speech and Language Processing, 2nd Edition, Pearson Education, 2009.</li> <li>Nitin Indurkha and Fred J. Damerau, —Handbook of Natural Language Processing, 2nd Edition, Chapman and Hall/CRC Press, 2010.</li> </ul> |

- Tanveer Siddiqui, U.S. Tiwary, —Natural Language Processing and Information Retrieval, Oxford University Press, 2008.
- Nitin Hardaniya, Jacob Perkins, “Natural Language Processing: Python and NLTK”, Packt Publishers, 2016.

**Web / NPTEL Resources:**

<http://pythonprogramming.net/tokenizing-words-sentences-nltk-tutorial/>

<http://www.nptelvideos.in/2012/11/natural-language-processing.html>

[http://github.com/keon/awesome-nlp](https://github.com/keon/awesome-nlp)

**CO PO Mapping**

| Cos | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3   | 2   | 2   | 2   | 3   | 2   | –   | –   | –   | 2    | 1    | 3    | 2    |
| CO2 | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO3 | 3   | 3   | 3   | 3   | 3   | 3   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO4 | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | 3    | 2    | 3    | 3    |
| CO5 | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 1   | 3    | 3    | 3    | 3    |

**Assessment Methodology**

| Assessment Methodology | Assessment Tools    | Marks |
|------------------------|---------------------|-------|
| Internal Test I        | Written Examination | 10    |
| Internal Test II       | Written Examination | 10    |
| Internal Test III      | Written Examination | 10    |
| Assessment             | Assignment          | 05    |
| Attendance             | Performance         | 05    |
| Total                  |                     | 40    |

|                    |                                   |                 |          |          |          |               |
|--------------------|-----------------------------------|-----------------|----------|----------|----------|---------------|
| <b>PEL 26 3 04</b> | <b>REINFORCEMENT<br/>LEARNING</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                                   | PE              | 3        | 0        | 0        | 3             |

### Course Prerequisite / Preamble

To learn Reinforcement Learning (RL), students should have a basic understanding of Python programming, mathematics, especially probability, statistics, and linear algebra, and machine learning concepts. They should also be familiar with basic data structures and algorithms. Knowledge of how AI models learn from data and a basic understanding of optimization techniques will help students understand how reinforcement learning enables agents to make decisions through trial and error.

### Course Objective

- Learn the concepts of reinforcement learning, Multi Armed bandits' problem, and Finite Markov Decision Process.
- Introduce Dynamic programming, Monte Carlo methods and Temporal-Difference Learning.
- Excel with Tabular Methods and Prediction with Approximation.
- Provide approximate solutions methods for Reinforcement learning. 5. Familiarize with applications and case studies of reinforcement learning.

### Course Outcome

|            |                                                                                                         |    |
|------------|---------------------------------------------------------------------------------------------------------|----|
| <b>CO1</b> | Understand the Reinforcement Learning, Multi Armed Bandits and Finite Markov Decision process.          | K3 |
| <b>CO2</b> | Apply Monte Carlo, Temporal Difference methods for policy evaluation and prediction.                    | K3 |
| <b>CO3</b> | Analyse the Tabular Methods and On-policy Prediction with Approximation.                                | K4 |
| <b>CO4</b> | Understand On-policy Control and Off-policy Methods with Approximation.                                 | K3 |
| <b>CO5</b> | Apply Eligibility Traces, Policy Gradient Methods to improve the performance of reinforcement learning. | K3 |

### Syllabus

|                                                                                                                                                                                                                                                                                                  |                     |            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------|
| <b>Unit 1</b>                                                                                                                                                                                                                                                                                    | <b>Introduction</b> | <b>(9)</b> |
| Reinforcement Learning, Elements of Reinforcement Learning, Limitations and Scope, Examples. Multi Armed Bandits: A K-armed Bandit Problem, Action-Value Methods, Incremental implementation, Tracking a Non-stationary problem, Optimistic initial values, UCB, GBA, Associative search. Finite |                     |            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                   |            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|------------|
| Markov Decision Process: The Agent-Environment Interface, Goals and Rewards, Returns and Episodes, Unified Notation for Episodic and Continuing Tasks, Policies and Value Functions, Optimal Policies and optimal Value Functions, Optimality and Approximation.                                                                                                                                                                                                                                                                                                                                                                |                                                   |            |
| <b>Unit 2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Dynamic Programming</b>                        | <b>(9)</b> |
| Policy Evaluation (Prediction), Policy Improvement, Policy Iteration, Value Iteration, Asynchronous dynamic programming, Generalized Policy Iteration, Efficiency of dynamic programming. Monte Carlo Methods: Monte Carlo Prediction, Monte Carlo Estimation of Action values, Monte Carlo Control, Monte Carlo Control without Exploring Starts, Off-policy prediction via Importance Sampling, Incremental implementation. Temporal-Difference Learning: TD Prediction, Advantages of TD Prediction Methods, Optimality of TD (0), Sarsa: On-policy TD control, Q-learning Off-policy TD control.                            |                                                   |            |
| <b>Unit 3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Planning and Learning with Tabular Methods</b> | <b>(9)</b> |
| Models and Planning, Dyna: Integrated Planning, acting and learning, Prioritized Sweeping, expected vs Sample updates, Trajectory sampling, Real-time dynamic programming, Planning at decision time, Heuristic search, Rollout algorithms, Monte carlo tree search. On-policy Prediction with Approximation: Value-function approximation, stochastic-gradient and semi-gradient methods, Linear methods, Feature construction for linear methods, selecting step-size parameters manually, Nonlinear function approximation: ANN, Least-squares TD, Memory based function approximation, Kernel-based function approximation. |                                                   |            |
| <b>Unit 4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>On-policy Control with Approximation</b>       | <b>(9)</b> |
| Episodic Semi-gradient Control, Semi-gradient n-step Sarsa, Average Reward: A New Problem Setting for Continuing Tasks, Deprecating the Discounted Setting, Differential Semi gradient n-step Sarsa, Off-policy Methods with Approximation: Semi-gradient Methods, Examples of Off-policy Divergence, The Deadly Triad, Linear Value-function Geometry, Gradient Descent in the Bellman Error, The Bellman Error is Not Learnable, Gradient-TD Methods, Emphatic-TD Methods, Reducing Variance.                                                                                                                                 |                                                   |            |
| <b>Unit 5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>Eligibility Traces</b>                         | <b>(9)</b> |
| The $\lambda$ -return, TD ( $\lambda$ ), n-step truncated $\lambda$ -return methods, Online $\lambda$ -return algorithm, True online TD ( $\lambda$ ), Stable off-policy methods with traces, Implementation issues. Policy Gradient Methods: Policy Approximation and its advantages, The Policy Gradient theorem, REINFORCE: Monte Carlo Policy Gradient, REINFORCE with Baseline, Actor-Critic methods, Policy gradient for continuing problems, Policy parameterization for continuous actions. Applications and Case studies                                                                                               |                                                   |            |

|                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books</b>                                                                                                                                                                                                                                                                                                                                                                                                           |
| <ul style="list-style-type: none"> <li>Sutton &amp; Barto, “Reinforcement Learning: An Introduction”, MIT Press 2018, 2nd Edition. .</li> </ul>                                                                                                                                                                                                                                                                             |
| <b>Reference</b>                                                                                                                                                                                                                                                                                                                                                                                                            |
| <ul style="list-style-type: none"> <li>Vincent François-Lavel, Peter Henderson, Riashat Islam, Marc G. Bellemare, Joelle Pineau “An Introduction to Deep Reinforcement Learning”, Now Publishers, 2018</li> <li>Csaba Szepesvari, “Algorithms for Reinforcement Learning”, Morgan &amp; Claypool Publishers, 2010</li> <li>Maxim Lapan “Deep Reinforcement Learning Hands-On” Packt publisher, 2nd edition, 2020</li> </ul> |
| <b>Web / NPTEL Resources:</b>                                                                                                                                                                                                                                                                                                                                                                                               |
| <ul style="list-style-type: none"> <li>Nptel Course: Reinforcement Learning: <a href="https://nptel.ac.in/courses/106/106/106106143/">https://nptel.ac.in/courses/106/106/106106143/</a></li> <li>Swayam Course: Reinforcement Learning: <a href="https://swayam.gov.in/nd1_noc19_cs55/preview">https://swayam.gov.in/nd1_noc19_cs55/preview</a></li> </ul>                                                                 |

| <b>CO PO Mapping</b> |     |     |     |     |     |     |     |     |     |      |      |      |      |
|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| COs                  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
| CO1                  | 3   | 2   | 2   | 2   | 3   | 2   | –   | –   | –   | 2    | 1    | 3    | 2    |
| CO2                  | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO3                  | 3   | 3   | 3   | 3   | 3   | 3   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO4                  | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | 3    | 2    | 3    | 3    |
| CO5                  | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 1   | 3    | 3    | 3    | 3    |

