

# **Curriculum of Diploma Programme in Information Science**



**Department of Science, Technology and Technical  
Education (DSTTE), Govt. of Bihar**

**State Board of Technical Education  
(SBTE), Bihar**

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## Semester – VI

### Teaching & Learning Scheme

| Course Codes | Category of course | Course Titles                                | Teaching & Learning Scheme<br>(Hours/Week) |          |                            |                               |                                 |                         |
|--------------|--------------------|----------------------------------------------|--------------------------------------------|----------|----------------------------|-------------------------------|---------------------------------|-------------------------|
|              |                    |                                              | Classroom Instruction<br>(CI)              |          | Lab<br>Instruction<br>(LI) | Notional<br>Hours<br>(TW+ SL) | Total<br>Hours<br>(CI+LI+TW+SL) | Total<br>Credits<br>(C) |
|              |                    |                                              | L                                          | T        |                            |                               |                                 |                         |
| 2418601      | PCC                | Cloud Computing                              | 03                                         | -        | 04                         | 02                            | 09                              | 06                      |
| 2418602      | PCC                | Computer Network with Linux & Windows        | 03                                         | -        | 04                         | 02                            | 09                              | 06                      |
| 2418603      | PEC                | Programme Electives* - Any One               | 03                                         | -        | 04                         | 02                            | 09                              | 06                      |
| 2400604      | OEC                | Open Electives**/ COE (Advanced - Any One)   | 03                                         | -        | 04                         | 02                            | 09                              | 06                      |
| 2418605      | PSI                | Major Project<br>(Common for all programmes) | -                                          | -        | 08                         | 04                            | 12                              | 06                      |
| <b>Total</b> |                    |                                              | <b>12</b>                                  | <b>-</b> | <b>24</b>                  | <b>12</b>                     | <b>48</b>                       | <b>30</b>               |

**Note: Prefix will be added to Course Code if applicable (T for Theory, P for Practical Paper and S for Term Work)**

**Legend:**

- CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)
- LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)
- Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.
- TW: Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)
- SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.
- C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)
- \*: Introduction to Machine Learning/ Mobile Application Development
- \*\* : 3D Printing & Design /Artificial Intelligence (AI)/ Drone Technology/ Electric Vehicle/ Industrial Automation & Control/ IOT/ Robotics/Transformer Manufacturing and Repairing/ Optical Fiber and 5G Communication

**Note:** TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

### Semester - VI Assessment Scheme

| Course Codes | Category of course | Course Titles                              | Assessment Scheme (Marks)           |                             |                                            |          |                                  |                                 | Total Marks (TA+TWA+LA) |
|--------------|--------------------|--------------------------------------------|-------------------------------------|-----------------------------|--------------------------------------------|----------|----------------------------------|---------------------------------|-------------------------|
|              |                    |                                            | Theory Assessment (TA)              |                             | Term work & Self-Learning Assessment (TWA) |          | Lab Assessment(LA)               |                                 |                         |
|              |                    |                                            | Progressive Theory Assessment (PTA) | End Theory Assessment (ETA) | Internal                                   | External | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |                         |
| 2418601      | PCC                | Cloud Computing                            | 30                                  | 70                          | 20                                         | 30       | 20                               | 30                              | 200                     |
| 2418602      | PCC                | Computer Network with Linux & Windows      | 30                                  | 70                          | 20                                         | 30       | 20                               | 30                              | 200                     |
| 2418603      | PEC                | Programme Electives*- Any One              | 30                                  | 70                          | 20                                         | 30       | 20                               | 30                              | 200                     |
| 2400604      | OEC                | Open Electives**/ COE (Advanced - Any One) | 30                                  | 70                          | 20                                         | 30       | 20                               | 30                              | 200                     |
| 2418605      | PSI                | Major Project (Common for all programmes)  | -                                   | -                           | 20                                         | 30       | 50                               | 100                             | 200                     |
| Total        |                    |                                            | 120                                 | 280                         | 100                                        | 150      | 130                              | 220                             | 1000                    |

**Note: Prefix will be added to Course Code if applicable (T for Theory, P for Practical Paper and S for Term Work)**

**Legend:**

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

\*: Introduction to Machine Learning/ Mobile Application Development

\*\* : 3D Printing & Design /Artificial Intelligence (AI)/ Drone Technology/ Electric Vehicle/ Industrial Automation & Control/ IOT/ Robotics/Transformer Manufacturing and Repairing/ Optical Fiber and 5G Communication

**Note:**

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

- A) **Course Code** : 2418601(T2418601/P2418601/S2418601)
- B) **Course Title** : Cloud Computing
- C) **Pre- requisite Course(s)** :
- D) **Rationale** :

Cloud computing has become a crucial computing paradigm, allowing the delivery of information, software, and shared resources over networks as services whenever they are needed. It encompasses various important elements such as different types of clouds, storage options within the cloud, security measures, and the monitoring and management of cloud resources. Acquiring expertise in these areas is vital for diploma graduates who intend to develop and sustain cloud-based services. Upon completing this course, students will have the skills to implement virtualization, create cloud-based storage solutions, apply security measures, and efficiently manage cloud services

- E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following course out comes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/laboratory/workshop/field/ industry.