| <b>Assessment Methodology</b> |                     |       |
|-------------------------------|---------------------|-------|
| Assessment Methodology        | Assessment Tools    | Marks |
| Internal Test I               | Written Examination | 10    |
| Internal Test II              | Written Examination | 10    |
| Internal Test III             | Written Examination | 10    |
| Assessment                    | Assignment          | 05    |
| Attendance                    | Performance         | 05    |
| Total                         |                     | 40    |

|                    |                           |                 |          |          |          |               |
|--------------------|---------------------------|-----------------|----------|----------|----------|---------------|
| <b>PEL 26 3 05</b> | <b>FEDERATED LEARNING</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                           | PE              | 3        | 0        | 0        | 3             |

|                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                      |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                      |
| To learn Federated Learning, students should have a basic understanding of Python programming, machine learning concepts, and data preprocessing techniques. They should also be familiar with deep learning basics, computer networks, and data privacy concepts. Knowledge of how AI models are trained and shared across multiple devices without exchanging raw data will help students understand the principles of Federated Learning. |                                                                                                      |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                      |
| 1. Understand the key concepts and issues behind Federated Learning<br>2. Get familiar with key theoretical results of Federated Learning<br>3. Understand the key concepts of reinforcement Learning                                                                                                                                                                                                                                        |                                                                                                      |
| <b>Course Outcome</b>                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                      |
| <b>CO1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                   | Knowledge of the basic concepts, architecture, and applications of FL. <b>K2</b>                     |
| <b>CO2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                   | Understanding of new research and application trends in FL. <b>K2</b>                                |
| <b>CO3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                   | Analyze distributed Machine Learning <b>K3</b>                                                       |
| <b>CO4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                   | Analyze horizontal federated learning <b>K4</b>                                                      |
| <b>CO5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                   | Understand the significance of Federated Learning for Vision, Language, and Recommendation <b>K5</b> |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                     |            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|------------|
| <b>Syllabus</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                     |            |
| <b>Unit I</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>Introduction</b>                 | <b>(9)</b> |
| Motivation, Federated Learning as a Solution, The Definition of Federated Learning, Categories of Federated Learning, Current Development in Federated Learning, Research Issues in Federated Learning, Open-Source Projects, Standardization Efforts, The Federated AI Ecosystem Background: Privacy-Preserving Machine Learning, PPML and Secure ML, Threat and Security Models, Privacy Threat Models, Adversary and Security Models, Privacy Preservation Techniques, Secure Multi- Party Computation, Homomorphic Encryption, Differential Privacy. |                                     |            |
| <b>Unit II</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Distributed Machine Learning</b> | <b>(9)</b> |
| Introduction to DML, The Definition of DML, DML Platforms, Scalability- Motivated DML, Large-Scale Machine Learning, Scalability-Oriented DML Schemes, Privacy-Motivated DML, Privacy-                                                                                                                                                                                                                                                                                                                                                                   |                                     |            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                    |            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|------------|
| Preserving Decision Trees, Privacy-Preserving Techniques, Privacy-Preserving DML Schemes, Privacy Preserving Gradient Descent, Vanilla Federated Learning, Privacy-Preserving Methods.                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                    |            |
| <b>Unit III</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Horizontal Federated Learning</b>                               | <b>(9)</b> |
| The Definition of HFL, Architecture of HFL, The Client- Server Architecture, The Peer-to-Peer Architecture, Global Model Evaluation, The Federated Averaging Algorithm, Federated Optimization, The FedAvg Algorithm, The Secured FedAvg Algorithm, Improvement of the FedAvg Algorithm, Communication Efficiency, Client Selection Vertical Federated Learning: The Definition of VFL, Architecture of VFL, Algorithms of VFL, Secure Federated Linear Regression, Secure Federated Tree-Boosting.                                                                                                       |                                                                    |            |
| <b>Unit IV</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>Federated Transfer Learning</b>                                 | <b>(9)</b> |
| Heterogeneous Federated Learning, Federated Transfer Learning, The FTL Framework, Additively Homomorphic Encryption, The FTL Training Process, The FTL Prediction Process, Security Analysis, Secret Sharing-Based FTL Incentive Mechanism Design for Federated Learning: Paying for Contributions, Profit- Sharing Games, Reverse Auctions, A Fairness-Aware Profit Sharing Framework, Modeling Contribution, Modeling Cost, Modeling Regret, Modeling Temporal Regret, The Policy Orchestrator, Computing Payoff Weightage.                                                                             |                                                                    |            |
| <b>Unit V</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Federated Learning for Vision, Language, and Recommendation</b> | <b>(9)</b> |
| Federated Learning for Computer Vision, Federated CV, Federated Learning for NLP, Federated NLP, Federated Learning for Recommendation Systems, Recommendation Model, Federated Recommendation System Federated Reinforcement Learning: Introduction to Reinforcement Learning, Policy, Reward, Value Function, Model of the Environment, RL Background Example, Reinforcement Learning Algorithms, Distributed Reinforcement Learning, Asynchronous Distributed Reinforcement Learning, Synchronous Distributed Reinforcement Learning, Federated Reinforcement Learning, Background and Categorization. |                                                                    |            |

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|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books</b>                                                                                                                                                                                                                                                                                                           |
| <ul style="list-style-type: none"> <li>Artificial Intelligence: A Modern Approach – Stuart Russell and Peter Norvig, Pearson, 2021.</li> <li>Deep Learning – Ian Goodfellow, Yoshua Bengio, and Aaron Courville, MIT Press, 2016.</li> <li>Speech and Language Processing – Daniel Jurafsky and James H. Martin.</li> </ul> |
| <b>Reference</b>                                                                                                                                                                                                                                                                                                            |

- Interpretable Machine Learning – Christoph Molnar.
- Reinforcement Learning: An Introduction – Richard S. Sutton and Andrew G. Barto.
- Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow – Aurélien Géron.
- Federated Learning – Qiang Yang.

#### Web / NPTEL Resources

[https://onlinecourses-archive.nptel.ac.in/noc18\\_cs40/preview?](https://onlinecourses-archive.nptel.ac.in/noc18_cs40/preview?)

[https://onlinecourses.nptel.ac.in/e-learning/preview/noc26\\_cs171?](https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_cs171?)

#### CO-PO Mapping

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3   | 2   | 2   | 2   | 3   | 2   | –   | –   | –   | 2    | 1    | 3    | 2    |
| CO2 | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO3 | 3   | 3   | 3   | 3   | 3   | 3   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO4 | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | 3    | 2    | 3    | 3    |
| CO5 | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 1   | 3    | 3    | 3    | 3    |

#### Assessment Methodology

| Assessment Methodology | Assessment Tools    | Marks |
|------------------------|---------------------|-------|
| Internal Test I        | Written Examination | 10    |
| Internal Test II       | Written Examination | 10    |
| Internal Test III      | Written Examination | 10    |
| Assessment             | Assignment          | 05    |
| Attendance             | Performance         | 05    |
| Total                  |                     | 40    |

|                    |                        |                 |          |          |          |               |
|--------------------|------------------------|-----------------|----------|----------|----------|---------------|
| <b>PEL 26 3 06</b> | <b>COMPUTER VISION</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                        | PE              | 3        | 0        | 0        | 3             |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                     |           |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|-----------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                     |           |
| <ul style="list-style-type: none"> <li>• Programming using Python</li> <li>• Linear Algebra (vectors, matrices, matrix operations)</li> <li>• Calculus (basic differentiation)</li> <li>• Probability and Statistics</li> <li>• Machine Learning fundamentals</li> <li>• Digital Image Processing basics</li> <li>• Basic understanding of Artificial Intelligence and Deep Learning</li> </ul>                                                                                                                     |                                                                                                     |           |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                     |           |
| <ul style="list-style-type: none"> <li>• Understand the fundamental concepts of computer vision and image formation.</li> <li>• Learn image processing techniques for feature extraction and enhancement.</li> <li>• Apply machine learning and deep learning methods for image analysis.</li> <li>• Develop computer vision applications for object detection, image classification, and segmentation.</li> <li>• Gain hands-on experience using Python and OpenCV to solve real-world vision problems.</li> </ul> |                                                                                                     |           |
| <b>Course Outcome</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                     |           |
| <b>CO1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Explain the fundamentals of computer vision, image representation, and image processing techniques. | <b>K2</b> |
| <b>CO2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Apply image preprocessing and feature extraction methods for image analysis.                        | <b>K2</b> |
| <b>CO3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Develop computer vision solutions using OpenCV and Python.                                          | <b>K3</b> |
| <b>CO4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Implement deep learning models for image classification, object detection, and image segmentation.  | <b>K4</b> |
| <b>CO5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Design and evaluate computer vision applications for real-world problems.                           | <b>K5</b> |