**After completion of the course, the students will be able to-**

- CO-1** Maintain various Cloud based service.
- CO-2** Implement virtualization in cloud.
- CO-3** Maintain storage in cloud.
- CO-4** Configure and manage cloud-based networks.
- CO-5** Implement security measures for cloud resources.

- F) **Suggested Course Articulation Matrix (CAM):**

| Course Outcomes (COs) | Programme Outcomes (POs)                        |                          |                                          |                           |                                                                           |                            |                            | Programme Specific Outcomes* (PSOs) |       |
|-----------------------|-------------------------------------------------|--------------------------|------------------------------------------|---------------------------|---------------------------------------------------------------------------|----------------------------|----------------------------|-------------------------------------|-------|
|                       | PO-1<br>Basic and Discipline Specific Knowledge | PO-2<br>Problem Analysis | PO-3<br>Design/ Development of Solutions | PO-4<br>Engineering Tools | PO-5<br>Engineering Practices for Society, Sustainability and Environment | PO-6<br>Project Management | PO-7<br>Life Long Learning | PSO-1                               | PSO-2 |
| <b>CO-1</b>           | 1                                               | -                        | 1                                        | -                         | -                                                                         | -                          | -                          |                                     |       |
| <b>CO-2</b>           | 1                                               | 2                        | 2                                        | 1                         | -                                                                         | 1                          | -                          |                                     |       |
| <b>CO-3</b>           | 1                                               | 2                        | 2                                        | 1                         | -                                                                         | 1                          | -                          |                                     |       |
| <b>CO-4</b>           | 1                                               | 2                        | 2                                        | 1                         | -                                                                         | 1                          | 2                          |                                     |       |
| <b>CO-5</b>           | 1                                               | 2                        | 2                                        | 1                         | -                                                                         | 1                          | -                          |                                     |       |
| <b>CO-6</b>           | 1                                               | 2                        | 2                                        | 1                         | -                                                                         | 1                          | 2                          |                                     |       |

**Legend:** High (3), Medium (2), Low (1) and No mapping (-)

\* PSOs will be developed by the respective program coordinator at the institute level. As per the latest NBA guidelines, formulating PSOs is optional

**G) Teaching & Learning Scheme:**

| Course Code | Course Title    | Scheme of Study (Hours/Week) |   |                      |                         |                           |                   |
|-------------|-----------------|------------------------------|---|----------------------|-------------------------|---------------------------|-------------------|
|             |                 | Classroom Instruction (CI)   |   | Lab Instruction (LI) | Notional Hours (TW+ SL) | Total Hours (CI+LI+TW+SL) | Total Credits (C) |
|             |                 | L                            | T |                      |                         |                           |                   |
| 2418601     | Cloud Computing | 03                           | - | 04                   | 02                      | 09                        | 06                |

**Legend:**

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

**Note:** TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

**H) Assessment Scheme:**

| Course Code | Course Title    | Assessment Scheme (Marks)           |                             |                                           |          |                                  |                                 | Total Marks (TA+TWA+LA) |
|-------------|-----------------|-------------------------------------|-----------------------------|-------------------------------------------|----------|----------------------------------|---------------------------------|-------------------------|
|             |                 | Theory Assessment (TA)              |                             | Term Work& Self-Learning Assessment (TWA) |          | Lab Assess ment (LA)             |                                 |                         |
|             |                 | Progressive Theory Assessment (PTA) | End Theory Assessment (ETA) | Internal                                  | External | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |                         |
| 2418601     | Cloud Computing | 30                                  | 70                          | 20                                        | 30       | 20                               | 30                              | 200                     |

**Legend:**

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**Note:**

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- I) Course Curriculum Detailing:** This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