|                                                                                                                                                                                                         |                                        |            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|------------|
| <b>Syllabus</b>                                                                                                                                                                                         |                                        |            |
| <b>Unit I</b>                                                                                                                                                                                           | <b>Fundamentals of Computer Vision</b> | <b>(9)</b> |
| Human vision and computer vision, image formation, image acquisition, digital image representation, pixels and image resolution, color models (RGB, HSV, and Grayscale), image processing fundamentals, |                                        |            |

|                                                                                                                                                                                                                                                                                                   |                                                |            |
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| and applications of computer vision in healthcare, security, robotics, autonomous vehicles, and industrial automation.                                                                                                                                                                            |                                                |            |
| <b>Unit II</b>                                                                                                                                                                                                                                                                                    | <b>Image Processing and Feature Extraction</b> | <b>(9)</b> |
| Image preprocessing, image enhancement, histogram equalization, image filtering, thresholding, edge detection, morphological operations, image transformations, noise removal, feature extraction, corner detection, SIFT, SURF, ORB, feature matching, and image quality improvement techniques. |                                                |            |
| <b>Unit III</b>                                                                                                                                                                                                                                                                                   | <b>Object Detection and Recognition</b>        | <b>(9)</b> |
| Image classification, template matching, face detection, object detection, object tracking, motion detection, feature-based recognition, implementation of computer vision algorithms using Python and OpenCV.                                                                                    |                                                |            |
| <b>Unit IV</b>                                                                                                                                                                                                                                                                                    | <b>Deep Learning for Computer Vision</b>       | <b>(9)</b> |
| Convolutional Neural Networks (CNNs), transfer learning, image classification, object detection using YOLO, SSD, and Faster R-CNN, semantic segmentation, instance segmentation, model evaluation, and performance analysis.                                                                      |                                                |            |
| <b>Unit V</b>                                                                                                                                                                                                                                                                                     | <b>Applications of Computer Vision</b>         | <b>(9)</b> |
| Face recognition, Optical Character Recognition (OCR), medical image analysis, autonomous vehicles, video analytics, gesture recognition, surveillance systems, industrial inspection, and development of a mini project using Python and OpenCV.                                                 |                                                |            |

|                                                                                                                                                                                                                                                                                                                          |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books</b>                                                                                                                                                                                                                                                                                                        |
| <ul style="list-style-type: none"> <li>• Computer Vision: Algorithms and Applications, Richard Szeliski, Springer, 2022.</li> <li>• Learning OpenCV 4 Computer Vision with Python, Packt Publishing.</li> <li>• Programming Computer Vision with Python, O'Reilly Media.</li> <li>• Deep Learning, MIT Press.</li> </ul> |
| <b>Reference</b>                                                                                                                                                                                                                                                                                                         |
| <ul style="list-style-type: none"> <li>• Multiple View Geometry in Computer Vision, Cambridge University Press.</li> <li>• Digital Image Processing, Pearson.</li> <li>• Computer Vision: Models, Learning, and Inference, Cambridge University Press.</li> </ul>                                                        |
| <b>Web / NPTEL Resources</b>                                                                                                                                                                                                                                                                                             |
| <a href="http://nptel.ac.in/courses/106106184">http://nptel.ac.in/courses/106106184</a><br><a href="http://nptel.ac.in/courses/117105079">http://nptel.ac.in/courses/117105079</a>                                                                                                                                       |

| <b>CO-PO Mapping</b> |     |     |     |     |     |     |     |     |     |      |      |      |      |
|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| COs                  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
| CO1                  | 3   | 2   | 2   | 2   | 3   | 2   | –   | –   | –   | 2    | 1    | 3    | 2    |
| CO2                  | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO3                  | 3   | 3   | 3   | 3   | 3   | 3   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO4                  | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | 3    | 2    | 3    | 3    |
| CO5                  | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 1   | 3    | 3    | 3    | 3    |

| <b>Assessment Methodology</b> |                         |              |
|-------------------------------|-------------------------|--------------|
| <b>Assessment Methodology</b> | <b>Assessment Tools</b> | <b>Marks</b> |
| Internal Test I               | Written Examination     | 10           |
| Internal Test II              | Written Examination     | 10           |
| Internal Test III             | Written Examination     | 10           |
| Assessment                    | Assignment              | 05           |
| Attendance                    | Performance             | 05           |
| Total                         |                         | 40           |

| <i>PEL</i> 26 3 07 | <i>TIME SERIES DATA ANALYSIS</i> | CATEGORY | L | T | P | CREDIT |
|--------------------|----------------------------------|----------|---|---|---|--------|
|                    |                                  | PE       | 3 | 0 | 0 | 3      |

| Course Prerequisite / Preamble                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                  |           |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|-----------|
| <ul style="list-style-type: none"> <li>• Python Programming</li> <li>• Statistics and Probability</li> <li>• Linear Algebra</li> <li>• Data Structures and Algorithms</li> <li>• Database Management Systems</li> <li>• Machine Learning Fundamentals</li> <li>• Data Visualization using Python (Matplotlib/Seaborn)</li> <li>• Basic knowledge of Pandas and NumPy</li> </ul>                                                                             |                                                                                                  |           |
| Course Objective                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                  |           |
| <ul style="list-style-type: none"> <li>• Understand the concepts and characteristics of time series data.</li> <li>• Learn statistical techniques for analyzing and forecasting time series.</li> <li>• Apply machine learning and deep learning models for time series prediction.</li> <li>• Develop forecasting models using Python and relevant libraries.</li> <li>• Evaluate and interpret forecasting models for real-world applications.</li> </ul> |                                                                                                  |           |
| Course Outcome                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                  |           |
| <b>CO1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Explain the fundamentals of time series data, components, and preprocessing techniques.          | <b>K2</b> |
| <b>CO2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Apply statistical methods for trend, seasonality, and forecasting analysis.                      | <b>K2</b> |
| <b>CO3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Develop time series forecasting models using Python and machine learning techniques.             | <b>K3</b> |
| <b>CO4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Implement deep learning models for time series prediction and evaluate their performance.        | <b>K4</b> |
| <b>CO5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Design and analyze real-world time series applications using appropriate forecasting techniques. | <b>K5</b> |

| <b>Syllabus</b>                                                                                                                                                                                                                                                                                                           |                                                     |            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|------------|
| <b>Unit I</b>                                                                                                                                                                                                                                                                                                             | <b>Fundamentals of Time Series Data</b>             | <b>(9)</b> |
| Time series data and its characteristics, types of time series, components of time series (trend, seasonality, cyclical, and irregular variations), time series visualization, data preprocessing, missing value handling, smoothing techniques, stationarity, autocorrelation, and applications of time series analysis. |                                                     |            |
| <b>Unit II</b>                                                                                                                                                                                                                                                                                                            | <b>Statistical Methods for Time Series Analysis</b> | <b>(9)</b> |
| Moving averages, exponential smoothing, decomposition techniques, autoregression (AR), moving average (MA), autoregressive moving average (ARMA), autoregressive integrated moving average (ARIMA), seasonal ARIMA (SARIMA), model identification, parameter estimation, and forecasting accuracy measures.               |                                                     |            |
| <b>Unit III</b>                                                                                                                                                                                                                                                                                                           | <b>Machine Learning for Time Series Forecasting</b> | <b>(9)</b> |
| Feature engineering for time series, regression models, decision trees, random forests, support vector regression, ensemble learning methods, forecasting using Scikit-learn, model evaluation metrics, cross-validation, and hyperparameter tuning.                                                                      |                                                     |            |
| <b>Unit IV</b>                                                                                                                                                                                                                                                                                                            | <b>Deep Learning for Time Series</b>                | <b>(9)</b> |
| Artificial Neural Networks (ANN), Recurrent Neural Networks (RNN), Long Short-Term Memory (LSTM), Gated Recurrent Units (GRU), sequence modeling, multivariate time series forecasting, model optimization, and performance evaluation using TensorFlow and Keras.                                                        |                                                     |            |
| <b>Unit V</b>                                                                                                                                                                                                                                                                                                             | <b>Applications of Time Series Analysis</b>         | <b>(9)</b> |
| Financial forecasting, stock market prediction, weather forecasting, demand forecasting, healthcare analytics, IoT sensor data analysis, anomaly detection, predictive maintenance, energy consumption forecasting, and implementation of a mini project using Python.                                                    |                                                     |            |

| <b>Text Books</b>                                                                                                                                                                                                   |
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| <ul style="list-style-type: none"> <li>• Time Series Analysis and Its Applications, Springer.</li> <li>• Forecasting: Principles and Practice.</li> <li>• Practical Time Series Forecasting with Python.</li> </ul> |
| <b>Reference</b>                                                                                                                                                                                                    |
| <ul style="list-style-type: none"> <li>• Introduction to Time Series and Forecasting.</li> <li>• Hands-On Time Series Analysis with Python.</li> </ul>                                                              |