**J) Theory Session Outcomes (TSOs) and Units: T2418601**

| Major Theory Session Outcomes (TSOs)                                                                                                                                                                                                                                                                                                                                                                                                               | Units                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Relevant COs Number(s) |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| <p><i>TSO 1a.</i> Explain different service and deployment models in cloud computing.</p> <p><i>TSO 1b.</i> Explain popular cloud stacks and their use cases.</p> <p><i>TSO 1c.</i> Evaluate the benefits, risks, and challenges associated with cloud computing</p> <p><i>TSO 1d.</i> Illustrate economic models and Service Level Agreements (SLAs) in cloud computing</p>                                                                       | <p><b>Unit-1.0 Introduction to Cloud Computing</b></p> <p>1.1 Definition and evolution of Cloud Computing and Cloud -Enabling Technologies,</p> <p>1.2 Service and Deployment Models</p> <p>1.3 Popular Cloud Stacks (commercial/paid and open sourced) and Use Cases</p> <p>1.4 Benefits, Risks, and Challenges of Cloud</p> <p>1.5 Computing Economic Models and SLA</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <b>CO-1</b>            |
| <p><i>TSO 2a.</i> Describe the functions of data centers components</p> <p><i>TSO 2b.</i> Analyze design considerations like requirements, power, efficiency, and redundancy</p> <p><i>TSO 2c.</i> Calculate of cloud data Centre</p> <p><i>TSO 2d.</i> Explain function of cloud management</p> <p><i>TSO 2e.</i> Explain deployment steps of cloud software.</p>                                                                                 | <p><b>Unit-2.0 Cloud Infrastructure</b></p> <p>2.1 Historical Perspective of Data Centers</p> <p>2.2 Datacenter Components: IT Equipment and Facilities</p> <p>2.3 Design Considerations: Networking, Requirements, Power, Efficiency, &amp; Redundancy</p> <p>2.4 Power Calculations, PUE and Challenges in Cloud Data Centers</p> <p>2.5 Cloud Management and Cloud Software Deployment Considerations</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>CO-2</b>            |
| <p><i>TSO 3a.</i> Recognize the necessity of virtualization in IT environments.</p> <p><i>TSO 3b.</i> Differentiate between types of virtualizations.</p> <p><i>TSO 3c.</i> Identify the appropriate hypervisors like VMware and Xen.</p> <p><i>TSO 3d.</i> Explain the various VM-based operations like creation, configuration, and management of VMs.</p> <p><i>TSO 3e.</i> Explain the virtualization concepts, technologies, and methods.</p> | <p><b>Unit-3.0 Introduction to Virtualization</b></p> <p>3.1 Definition and basic concepts of virtualization.</p> <p>3.2 Understanding the need for virtualization in IT environments.</p> <p>3.3 Types of Virtualizations</p> <ul style="list-style-type: none"> <li>• Full virtualization vs. para-virtualization.</li> <li>• Hardware virtualization vs. software virtualization.</li> </ul> <p>3.4 Hypervisors</p> <ul style="list-style-type: none"> <li>• Types of hypervisors: Type 1 (bare-metal) and Type 2 (hosted).</li> <li>• Role of Hypervisor</li> <li>• Popular hypervisors: VMware, Xen.</li> </ul> <p>3.5 Virtual Machines (VMs)</p> <ul style="list-style-type: none"> <li>• Creating, configuring, and managing virtual machines.</li> <li>• Understanding VM snapshots and cloning.</li> </ul> <p>3.6 Storage Virtualization</p> <ul style="list-style-type: none"> <li>• Virtualized storage concepts.</li> <li>• Understanding storage virtualization technologies and methods.</li> </ul> | <b>CO-3</b>            |

| Major Theory Session Outcomes (TSOs)                                                                                                                                                                                                                                                                                                                                        | Units                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Relevant COs Number(s) |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| <p><i>TSO 4a.</i> Explain the functions of cloud storage.</p> <p><i>TSO 4b.</i> Explain the function of different distributed file systems.</p> <p><i>TSO 4c.</i> Explain the function of cloud databases, focusing on MongoDB.</p> <p><i>TSO 4d.</i> List and explain the Cloud object storage solutions such as Amazon S3, OpenStack Swift, and Google Cloud Storage.</p> | <p><b>Unit-4.0 Cloud Storage</b></p> <p>4.1 Introduction to Storage Systems</p> <p>4.2 Cloud Storage Concepts</p> <p>4.3 Cloud Databases (MongoDB)</p> <p>4.4 Cloud Object Storage (Amazon S3, OpenStack Swift, Google Cloud Storage object: cold line)</p>                                                                                                                                                                                            | CO-4                   |
| <p><i>TSO 5a.</i> Explain the given security related risk in Cloud Computing.</p> <p><i>TSO 5b.</i> Explain then specified feature of key security terminology for data security</p> <p><i>TSO 5c.</i> Write steps to implement the given Technology for Securing the Data on cloud</p> <p><i>TSO 5d.</i> Explain the given feature of Security-AS-A-Cloud Service.</p>     | <p><b>Unit-5.0 Security in Cloud Computing</b></p> <p>5.1 Cloud Security Fundamentals</p> <p>5.2 Cloud Risk, Cloud Risk division</p> <ul style="list-style-type: none"> <li>▪ Polity and Organizational Risks</li> <li>▪ Technical Risks</li> <li>▪ Legal Risks</li> </ul> <p>5.3 Technologies for Data Security risk.</p> <p>5.4 Digital identity and access management,</p> <p>5.5 Content level security</p> <p>5.6 Security-AS-A-Cloud Service</p> | CO-5                   |