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| <ul style="list-style-type: none"> <li>• Deep Learning.</li> </ul>                                                                                                                 |
| <b>Web / NPTEL Resources</b>                                                                                                                                                       |
| <a href="http://nptel.ac.in/courses/111106148">http://nptel.ac.in/courses/111106148</a><br><a href="http://nptel.ac.in/courses/106106184">http://nptel.ac.in/courses/106106184</a> |

| <b>CO-PO Mapping</b> |     |     |     |     |     |     |     |     |     |      |      |      |      |
|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| COs                  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
| CO1                  | 3   | 2   | 2   | 2   | 3   | 2   | –   | –   | –   | 2    | 1    | 3    | 2    |
| CO2                  | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO3                  | 3   | 3   | 3   | 3   | 3   | 3   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO4                  | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | 3    | 2    | 3    | 3    |
| CO5                  | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 1   | 3    | 3    | 3    | 3    |

| <b>Assessment Methodology</b> |                     |       |
|-------------------------------|---------------------|-------|
| Assessment Methodology        | Assessment Tools    | Marks |
| Internal Test I               | Written Examination | 10    |
| Internal Test II              | Written Examination | 10    |
| Internal Test III             | Written Examination | 10    |
| Assessment                    | Assignment          | 05    |
| Attendance                    | Performance         | 05    |
| Total                         |                     | 40    |

| <i>PEL</i> 26 3 08 | <i>LARGE LANGUAGE MODELS</i> | CATEGORY | L | T | P | CREDIT |
|--------------------|------------------------------|----------|---|---|---|--------|
|                    |                              | PE       | 3 | 0 | 0 | 3      |

| Course Prerequisite / Preamble                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                  |           |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|-----------|
| <ul style="list-style-type: none"> <li>• Python Programming</li> <li>• Data Structures and Algorithms</li> <li>• Linear Algebra</li> <li>• Probability and Statistics</li> <li>• Machine Learning Fundamentals</li> <li>• Deep Learning and Neural Networks</li> <li>• Natural Language Processing (NLP)</li> <li>• Python libraries such as NumPy, Pandas, PyTorch, or TensorFlow</li> </ul>                                                                                                                    |                                                                                                                  |           |
| Course Objective                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                  |           |
| <ul style="list-style-type: none"> <li>• Understand the fundamentals and architecture of Large Language Models (LLMs).</li> <li>• Learn transformer-based architectures and pre-trained language models.</li> <li>• Apply prompt engineering, fine-tuning, and Retrieval-Augmented Generation (RAG) techniques.</li> <li>• Develop AI-powered applications using Large Language Models and modern frameworks.</li> <li>• Evaluate the ethical, security, and deployment aspects of LLM-based systems.</li> </ul> |                                                                                                                  |           |
| Course Outcome                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                  |           |
| <b>CO1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Explain the fundamentals, architecture, and evolution of Large Language Models.                                  | <b>K2</b> |
| <b>CO2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Apply transformer architectures and pre-trained language models for natural language processing tasks.           | <b>K2</b> |
| <b>CO3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Develop applications using prompt engineering, fine-tuning, and Retrieval-Augmented Generation (RAG).            | <b>K3</b> |
| <b>CO4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Implement Large Language Models using modern AI frameworks and evaluate their performance.                       | <b>K4</b> |
| <b>CO5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Design responsible and scalable LLM-based solutions by considering ethical, security, and deployment challenges. | <b>K5</b> |

| <b>Syllabus</b>                                                                                                                                                                                                                                                                                                                          |                                                                  |            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|------------|
| <b>Unit I</b>                                                                                                                                                                                                                                                                                                                            | <b>Fundamentals of Large Language Models</b>                     | <b>(9)</b> |
| Introduction to Artificial Intelligence, Machine Learning, Deep Learning, and Natural Language Processing, evolution of language models, Large Language Models (LLMs), text representation, tokenization, embeddings, attention mechanism, transformer architecture, encoder and decoder models, scaling laws, and applications of LLMs. |                                                                  |            |
| <b>Unit II</b>                                                                                                                                                                                                                                                                                                                           | <b>Pre-trained Language Models and Transformer Architectures</b> | <b>(9)</b> |
| Transformer architecture, BERT, GPT, T5, LLaMA, encoder-only, decoder-only, and encoder-decoder models, transfer learning, masked language modeling, causal language modeling, sequence-to-sequence learning, model training, and evaluation metrics.                                                                                    |                                                                  |            |
| <b>Unit III</b>                                                                                                                                                                                                                                                                                                                          | <b>Prompt Engineering and Retrieval-Augmented Generation</b>     | <b>(9)</b> |
| Prompt engineering techniques, zero-shot, one-shot, few-shot prompting, chain-of-thought prompting, prompt optimization, Retrieval-Augmented Generation (RAG), vector embeddings, vector databases, semantic search, fine-tuning, parameter-efficient fine-tuning (LoRA, PEFT), and model adaptation.                                    |                                                                  |            |
| <b>Unit IV</b>                                                                                                                                                                                                                                                                                                                           | <b>Building LLM Applications</b>                                 | <b>(9)</b> |
| LLM APIs, Hugging Face Transformers, LangChain, OpenAI API, agents, function calling, conversational AI, chatbots, document question answering, summarization, translation, code generation, multimodal language models, model evaluation, and performance optimization.                                                                 |                                                                  |            |
| <b>Unit V</b>                                                                                                                                                                                                                                                                                                                            | <b>Ethics, Security, and Deployment of LLMs</b>                  | <b>(9)</b> |
| Responsible AI, bias and fairness, hallucination mitigation, explainability, privacy, security, prompt injection attacks, model alignment, LLM deployment, cloud-based AI services, edge deployment, monitoring, governance, and real-world case studies.                                                                                |                                                                  |            |

| <b>Text Books</b>                                                                                                                                                                                                |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Natural Language Processing with Transformers, O'Reilly Media.</li> <li>• Speech and Language Processing.</li> <li>• Deep Learning, MIT Press.</li> </ul>               |
| <b>Reference</b>                                                                                                                                                                                                 |
| <ul style="list-style-type: none"> <li>• Transformers for Natural Language Processing, Packt Publishing.</li> <li>• Generative AI with Python and PyTorch.</li> <li>• Hands-On Large Language Models.</li> </ul> |

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|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Web / NPTEL Resources</b>                                                                                                                                                       |
| <a href="http://nptel.ac.in/courses/106106211">http://nptel.ac.in/courses/106106211</a><br><a href="http://nptel.ac.in/courses/106105077">http://nptel.ac.in/courses/106105077</a> |

| <b>CO-PO Mapping</b> |     |     |     |     |     |     |     |     |     |      |      |      |      |
|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| COs                  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
| CO1                  | 3   | 2   | 2   | 2   | 3   | 2   | –   | –   | –   | 2    | 1    | 3    | 2    |
| CO2                  | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO3                  | 3   | 3   | 3   | 3   | 3   | 3   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO4                  | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | 3    | 2    | 3    | 3    |
| CO5                  | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 1   | 3    | 3    | 3    | 3    |

| <b>Assessment Methodology</b> |                     |       |
|-------------------------------|---------------------|-------|
| Assessment Methodology        | Assessment Tools    | Marks |
| Internal Test I               | Written Examination | 10    |
| Internal Test II              | Written Examination | 10    |
| Internal Test III             | Written Examination | 10    |
| Assessment                    | Assignment          | 05    |
| Attendance                    | Performance         | 05    |
| Total                         |                     | 40    |