**Note:** One major TSO may require more than one Theory session/Period.

#### K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2418601

| Practical/Lab Session Outcomes (LSOs)                                                                                                                                                                                                                                   | S. No. | Laboratory Experiment/Practical Titles                                                                                                                                                                                                                | Relevant COs Number(s) |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| <p><i>LSO 1.1.</i> Use Goggle Doc to make spreadsheet and notes</p> <p><i>LSO 1.2.</i> Configure cloud using Just Cloud</p>                                                                                                                                             | 1.     | <p>a) Perform Collaborative Document Editing with Google Docs</p> <p>b) Set Up and Configuring Just Cloud for Cloud Storage</p>                                                                                                                       | CO-1, CO-2             |
| <p><i>LSO 2.1.</i> Upload, download, and share files on different cloud storage (e.g., Dropbox, Google Drive).</p> <p><i>LSO 2.2.</i> Create accounts on any one of Amazon S3, OpenStack Swift, Google Cloud Storage.</p> <p><i>LSO 2.3.</i> Create virtual machine</p> | 2.     | <p>a) Sign up for any one of Amazon S3, OpenStack Swift, Google Cloud</p> <p>b) Configure the account for administrative control</p> <p>c) Perform File Management in Cloud Storage Platforms</p> <p>d) Create a virtual machine Using hypervisor</p> | CO-3 and CO-4          |
| <p><i>LSO 3.1</i> Install MongoDB on a cloud instance.</p> <p><i>LSO 3.2</i> Create buckets/containers</p> <p><i>LSO 3.3</i> Implement Cloud Object Storage Solutions</p>                                                                                               | 3      | <p>a) Set Up MongoDB on AWS EC2 Instance</p> <p>b) Create buckets/containers and upload objects</p> <p>c) Implement Cloud Object Storage Solutions</p>                                                                                                | CO4                    |
| <p><i>LSO 4.1</i> Implement Access Controls and DLP Solutions</p> <p><i>LSO 4.2</i> Set Up Access Management Policies in AWS / Google Cloud</p> <p><i>LSO 4.3</i> Recover Data using loss Prevention (DLP) Tools</p>                                                    | 4.     | <p>a) Configure access controls to implement data loss prevention (DLP) solutions to prevent unauthorized access and data leakage.</p> <p>b) Set up access management policies and roles using cloud service provider consoles</p>                    | CO-5                   |

| Practical/Lab Session Outcomes (LSOs)                                                                                                                                                                                  | S. No. | Laboratory Experiment/Practical Titles                                                    | Relevant COs Number(s) |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------------------------------------------------------------------------------------------|------------------------|
| LSO 4.4 Implement Role-Based Access Control in Cloud Environments<br>LSO 4.5 Access Control Lists (ACLs) Configuration in AWS S3 and Google Cloud Storage<br>LSO 4.6 Implement Security-as-a-Service (SECaaS) in cloud |        | c) Implement Data Security Technologies in Cloud Implement Security-as-a-Service (SECaaS) |                        |

**Note:** In addition to above listed practical, students are suggested to practice all the examples covered by the teacher during theory sessions.

**L) Suggested Term Work and Self Learning: S2418601** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

**a. Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

**b. Micro Projects:**

A single micro-project will be assigned to each student at the beginning of the semester. In the first four semesters, micro-projects will be conducted in groups. However, in the fifth and sixth semesters, students are encouraged to undertake individual micro-projects to enhance their problem-solving skills and confidence, preparing them for industry projects. In exceptional cases where group projects are necessary, the group size should not exceed three students.

The micro-project may involve industry applications, internet-based projects, workshops, laboratory tasks, or fieldwork. Each micro-project should cover at least two Course Outcomes (COs), integrating Program Outcomes (PrOs), Unit Outcomes (UOs), and Additional Desirable Outcomes (ADOs). Students must maintain a dated work diary documenting their individual contributions to the project and present a seminar on their work before submission. The total duration of the micro-project should be at least 16 student engagement hours throughout the semester. Students are required to submit their micro-projects by the end of the semester to foster industry-oriented competencies.

A suggested list of micro-projects is provided below, and additional projects may be included by faculty:

- Prepare a case study report on Amazon Cloud Services.
  - Prepare a case study report on Google App Engine.
  - Build infrastructure as a service using OpenStack.
  - Develop a Personal Cloud using a custom cloud solution and Raspberry Pi.
- (Students may use file and sequence data types to develop above listed applications)

**c. Other Activities:**

- Analyze real-world case studies of organizations implementing cloud computing solutions.
- Join online courses or certifications in cloud computing platforms such as AWS, Azure, or Google Cloud.
- Set up personal cloud environments using platforms like AWS Free Tier, Google Cloud Platform (GCP) Free Tier
- Participate in hackathons or coding competitions focused on cloud computing challenges.

**M) Suggested Course Evaluation Matrix:** The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

| COs         | Course Evaluation Matrix                                  |                             |                                     |                |                   |                                  |                                 |
|-------------|-----------------------------------------------------------|-----------------------------|-------------------------------------|----------------|-------------------|----------------------------------|---------------------------------|
|             | Theory Assessment (TA)**                                  |                             | Term Work Assessment (TWA)          |                |                   | Lab Assessment (LA)#             |                                 |
|             | Progressive Theory Assessment (PTA)<br>Class/Mid Sem Test | End Theory Assessment (ETA) | Term Work& Self Learning Assessment |                |                   | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |
|             |                                                           |                             | Assignments                         | Micro Projects | Other Activities* |                                  |                                 |
| CO-1        | 15%                                                       | 15%                         | 15%                                 | 20%            | 20%               | 10%                              | 20%                             |
| CO-2        | 20%                                                       | 25%                         | 20%                                 | 20%            | 20%               | 10%                              | 20%                             |
| CO-3        | 25%                                                       | 25%                         | 25%                                 | 20%            | 20%               | 30%                              | 20%                             |
| CO-4        | 20%                                                       | 20%                         | 20%                                 | 20%            | 20%               | 30%                              | 20%                             |
| CO-5        | 20%                                                       | 25%                         | 20%                                 | 20%            | 20%               | 20%                              | 20%                             |
| Total Marks | 30                                                        | 70                          | 20                                  | 20             | 10                | 20                               | 30                              |
|             |                                                           |                             | 50                                  |                |                   |                                  |                                 |