|                    |                                        |                 |          |          |          |               |
|--------------------|----------------------------------------|-----------------|----------|----------|----------|---------------|
| <b>PEL 26 3 09</b> | <b>QUANTUM ARTIFICIAL INTELLIGENCE</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                                        | PE              | 3        | 0        | 0        | 3             |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                             |           |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|-----------|
| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                             |           |
| <ul style="list-style-type: none"> <li>• Python Programming</li> <li>• Linear Algebra (vectors, matrices, eigenvalues, eigenvectors)</li> <li>• Probability and Statistics</li> <li>• Data Structures and Algorithms</li> <li>• Machine Learning Fundamentals</li> <li>• Artificial Intelligence</li> <li>• Quantum Computing Basics</li> <li>• Basic knowledge of Python libraries such as NumPy and Qiskit</li> </ul>                                                                           |                                                                                                             |           |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                             |           |
| <ul style="list-style-type: none"> <li>• Understand the principles of quantum computing and their role in Artificial Intelligence.</li> <li>• Learn quantum algorithms and quantum machine learning techniques.</li> <li>• Apply quantum computing frameworks to develop AI solutions.</li> <li>• Explore hybrid quantum-classical models for solving complex AI problems.</li> <li>• Evaluate the potential, limitations, and future applications of Quantum Artificial Intelligence.</li> </ul> |                                                                                                             |           |
| <b>Course Outcome</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                             |           |
| <b>CO1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Explain the fundamentals of quantum computing and Quantum Artificial Intelligence.                          | <b>K2</b> |
| <b>CO2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Apply quantum computing concepts and quantum algorithms to solve AI problems.                               | <b>K2</b> |
| <b>CO3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Develop quantum machine learning models using quantum computing frameworks.                                 | <b>K3</b> |
| <b>CO4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Implement hybrid quantum-classical AI solutions and evaluate their performance.                             | <b>K4</b> |
| <b>CO5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Analyze real-world applications, challenges, and ethical considerations of Quantum Artificial Intelligence. | <b>K5</b> |

|                 |                                                        |            |
|-----------------|--------------------------------------------------------|------------|
| <b>Syllabus</b> |                                                        |            |
| <b>Unit I</b>   | <b>Fundamentals of Quantum Artificial Intelligence</b> | <b>(9)</b> |

|                                                                                                                                                                                                                                                                                                                        |                                                  |            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|------------|
| Introduction to Artificial Intelligence and Quantum Computing, classical computing versus quantum computing, qubits, quantum states, superposition, entanglement, quantum gates, quantum circuits, quantum measurement, Bloch sphere, quantum hardware platforms, and applications of Quantum Artificial Intelligence. |                                                  |            |
| <b>Unit II</b>                                                                                                                                                                                                                                                                                                         | <b>Quantum Computing and Quantum Algorithms</b>  | <b>(9)</b> |
| Quantum logic gates, quantum circuit design, quantum teleportation, quantum Fourier transform, Grover's search algorithm, Shor's algorithm, variational quantum algorithms, quantum optimization, quantum simulation, and quantum programming using Qiskit.                                                            |                                                  |            |
| <b>Unit III</b>                                                                                                                                                                                                                                                                                                        | <b>Quantum Machine Learning</b>                  | <b>(9)</b> |
| Introduction to Quantum Machine Learning (QML), quantum data encoding, quantum feature maps, quantum kernels, variational quantum circuits, quantum neural networks, quantum support vector machines, quantum classifiers, quantum clustering, and hybrid quantum-classical machine learning models.                   |                                                  |            |
| <b>Unit IV</b>                                                                                                                                                                                                                                                                                                         | <b>Quantum AI Frameworks and Applications</b>    | <b>(9)</b> |
| Quantum programming using Qiskit and PennyLane, hybrid quantum-classical workflows, optimization techniques, healthcare applications, financial modeling, cybersecurity, drug discovery, image processing, natural language processing, robotics, and autonomous systems.                                              |                                                  |            |
| <b>Unit V</b>                                                                                                                                                                                                                                                                                                          | <b>Ethics, Challenges, and Future Directions</b> | <b>(9)</b> |
| Scalability challenges, noisy intermediate-scale quantum (NISQ) devices, quantum error correction, responsible AI, ethical considerations, security implications, quantum advantage, cloud-based quantum computing, industrial case studies, and emerging trends in Quantum Artificial Intelligence.                   |                                                  |            |

|                                                                                                                                                                                                                                       |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books</b>                                                                                                                                                                                                                     |
| <ul style="list-style-type: none"> <li>Quantum Computation and Quantum Information, Cambridge University Press.</li> <li>Quantum Machine Learning, Academic Press.</li> <li>Programming Quantum Computers, O'Reilly Media.</li> </ul> |
| <b>Reference</b>                                                                                                                                                                                                                      |
| <ul style="list-style-type: none"> <li>Machine Learning with Quantum Computers, Springer.</li> <li>Dancing with Qubits, Packt Publishing.</li> <li>Quantum Computing for Computer Scientists, Cambridge University Press.</li> </ul>  |

|                                                                                                                                                                                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Web / NPTEL Resources</b>                                                                                                                                                       |
| <a href="http://nptel.ac.in/courses/106106235">http://nptel.ac.in/courses/106106235</a><br><a href="http://nptel.ac.in/courses/106106139">http://nptel.ac.in/courses/106106139</a> |

| <b>CO-PO Mapping</b> |     |     |     |     |     |     |     |     |     |      |      |      |      |
|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| COs                  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
| CO1                  | 3   | 2   | 2   | 2   | 3   | 2   | –   | –   | –   | 2    | 1    | 3    | 2    |
| CO2                  | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO3                  | 3   | 3   | 3   | 3   | 3   | 3   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO4                  | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | 3    | 2    | 3    | 3    |
| CO5                  | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 1   | 3    | 3    | 3    | 3    |

| <b>Assessment Methodology</b> |                     |       |
|-------------------------------|---------------------|-------|
| Assessment Methodology        | Assessment Tools    | Marks |
| Internal Test I               | Written Examination | 10    |
| Internal Test II              | Written Examination | 10    |
| Internal Test III             | Written Examination | 10    |
| Assessment                    | Assignment          | 05    |
| Attendance                    | Performance         | 05    |
| Total                         |                     | 40    |

|                    |                 |                 |          |          |          |               |
|--------------------|-----------------|-----------------|----------|----------|----------|---------------|
| <b>PEL 26 3 10</b> | <b>ROBOTICS</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                 | PE              | 3        | 0        | 0        | 3             |

#### Course Prerequisite / Preamble

- Python or C++ Programming
- Linear Algebra
- Calculus
- Probability and Statistics
- Artificial Intelligence Fundamentals
- Machine Learning Basics
- Sensors and Actuators
- Control Systems

#### Course Objective

- Understand the fundamentals of robotics and robotic system components.
- Learn robot kinematics, dynamics, sensing, and motion planning techniques.
- Apply Artificial Intelligence and Machine Learning concepts in robotic systems.
- Develop robotic applications using Robot Operating System (ROS) and simulation tools.
- Design intelligent robotic systems for real-world automation and autonomous applications.

#### Course Outcome

|            |                                                                                                                                          |           |
|------------|------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| <b>CO1</b> | Explain the fundamentals of robotics, robot components, and robotic system architecture.                                                 | <b>K2</b> |
| <b>CO2</b> | Apply robot kinematics, dynamics, sensing, and motion planning techniques to robotic systems.                                            | <b>K2</b> |
| <b>CO3</b> | Develop robotic applications using Robot Operating System (ROS), sensors, and simulation tools.                                          | <b>K3</b> |
| <b>CO4</b> | Implement Artificial Intelligence and Machine Learning techniques for autonomous robotic systems.                                        | <b>K4</b> |
| <b>CO5</b> | Design and evaluate robotic solutions for industrial, healthcare, and service applications while considering ethical and safety aspects. | <b>K5</b> |

#### Syllabus

|                                                                                                                                                                                                                                                                                                                      |                                                    |            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|------------|
| <b>Unit I</b>                                                                                                                                                                                                                                                                                                        | <b>Fundamentals of Robotics</b>                    | <b>(9)</b> |
| Introduction to robotics, history and evolution of robots, robot anatomy, robot configurations, degrees of freedom, robotic system components, sensors and actuators, end effectors, robot coordinate systems, robotic applications, industrial robots, service robots, collaborative robots, and autonomous robots. |                                                    |            |
| <b>Unit II</b>                                                                                                                                                                                                                                                                                                       | <b>Robot Kinematics and Motion Planning</b>        | <b>(9)</b> |
| Forward kinematics, inverse kinematics, homogeneous transformation matrices, robot workspace, trajectory planning, path planning, motion control, robot dynamics, control strategies, localization, mapping, obstacle avoidance, and navigation techniques.                                                          |                                                    |            |
| <b>Unit III</b>                                                                                                                                                                                                                                                                                                      | <b>Sensors, Vision, and Robot Operating System</b> | <b>(9)</b> |
| Robot sensors, proximity sensors, ultrasonic sensors, infrared sensors, LiDAR, cameras, force and torque sensors, sensor fusion, computer vision for robotics, Robot Operating System (ROS), ROS architecture, simulation using Gazebo, and robotic programming.                                                     |                                                    |            |
| <b>Unit IV</b>                                                                                                                                                                                                                                                                                                       | <b>Artificial Intelligence in Robotics</b>         | <b>(9)</b> |
| Artificial Intelligence for robotics, machine learning, reinforcement learning, deep learning, autonomous decision making, robotic perception, simultaneous localization and mapping (SLAM), robotic manipulation, grasp planning, human-robot interaction, and multi-robot systems.                                 |                                                    |            |
| <b>Unit V</b>                                                                                                                                                                                                                                                                                                        | <b>Robotics Applications</b>                       | <b>(9)</b> |
| Industrial automation, healthcare robots, medical and surgical robots, agricultural robots, warehouse automation, autonomous vehicles, drones, underwater robots, space robotics, ethical issues, safety standards, emerging trends in robotics, and implementation of a robotics mini project using ROS and Python. |                                                    |            |

|                                                                                                                                                                                                                                                                |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books</b>                                                                                                                                                                                                                                              |
| <ul style="list-style-type: none"> <li>• Introduction to Robotics: Mechanics and Control, 4th Edition, Pearson.</li> <li>• Robotics, Vision and Control, Springer.</li> <li>• Programming Robots with ROS, O'Reilly Media.</li> </ul>                          |
| <b>Reference</b>                                                                                                                                                                                                                                               |
| <ul style="list-style-type: none"> <li>• Modern Robotics: Mechanics, Planning, and Control, Cambridge University Press.</li> <li>• Springer Handbook of Robotics, Springer.</li> <li>• Robot Operating System (ROS) for Absolute Beginners, Apress.</li> </ul> |
| <b>Web / NPTEL Resources</b>                                                                                                                                                                                                                                   |