**Legend:**

\*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

\*\* : Mentioned under point- (N)

# : Mentioned under point- (O)

**Note:**

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

**N) Suggested Specification Table for End Semester Theory Assessment:** Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

| Unit Title and Number                           | Total Classroom Instruction (CI) Hours | Relevant COs Number(s) | Total Marks | ETA (Marks)  |                   |                         |
|-------------------------------------------------|----------------------------------------|------------------------|-------------|--------------|-------------------|-------------------------|
|                                                 |                                        |                        |             | Remember (R) | Understanding (U) | Application & above (A) |
| <b>Unit-1.0</b> Introduction to Cloud Computing | 6                                      | CO-1                   | 10          | 3            | 3                 | 4                       |
| <b>Unit-2.0</b> Cloud Infrastructure            | 8                                      | CO-2                   | 10          | 3            | 3                 | 4                       |
| <b>Unit-3.0</b> Introduction to Virtualization  | 12                                     | CO-3                   | 18          | 6            | 4                 | 8                       |
| <b>Unit-4.0</b> Cloud Storage                   | 10                                     | CO-4                   | 14          | 4            | 4                 | 6                       |
| <b>Unit-5.0</b> Security in Cloud Computing     | 12                                     | CO-5                   | 18          | 4            | 6                 | 8                       |
| <b>Total</b>                                    | <b>48</b>                              | <b>-</b>               | <b>70</b>   | <b>20</b>    | <b>20</b>         | <b>30</b>               |

**Note:** Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

**O) Suggested Assessment Table for Laboratory (Practical):**

| S. No. | Laboratory Practical Titles                                                                                                  | Relevant COs Number(s) | PLA/ELA     |           |               |
|--------|------------------------------------------------------------------------------------------------------------------------------|------------------------|-------------|-----------|---------------|
|        |                                                                                                                              |                        | Performance |           | Viva-Voce (%) |
|        |                                                                                                                              |                        | PRA* (%)    | PDA** (%) |               |
| 1.     | Perform Collaborative Document Editing with Google Docs                                                                      | CO-1, CO-2             | 40          | 50        | 10            |
| 2.     | Setting Up and Configuring Just Cloud for Cloud Storage                                                                      | CO-1, CO-2             | 40          | 50        | 10            |
| 3.     | Sign up for any one of Amazon S3, OpenStack Swift, and Google Cloud                                                          | CO-3, CO-4             | 40          | 50        | 10            |
| 4.     | Configure the account for administrative control                                                                             | CO-3, CO- 4            | 40          | 50        | 10            |
| 5.     | Perform File Management in Cloud Storage Platforms                                                                           | CO-3, CO-4             | 40          | 50        | 10            |
| 6.     | Create a virtual machine Using hypervisor                                                                                    | CO-3, 4                | 40          | 50        | 10            |
| 7.     | Set Up MongoDB on AWS EC2 Instance                                                                                           | CO-4                   | 40          | 50        | 10            |
| 8.     | Create buckets/containers and upload objects                                                                                 | CO-4                   | 40          | 50        | 10            |
| 9.     | Implement Cloud Object Storage Solutions                                                                                     | CO-4                   | 40          | 50        | 10            |
| 9.     | Configure access controls to implement data loss prevention (DLP) solutions to prevent unauthorized access and data leakage. | CO-5                   | 40          | 50        | 10            |
| 10.    | Set up access management policies and roles using cloud service provider consoles                                            | CO-5                   | 40          | 50        | 10            |
| 11.    | Implement Data Security Technologies in Cloud Implement Security-as-a-Service (SECaaS)                                       | CO-5                   | 40          | 50        | 10            |

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

**Note:** This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

**P) Suggested Instructional/Implementation Strategies:** Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Field Trips, Portfolio Based, Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field Information and Communications Technology (ICT)Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Session, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

**Q) List of Major Laboratory Equipment, Tools and Software:**

| S. No. | Name of Equipment, Tools and Software | Broad Specifications                                                                                                    | Relevant Experiment/Practical Number |
|--------|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------|--------------------------------------|
| 1.     | Computer System                       | Processor Intel Core i5, 4 GB RAM, 15 GB free disk space                                                                | All                                  |
| 2.     | Software Requirement                  | Apache Tomcat, Java, Python, Virtualization Software<br>Academic version of any public cloud service (Google/AWS/Azure) | All                                  |

**R) Suggested Learning Resources:****(a) Books:**

| S. No. | Titles                                   | Author(s)                                             | Publisher and Edition with ISBN                                |
|--------|------------------------------------------|-------------------------------------------------------|----------------------------------------------------------------|
| 1.     | Cloud Computing Principals and Paradigms | Buyya Rajkumar, J. Broberg, A. Goscinski              | A John Wilwy& Sons, Inc., Publication, ISBN: 978-0-470-88799-8 |
| 2.     | Cloud Computing                          | Sharma Rishabh                                        | Wiley Publication, ISBN: 978-81-265-5306-8                     |
| 3.     | Mastering Cloud Computing                | Buyya Rajkumar, Vecchiola Christian, Selvi S Thamarai | McGraw Hill Publication, ISBN: 978-1-25-902995-0               |
| 4.     | Cloud Computing                          | Singh Shailendra                                      | Oxford University Press, ISBN: 9780199477388                   |

**(b) Online Educational Resources:**

1. <http://nptel.ac.in/courses/106105167/1>
2. <https://www.techopedia.com/definition/2/cloud-computing>
3. <https://onlinelibrary.wiley.com/doi/book/10.1002/9780470940105>
4. <http://www.chinacloud.cn/upload/2011-07/11073107539898.pdf>

**Note:** Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

\*\*\*\*\*

- A) **Course Code** : 2418602(T2418602/P2418602/S2418602)
- B) **Course Title** : Computer Network with Linux and Windows (CSE, AIML)
- C) **Pre-requisite Course(s)** :
- D) **Rationale** :

Computer networking refers to the group of connected computers and other digital devices to share resources and exchange information. It involves the use of hardware and software technologies that enable communication between computers and other devices. This course deals with the technology of Computer networking including necessary software and hardware components. Students will be able to apply their knowledge and skills to set up and maintain small computer networks using Windows and Linux platforms.

- E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor, and Affective) in classroom/ laboratory/ workshop/ field/ industry.

**After completion of the course, the students will be able to-**

**CO-1** Share Files/Devices on LAN.

**CO-2** Select the appropriate type of wireless/wire-bound media for network connectivity.

**CO-3** Create subnets using the given IPv4 address.

**CO-4** Manage network interfaces and network services on Linux systems.

**CO-5** Manage network interfaces and network services on Windows systems.

- F) **Suggested Course Articulation Matrix (CAM):**

| Course Outcomes (COs) | Programme Outcomes (POs)                        |                          |                                          |                           |                                                                           |                            |                            | Programme Specific Outcomes* (PSOs) |       |
|-----------------------|-------------------------------------------------|--------------------------|------------------------------------------|---------------------------|---------------------------------------------------------------------------|----------------------------|----------------------------|-------------------------------------|-------|
|                       | PO-1<br>Basic and Discipline Specific Knowledge | PO-2<br>Problem Analysis | PO-3<br>Design/ Development of Solutions | PO-4<br>Engineering Tools | PO-5<br>Engineering Practices for Society, Sustainability and Environment | PO-6<br>Project Management | PO-7<br>Life Long Learning | PSO-1                               | PSO-2 |
| CO-1                  | 1                                               | -                        | -                                        | -                         | -                                                                         | -                          | 1                          |                                     |       |
| CO-2                  | 2                                               | 1                        | 1                                        | 1                         | 1                                                                         | -                          | 1                          |                                     |       |
| CO-3                  | 2                                               | 1                        | 2                                        | 1                         | 1                                                                         | 1                          | -                          |                                     |       |
| CO-4                  | 2                                               | 1                        | 2                                        | 1                         | -                                                                         | 1                          | 1                          |                                     |       |
| CO-5                  | 2                                               | 1                        | 2                                        | 1                         | -                                                                         | 1                          | -                          |                                     |       |

**Legend:** High (3), Medium (2), Low (1) and No mapping (-)

\* PSOs will be developed by the respective program coordinator at the institute level. As per the latest NBA guidelines, formulating PSOs is optional

**G) Teaching & Learning Scheme:**

| Course Code    | Course Title                            | Scheme of Study (Hours/Week) |   |                      |                         |                           |                   |
|----------------|-----------------------------------------|------------------------------|---|----------------------|-------------------------|---------------------------|-------------------|
|                |                                         | Classroom Instruction (CI)   |   | Lab Instruction (LI) | Notional Hours (TW+ SL) | Total Hours (CI+LI+TW+SL) | Total Credits (C) |
|                |                                         | L                            | T |                      |                         |                           |                   |
| <b>2418602</b> | Computer Network with Linux and Windows | 03                           | - | 04                   | 02                      | 09                        | 06                |

**Legend:**

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

**Note:** TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

**H) Assessment Scheme:**

| Course Code | Course Title                            | Assessment Scheme (Marks)           |                             |                                            |          |                                  |                                 | Total Marks (TA+TWA+LA) |
|-------------|-----------------------------------------|-------------------------------------|-----------------------------|--------------------------------------------|----------|----------------------------------|---------------------------------|-------------------------|
|             |                                         | Theory Assessment (TA)              |                             | Term Work & Self-Learning Assessment (TWA) |          | Lab Assessment (LA)              |                                 |                         |
|             |                                         | Progressive Theory Assessment (PTA) | End Theory Assessment (ETA) | Internal                                   | External | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |                         |
| 2418602     | Computer Network with Linux and Windows | 30                                  | 70                          | 20                                         | 30       | 20                               | 30                              | 200                     |

**Legend:**

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.)