<http://nptel.ac.in/courses/112101099>

<http://nptel.ac.in/courses/106105077>

### CO-PO Mapping

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 2   | 2   | 3   | 2   | 3   | 2   | –   | –   | –   | 2    | 1    | 3    | 2    |
| CO2 | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO3 | 3   | 3   | 3   | 3   | 3   | 3   | 2   | –   | –   | 2    | 2    | 3    | 3    |
| CO4 | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | 3    | 2    | 3    | 3    |
| CO5 | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 1   | 3    | 3    | 3    | 3    |

### Assessment Methodology

| Assessment Methodology | Assessment Tools    | Marks |
|------------------------|---------------------|-------|
| Internal Test I        | Written Examination | 10    |
| Internal Test II       | Written Examination | 10    |
| Internal Test III      | Written Examination | 10    |
| Assessment             | Assignment          | 05    |
| Attendance             | Performance         | 05    |
| Total                  |                     | 40    |

| <i>PEL</i> 26 3 11 | <i>AGENTIC AI</i> | CATEGORY | L | T | P | CREDIT |
|--------------------|-------------------|----------|---|---|---|--------|
|                    |                   | PE       | 3 | 0 | 0 | 3      |

| Course Prerequisite / Preamble                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                   |           |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|-----------|
| <ul style="list-style-type: none"> <li>• Python Programming</li> <li>• Data Structures and Algorithms</li> <li>• Machine Learning Fundamentals</li> <li>• Deep Learning Basics</li> <li>• Natural Language Processing (NLP)</li> <li>• Large Language Models (LLMs)</li> <li>• APIs and Web Services</li> <li>• Python libraries such as NumPy, Pandas, PyTorch, or TensorFlow</li> </ul>                                                                                                                                                                           |                                                                                                                   |           |
| Course Objective                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                   |           |
| <ul style="list-style-type: none"> <li>• Understand the concepts, architecture, and capabilities of Agentic AI systems.</li> <li>• Learn autonomous reasoning, planning, memory, and decision-making techniques used in AI agents.</li> <li>• Develop intelligent AI agents using Large Language Models, tools, APIs, and multi-agent frameworks.</li> <li>• Apply Agentic AI to solve real-world problems through autonomous task execution and collaboration.</li> <li>• Evaluate the ethical, security, and deployment aspects of Agentic AI systems.</li> </ul> |                                                                                                                   |           |
| Course Outcome                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                   |           |
| <b>CO1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Explain the fundamentals, architecture, and working principles of Agentic AI systems.                             | <b>K2</b> |
| <b>CO2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Apply reasoning, planning, memory, and tool integration techniques for autonomous AI agents.                      | <b>K2</b> |
| <b>CO3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Develop AI agents using Large Language Models, APIs, and modern agent frameworks.                                 | <b>K3</b> |
| <b>CO4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Implement single-agent and multi-agent systems for solving real-world applications.                               | <b>K4</b> |
| <b>CO5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Design secure, ethical, and scalable Agentic AI solutions while evaluating their performance and societal impact. | <b>K5</b> |

| <b>Syllabus</b>                                                                                                                                                                                                                                                                                                             |                                                   |            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|------------|
| <b>Unit I</b>                                                                                                                                                                                                                                                                                                               | <b>Fundamentals of Agentic AI</b>                 | <b>(9)</b> |
| Introduction to Artificial Intelligence, Generative AI, Large Language Models, evolution of AI agents, fundamentals of Agentic AI, intelligent agents, agent architectures, autonomous decision making, reasoning, planning, memory, perception, environment interaction, agent life cycle, and applications of Agentic AI. |                                                   |            |
| <b>Unit II</b>                                                                                                                                                                                                                                                                                                              | <b>Large Language Models and Agent Frameworks</b> | <b>(9)</b> |
| Transformer architecture overview, Large Language Models, prompt engineering, function calling, tool use, Retrieval-Augmented Generation (RAG), vector embeddings, vector databases, LangChain, LangGraph, AutoGen, CrewAI, Semantic Kernel, and agent orchestration frameworks.                                            |                                                   |            |
| <b>Unit III</b>                                                                                                                                                                                                                                                                                                             | <b>Autonomous Agents and Multi-Agent Systems</b>  | <b>(9)</b> |
| Agent planning, task decomposition, workflow automation, memory management, knowledge retrieval, autonomous reasoning, reactive and proactive agents, multi-agent communication, collaboration, negotiation, coordination, distributed AI systems, and human-in-the-loop systems.                                           |                                                   |            |
| <b>Unit IV</b>                                                                                                                                                                                                                                                                                                              | <b>Building Intelligent AI Agents</b>             | <b>(9)</b> |
| Design and implementation of AI agents using Python, OpenAI APIs, Hugging Face models, API integration, web search tools, database connectivity, document processing, conversational AI, autonomous assistants, code generation agents, evaluation techniques, and performance optimization.                                |                                                   |            |
| <b>Unit V</b>                                                                                                                                                                                                                                                                                                               | <b>Applications, Ethics, and Deployment</b>       | <b>(9)</b> |
| AI assistants, business process automation, healthcare, finance, education, cybersecurity, software engineering assistants, robotics integration, cloud deployment, monitoring, responsible AI, privacy, bias, explainability, AI governance, security threats, prompt injection attacks, and future trends in Agentic AI.  |                                                   |            |

| <b>Text Books</b>                                                                                                                                                                                      |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>AI Engineering, O'Reilly Media.</li> <li>Hands-On Large Language Models, O'Reilly Media.</li> <li>Building LLM Powered Applications, O'Reilly Media.</li> </ul> |
| <b>Reference</b>                                                                                                                                                                                       |
| <ul style="list-style-type: none"> <li>Natural Language Processing with Transformers, O'Reilly Media.</li> </ul>                                                                                       |

- Designing Machine Learning Systems, O'Reilly Media.
- Speech and Language Processing, Pearson.

#### Web / NPTEL Resources

<http://nptel.ac.in/courses/106105077>

<http://nptel.ac.in/courses/106106211>

#### CO-PO Mapping

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3   | 2   | 2   | 2   | 3   | 2   | –   | –   | –   | 2    | 1    | 3    | 2    |
| CO2 | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO3 | 3   | 3   | 3   | 3   | 3   | 3   | 1   | –   | 1   | 2    | 2    | 3    | 3    |
| CO4 | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 1   | 1   | 3    | 2    | 3    | 3    |
| CO5 | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 2   | 3    | 3    | 3    | 3    |

#### Assessment Methodology

| Assessment Methodology | Assessment Tools    | Marks |
|------------------------|---------------------|-------|
| Internal Test I        | Written Examination | 10    |
| Internal Test II       | Written Examination | 10    |
| Internal Test III      | Written Examination | 10    |
| Assessment             | Assignment          | 05    |
| Attendance             | Performance         | 05    |
| Total                  |                     | 40    |

|                    |                      |                 |          |          |          |               |
|--------------------|----------------------|-----------------|----------|----------|----------|---------------|
| <b>PEL 26 3 12</b> | <b>DIGITAL TWINS</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |                      | PE              | 3        | 0        | 0        | 3             |

| <b>Course Prerequisite / Preamble</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                   |           |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|-----------|
| <ul style="list-style-type: none"> <li>• Python Programming</li> <li>• Data Structures and Algorithms</li> <li>• Internet of Things (IoT)</li> <li>• Sensors and Embedded Systems</li> <li>• Database Management Systems</li> <li>• Artificial Intelligence and Machine Learning Fundamentals</li> <li>• Cloud Computing Basics</li> <li>• Data Analytics and Visualization</li> </ul>                                                                                                                                                                 |                                                                                                   |           |
| <b>Course Objective</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                   |           |
| <ul style="list-style-type: none"> <li>• Understand the concepts, architecture, and components of Digital Twin technology.</li> <li>• Learn data acquisition, modeling, simulation, and real-time monitoring techniques.</li> <li>• Apply Artificial Intelligence, IoT, and cloud technologies to develop Digital Twin solutions.</li> <li>• Design Digital Twin models for industrial, healthcare, smart city, and manufacturing applications.</li> <li>• Evaluate the performance, security, and ethical aspects of Digital Twin systems.</li> </ul> |                                                                                                   |           |
| <b>Course Outcome</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                   |           |
| <b>CO1</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Explain the fundamentals, architecture, and components of Digital Twin technology.                | <b>K2</b> |
| <b>CO2</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Apply IoT, sensors, data acquisition, and simulation techniques for Digital Twin development.     | <b>K2</b> |
| <b>CO3</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Develop Digital Twin models using AI, Machine Learning, cloud platforms, and visualization tools. | <b>K3</b> |
| <b>CO4</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Implement Digital Twin applications for real-time monitoring, prediction, and optimization.       | <b>K4</b> |
| <b>CO5</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Design secure, scalable, and sustainable Digital Twin solutions for real-world applications.      | <b>K5</b> |

| <b>Syllabus</b>                                                                                                                                                                                                                                                                                                            |                                                    |            |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|------------|
| <b>Unit I</b>                                                                                                                                                                                                                                                                                                              | <b>Fundamentals of Digital Twins</b>               | <b>(9)</b> |
| Introduction to Digital Twins, evolution and concepts, physical and virtual systems, Digital Twin architecture, components of Digital Twins, data acquisition, sensors, IoT devices, communication protocols, cyber-physical systems, real-time data integration, lifecycle management, and applications of Digital Twins. |                                                    |            |
| <b>Unit II</b>                                                                                                                                                                                                                                                                                                             | <b>Data Acquisition and Digital Twin Modeling</b>  | <b>(9)</b> |
| IoT sensors, embedded systems, data collection techniques, cloud computing, edge computing, data preprocessing, data integration, simulation models, virtual representation, system modeling, data visualization, interoperability, and Digital Twin platforms.                                                            |                                                    |            |
| <b>Unit III</b>                                                                                                                                                                                                                                                                                                            | <b>Artificial Intelligence for Digital Twins</b>   | <b>(9)</b> |
| Machine Learning for Digital Twins, predictive analytics, anomaly detection, predictive maintenance, optimization techniques, deep learning models, time series analysis, data-driven decision making, model validation, performance evaluation, and intelligent automation.                                               |                                                    |            |
| <b>Unit IV</b>                                                                                                                                                                                                                                                                                                             | <b>Development and Deployment of Digital Twins</b> | <b>(9)</b> |
| Digital Twin development frameworks, cloud-based Digital Twins, Microsoft Azure Digital Twins, AWS IoT TwinMaker, Siemens Digital Twin concepts, API integration, dashboards, visualization, cybersecurity, scalability, deployment strategies, and performance monitoring.                                                |                                                    |            |
| <b>Unit V</b>                                                                                                                                                                                                                                                                                                              | <b>Applications and Future Trends</b>              | <b>(9)</b> |
| Digital Twins in smart manufacturing, Industry 4.0, healthcare, smart cities, transportation, energy management, agriculture, robotics, autonomous systems, sustainability, ethical considerations, security, governance, industrial case studies, and implementation of a Digital Twin mini project.                      |                                                    |            |

| <b>Text Books</b>                                                                                                                                                                             |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Digital Twin Driven Smart Manufacturing, Academic Press.</p> <p>Digital Twin Fundamentals and Applications, Wiley.</p> <p>Internet of Things: A Hands-On Approach, Universities Press.</p> |
| <b>Reference</b>                                                                                                                                                                              |
| <p>Designing Distributed Systems, O'Reilly Media.</p> <p>Artificial Intelligence: A Modern Approach, Pearson.</p> <p>Cloud Computing: Concepts, Technology &amp; Architecture, Pearson.</p>   |

|                                                                                                                                                                                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Web / NPTEL Resources</b>                                                                                                                                                       |
| <a href="http://nptel.ac.in/courses/106105166">http://nptel.ac.in/courses/106105166</a><br><a href="http://nptel.ac.in/courses/106105077">http://nptel.ac.in/courses/106105077</a> |

| <b>CO-PO Mapping</b> |     |     |     |     |     |     |     |     |     |      |      |      |      |
|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| COs                  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
| CO1                  | 2   | 2   | 2   | 2   | 3   | 2   | –   | –   | –   | 2    | 1    | 3    | 2    |
| CO2                  | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO3                  | 3   | 3   | 3   | 3   | 3   | 3   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO4                  | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | 3    | 2    | 3    | 3    |
| CO5                  | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 1   | 3    | 3    | 3    | 3    |

| <b>Assessment Methodology</b>  |                         |              |
|--------------------------------|-------------------------|--------------|
| <b>Assessment Methodology</b>  | <b>Assessment Tools</b> | <b>Marks</b> |
| Continuous Internal Assessment | Assignment / Tutorial   | 10           |
| Internal Test I                | Written Examination     | 05           |
| Internal Test II               | Written Examination     | 05           |
| Model Examination              | Written Examination     | 10           |
| Attendance                     | Performance             | 10           |
| Total                          |                         | 40           |

|                    |              |                 |          |          |          |               |
|--------------------|--------------|-----------------|----------|----------|----------|---------------|
| <b>PEL 26 3 13</b> | <b>MLOps</b> | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                    |              | PE              | 3        | 0        | 0        | 3             |

### Course Prerequisite / Preamble

Students should have a basic understanding of Python programming, Machine Learning concepts, statistics, data preprocessing, and software development practices. Familiarity with version control using Git, Linux commands, cloud computing basics, and database management will help students understand MLOps tools and deployment workflows more effectively.

### Course Objective

- Understand the principles and lifecycle of Machine Learning Operations (MLOps).
- Learn version control, experiment tracking, and model management techniques.
- Develop skills in automating ML pipelines using CI/CD practices.
- Understand model deployment, monitoring, and maintenance in production environments.
- Gain hands-on experience with popular MLOps tools and cloud-based deployment platforms.

### Course Outcome

|            |                                                                                            |           |
|------------|--------------------------------------------------------------------------------------------|-----------|
| <b>CO1</b> | Explain the concepts, architecture, and lifecycle of MLOps.                                | <b>K2</b> |
| <b>CO2</b> | Apply version control, data management, and experiment tracking techniques in ML projects. | <b>K2</b> |
| <b>CO3</b> | Design automated Machine Learning pipelines using CI/CD and workflow orchestration tools.  | <b>K3</b> |
| <b>CO4</b> | Deploy, monitor, and manage Machine Learning models in production environments.            | <b>K4</b> |
| <b>CO5</b> | Develop end-to-end MLOps solutions using industry-standard tools and cloud platforms.      | <b>K5</b> |

### Syllabus

|                                                                                                                                                                                                                                                      |                              |            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|------------|
| <b>Unit I</b>                                                                                                                                                                                                                                        | <b>Introduction to MLOps</b> | <b>(9)</b> |
| Introduction to MLOps, Machine Learning lifecycle, challenges in deploying ML models, DevOps vs MLOps, MLOps architecture, reproducibility in ML, collaboration between data scientists and operations teams, overview of MLOps tools and platforms. |                              |            |