**Note:**

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

- A) Course Curriculum Detailing:** This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Indian Knowledge System (IKS) and others must be integrated appropriately.

**J) Theory Session Outcomes (TSOs) and Units: T2418602**

| Major Theory Session Outcomes (TSOs)                                                                                                                                                                                                                                                                                           | Units                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Relevant COs Number(s) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| TS01.a Categories computer network based on scope and connection.<br>TS01.b Explain the use of basic network services<br>TS01.c Compare the layered structure of OSI and TCP/IP.<br>TS01.d Explain the functions of each layer of the TCP/IP model.<br>TS01.e Differentiate different network topologies                       | <b>Unit-1.0 Introduction to Computer Networks</b><br><br>1.1 Introduction to Computer Networks, Advantages of Computer Networks, Types of Computer Networks<br>1.2 Basic Network services: File sharing, device sharing, Internet Connection Sharing<br>1.3 <b>Network Communication Models:</b> OSI Reference Model and function of each layer, TCP/IP Model, and mapping of OSI layers with TC/IP model<br>1.4 <b>Network Topologies:</b> Bus Topology, Ring Topology, Star Topology, Mesh Topology, Tree Topology                          | CO-1                   |
| TSO.2.a Explain the characteristics of different wired media<br>TSO.2.b Select appropriate transmission media for a given network.<br>TSO.2.c Explain the different modes of data transmission<br>TSO.2.d Describe the functions of various network connecting devices<br>TSO.2.e Explain the purpose of Firewall in a network | <b>Unit-2.0 Transmission media, mode, and Network Device:</b><br><br>2.1 Wired Media – Coaxial, UTP, STP, Fiber Optic Cables<br>2.2 Wireless Media- Electromagnetic spectrum, Radio Transmission, Microwave Transmission, Infrared Transmission, Satellite Communication<br>2.3 Mode of Communication: Simplex, Half Duplex, Full Duplex<br>2.4 Network connecting Devices Network Interface Cards (NICs), Modem, Switches- Layer2 and Layer3, Routers, Gateways, RJ45 & RJ11 connectors<br>2.5 Concept of Firewall and its use in Networking | CO-2                   |
| TSO.3.a Differentiate different Network computing models<br>TSO.3.b Calculate subnet ID and subnet mask for a given IP address<br>TSO.3.c Explain the concept of classless Addressing<br>TSO.3.d Explain the function of network address translation                                                                           | <b>Unit-3.0 Network Computing Models and Network Layer</b><br><br>3.1 Network Computing Models: Architecture and functionality of - Client-server, peer-to-peer, distributed computing<br>3.2 Internet Protocol<br>- Logical Addressing<br>- IPv4 Address                                                                                                                                                                                                                                                                                     | CO-3                   |

| Major Theory Session Outcomes (TSOs)                                                                                                                                                                                                                                              | Units                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Relevant COs Number(s) |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| TSO.3.e Explain the structure of the IPv6 Address scheme                                                                                                                                                                                                                          | <ul style="list-style-type: none"> <li>- Address Space</li> <li>- Notations</li> <li>- Classful Addressing:</li> <li>- Net-id, Host-id, Subnet Mask</li> <li>- Subnetting</li> <li>- Classless Addressing: Super netting</li> <li>- Network Address Translation (NAT)</li> <li>- Introduction to IPv6 Address</li> <li>- Role and functions of network gateways</li> </ul> 3.3 Address Mapping, Error Reporting                                                                                                                                                                                                                                                                                  |                        |
| TSO.4.a Configure IP address and subnet on the Linux Platform<br>TSO.4.b Configure network routing and DNS settings.<br>TSO.4.c Configure bridge interfaces on Linux systems<br>TSO.4.d Configure VLANs on Linux system<br>TSO.4.e Diagnose the common network issues using Linux | <b>Unit-4.0 Networking with Linux</b><br><br>4.1 Configuring IP addresses manually and through DHCP on a Linux system.<br>4.2 Configure network interfaces/devices/links <ul style="list-style-type: none"> <li>- Configuration of different network services/protocols <ul style="list-style-type: none"> <li>- Domain Name System (DNS)</li> <li>- Dynamic Host Configuration Protocol (DHCP)</li> <li>- File Transfer Protocol (FTP)</li> <li>- web server for hosting websites</li> <li>- Hypertext Transfer Protocol (HTTP)</li> </ul> </li> </ul> 4.3 Network Interface Bonding<br>4.4 Internetworking on Linux Systems: Bridging<br>4.5 Remote Access<br>4.6 Network troubleshooting tool | <b>CO-4</b>            |
| TSO.5.a Configure IP address and subnet on the Windows<br>TSO.5.b Configure the network interface card using the Windows platform<br>TSO.5.c Configure different application layer protocols on the Windows Platform<br>TSO.5.d Diagnose the common network issues using Windows  | <b>Unit-5.0 Networking with Windows</b><br><br>5.1 Network Configuration<br>5.2 Configuration of different network services <ul style="list-style-type: none"> <li>- Domain Name System (DNS)</li> <li>- Dynamic Host Configuration Protocol (DHCP)</li> <li>- File Transfer Protocol (FTP)</li> <li>- web server for hosting websites</li> <li>- Hypertext Transfer Protocol (HTTP)</li> </ul> 5.3 Network Security<br>5.4 Remote Access<br>5.5 Network Troubleshooting                                                                                                                                                                                                                         | <b>CO-5</b>            |