|                                                                                                                                                                                                                                                                        |                                                  |            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|------------|
| <b>Unit II</b>                                                                                                                                                                                                                                                         | <b>Version Control and Experiment Management</b> | <b>(9)</b> |
| Version control using Git, data versioning, model versioning, experiment tracking, metadata management, model registry, reproducible experiments, collaborative development, introduction to MLflow and DVC.                                                           |                                                  |            |
| <b>Unit III</b>                                                                                                                                                                                                                                                        | <b>ML Pipelines and CI/CD</b>                    | <b>(9)</b> |
| Machine Learning pipelines, workflow automation, feature engineering pipelines, continuous integration, continuous delivery, continuous training, containerization using Docker, orchestration with Kubernetes, pipeline automation using Kubeflow and Apache Airflow. |                                                  |            |
| <b>Unit IV</b>                                                                                                                                                                                                                                                         | <b>Model Deployment and Monitoring</b>           | <b>(9)</b> |
| Deployment strategies, REST APIs, batch and real-time inference, cloud deployment, model serving, monitoring model performance, concept drift, data drift, logging, alerting, model retraining, scalability and security considerations.                               |                                                  |            |
| <b>Unit V</b>                                                                                                                                                                                                                                                          | <b>MLOps Tools and Industry Applications</b>     | <b>(9)</b> |
| MLflow, Kubeflow, TensorFlow Extended (TFX), DVC, Jenkins, GitHub Actions, Azure ML, AWS SageMaker, Google Vertex AI, best practices, case studies, ethics, governance, and future trends in MLOps.                                                                    |                                                  |            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books</b>                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <ul style="list-style-type: none"> <li>Noah Gift and Alfredo Deza, Practical MLOps, O'Reilly Media, 2021.</li> <li>Mark Treveil, Nicolas Omont, Clément Stenac, et al., Introducing MLOps, O'Reilly Media, 2020.</li> </ul>                                                                                                                                                                                                               |
| <b>Reference</b>                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <ul style="list-style-type: none"> <li>Emmanuel Ameisen, Building Machine Learning Powered Applications, O'Reilly Media, 2020.</li> <li>Chip Huyen, Designing Machine Learning Systems, O'Reilly Media, 2022.</li> <li>Andriy Burkov, Machine Learning Engineering, True Positive Inc., 2020.</li> <li>Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras &amp; TensorFlow, 3rd Edition, O'Reilly Media, 2022.</li> </ul> |
| <b>Web / NPTEL Resources</b>                                                                                                                                                                                                                                                                                                                                                                                                              |
| <a href="http://nptel.ac.in/courses/106106139">http://nptel.ac.in/courses/106106139</a><br><a href="http://nptel.ac.in/courses/106105167">http://nptel.ac.in/courses/106105167</a>                                                                                                                                                                                                                                                        |

| <b>CO-PO Mapping</b> |     |     |     |     |     |     |     |     |     |      |      |      |      |
|----------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| COs                  | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
| CO1                  | 3   | 2   | 1   | 1   | 2   | –   | –   | –   | –   | 1    | –    | 2    | CO1  |
| CO2                  | 3   | 3   | 2   | 2   | 3   | –   | –   | –   | 1   | 1    | –    | 2    | CO2  |
| CO3                  | 2   | 3   | 3   | 3   | 3   | –   | –   | –   | 2   | 2    | 1    | 2    | CO3  |
| CO4                  | 2   | 3   | 3   | 3   | 3   | –   | –   | –   | 2   | 2    | 1    | 2    | CO4  |
| CO5                  | 2   | 3   | 2   | 2   | 3   | 2   | 1   | 3   | 2   | 2    | 1    | 3    | CO5  |

| <b>Assessment Methodology</b> |                     |       |
|-------------------------------|---------------------|-------|
| Assessment Methodology        | Assessment Tools    | Marks |
| Internal Test I               | Written Examination | 10    |
| Internal Test II              | Written Examination | 10    |
| Internal Test III             | Written Examination | 10    |
| Assessment                    | Assignment          | 05    |
| Attendance                    | Performance         | 05    |
| Total                         |                     | 40    |

| <i>PEL</i> 26 3 14 | <i>GENERATIVE AI</i> | CATEGORY | L | T | P | CREDIT |
|--------------------|----------------------|----------|---|---|---|--------|
|                    |                      | PE       | 3 | 0 | 0 | 3      |

### Course Prerequisite / Preamble

Students should have a basic understanding of Python programming, data structures, linear algebra, probability, statistics, and Machine Learning concepts. Familiarity with Deep Learning, neural networks, Natural Language Processing (NLP), and basic cloud computing concepts will help students understand Generative AI models and applications effectively.

### Course Objective

- Understand the fundamentals and evolution of Generative AI.
- Learn the architectures and working principles of generative models such as GANs, VAEs, Transformers, and Large Language Models.
- Develop skills in prompt engineering, fine-tuning, and deploying Generative AI models.
- Explore multimodal AI applications for text, image, audio, and video generation.
- Understand ethical, legal, and responsible AI practices in Generative AI development.

### Course Outcome

|            |                                                                                                               |           |
|------------|---------------------------------------------------------------------------------------------------------------|-----------|
| <b>CO1</b> | Explain the concepts, architectures, and applications of Generative AI.                                       | <b>K2</b> |
| <b>CO2</b> | Apply generative models such as GANs, VAEs, and Transformer-based architectures for content generation.       | <b>K2</b> |
| <b>CO3</b> | Design effective prompts and implement fine-tuning techniques for Large Language Models.                      | <b>K3</b> |
| <b>CO4</b> | Develop Generative AI applications for text, image, audio, and multimodal content generation.                 | <b>K4</b> |
| <b>CO5</b> | Evaluate Generative AI systems considering performance, ethics, security, bias, and responsible AI practices. | <b>K5</b> |

### Syllabus

|               |                                      |            |
|---------------|--------------------------------------|------------|
| <b>Unit I</b> | <b>Introduction to Generative AI</b> | <b>(9)</b> |
|---------------|--------------------------------------|------------|

|                                                                                                                                                                                                                                                                                    |                                                            |            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|------------|
| Introduction to Artificial Intelligence, Machine Learning, Deep Learning, evolution of Generative AI, discriminative vs generative models, applications of Generative AI, AI ecosystem, foundation models, overview of Large Language Models (LLMs), ethical and societal impacts. |                                                            |            |
| <b>Unit II</b>                                                                                                                                                                                                                                                                     | <b>Generative Models</b>                                   | <b>(9)</b> |
| Probability distributions, autoregressive models, Variational Autoencoders (VAEs), Generative Adversarial Networks (GANs), diffusion models, model training techniques, evaluation metrics, image synthesis and content generation.                                                |                                                            |            |
| <b>Unit III</b>                                                                                                                                                                                                                                                                    | <b>Transformers and Large Language Models</b>              | <b>(9)</b> |
| Transformer architecture, attention mechanism, encoder-decoder models, GPT, BERT, T5, tokenization, embeddings, prompt engineering, Retrieval-Augmented Generation (RAG), fine-tuning, parameter-efficient tuning (LoRA), reinforcement learning from human feedback (RLHF).       |                                                            |            |
| <b>Unit IV</b>                                                                                                                                                                                                                                                                     | <b>Multimodal Generative AI</b>                            | <b>(9)</b> |
| Text generation, image generation, image captioning, audio and speech generation, video generation, multimodal foundation models, AI assistants, Generative AI APIs, deployment using cloud platforms, AI application development.                                                 |                                                            |            |
| <b>Unit V</b>                                                                                                                                                                                                                                                                      | <b>Responsible Generative AI and Industry Applications</b> | <b>(9)</b> |
| Bias and fairness, explainability, hallucinations, privacy, security, copyright and intellectual property, AI governance, model evaluation, responsible AI practices, enterprise applications, healthcare, education, finance, software development, future trends.                |                                                            |            |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Text Books</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <ul style="list-style-type: none"> <li>David Foster, Generative Deep Learning, 2nd Edition, O'Reilly Media, 2023.</li> <li>Sebastian Raschka, Build a Large Language Model (From Scratch), Manning Publications, 2024.</li> </ul>                                                                                                                                                                                                                                                                         |
| <b>Reference</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <ul style="list-style-type: none"> <li>Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press, 2016.</li> <li>Chip Huyen, AI Engineering: Building Applications with Foundation Models, O'Reilly Media, 2025.</li> <li>Lewis Tunstall, Leandro von Werra, Thomas Wolf, Natural Language Processing with Transformers, O'Reilly Media, 2022.</li> <li>Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras &amp; TensorFlow, 3rd Edition, O'Reilly Media, 2022.</li> </ul> |
| <b>Web / NPTEL Resources</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |

<http://nptel.ac.in/courses/106106184>

<http://nptel.ac.in/courses/106106211>

<http://nptel.ac.in/courses/106105077>

### CO-PO Mapping

| COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| CO1 | 3   | 2   | 2   | 2   | 3   | 2   | –   | –   | –   | 2    | 1    | 3    | 2    |
| CO2 | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO3 | 3   | 3   | 3   | 3   | 3   | 3   | 1   | –   | –   | 2    | 2    | 3    | 3    |
| CO4 | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 1   | –   | 3    | 2    | 3    | 3    |
| CO5 | 3   | 3   | 3   | 3   | 3   | 3   | 2   | 2   | 1   | 3    | 3    | 3    | 3    |

### Assessment Methodology

| Assessment Methodology | Assessment Tools    | Marks |
|------------------------|---------------------|-------|
| Internal Test I        | Written Examination | 10    |
| Internal Test II       | Written Examination | 10    |
| Internal Test III      | Written Examination | 10    |
| Assessment             | Assignment          | 05    |
| Attendance             | Performance         | 05    |
| Total                  |                     | 40    |