**Note:** One major TSO may require more than one Theory session/Period.

**K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2418602**

| Practical/Lab Session Outcomes (LSOs) |                                                                       | S. No. | Laboratory Experiment/Practical Titles                                                                                                                                                                                                                                                                                                                                                                                                                                        | Relevant COs Number (s) |
|---------------------------------------|-----------------------------------------------------------------------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| LSO.1.1                               | Share resources on a Network                                          | 1.     | Share Files/Folders, Devices, and Printers in the Network and access the shared resource from the other node.                                                                                                                                                                                                                                                                                                                                                                 | CO-1                    |
| LSO.1.2                               | Identify the topology in the given Network.                           |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                         |
| LSO.2.1                               | Make straight UTP cable                                               | 2.     | <ul style="list-style-type: none"> <li>Prepare and test straight UTP cable for data transfer</li> <li>Prepare and test cross UTP cable for data transfer</li> <li>Create wi-fi environment</li> <li>Configure and test Repeater in network</li> <li>Configure and test Layer-2 Switch in a network</li> <li>Install and Configure firewall on a network</li> </ul>                                                                                                            | CO-2                    |
| LSO.2.2                               | Make cross UTP cable                                                  |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                         |
| LSO.2.3                               | Install Repeater on a network                                         |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                         |
| LSO.2.4                               | Install Layer-2 switch on a network                                   |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                         |
| LSO.2.5                               | Install S/w-based firewall on a network                               |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                         |
| LSO.3.1                               | Configure static IP addresses in the Computer system                  | 3.     | <ul style="list-style-type: none"> <li>Configure static IP addresses in network and internet settings</li> <li>Run Wireshark to analyze IP packets</li> <li>Configure NAT to enable devices on a private network to access the internet using a single public IP address</li> </ul>                                                                                                                                                                                           | CO-3                    |
| LSO.3.2                               | Analyze IP packets                                                    |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                         |
| LSO.3.3                               | Configure NAT to access the internet using a single public IP address |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                         |
| LSO.4.1                               | Configure the network interface on a Linux Platform                   | 4.     | <ul style="list-style-type: none"> <li>Configure the network interface using the Linux command</li> <li>Configure a DHCP server to dynamically assign IP addresses in the Linux system.</li> <li>Create an FTP server for file transfer in Linux system.</li> <li>Set up a web server for hosting websites in Linux system.</li> <li>Configure bridge interfaces on Linux systems</li> <li>Troubleshoot the network issues using Linux command in the Linux system</li> </ul> | CO-4                    |
| LSO.4.2                               | Configure DHCP on Linux Platform                                      |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                         |
| LSO.4.3                               | Configure FTP on Linux Platform                                       |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                         |
| LSO.4.4                               | Configure Web server on Linux Platform                                |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                         |
| LSO.4.5                               | Configure bridge interfaces on Linux systems                          |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                         |
| LSO.4.6                               | Troubleshoot the network issues using Linux commands                  |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                         |
| LSO.5.1                               | Configure DHCP on Windows Platform                                    | 5.     | <ul style="list-style-type: none"> <li>Configure a DHCP server to dynamically assign IP addresses on the Windows system.</li> <li>Create an FTP server for file transfer on the Windows system.</li> <li>Set up a web server for hosting websites on the windows system.</li> <li>Troubleshoot the network issues using windows command in windows system</li> </ul>                                                                                                          | CO-5                    |
| LSO.5.2                               | Configure FTP on Windows Platform                                     |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                         |
| LSO.5.3                               | Configure Web server on Windows Platform                              |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                         |
| LSO.5.4                               | Troubleshoot the network issues using Windows commands                |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                         |

**L) Suggested Term Work and Self Learning: S2418602**

**a. Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted Cos.

**b. Micro Projects:**

1. Set up and configure VLANs to logically partition a network into separate broadcast domains, allowing for improved network security and performance
2. Configure and deploy a load balancer on a Linux machine to distribute incoming network traffic across multiple servers.
3. Configure and deploy a network file-sharing service such as Samba or NFS to allow clients to share files and resources on the network.

**c. Other Activities:**

**M) Suggested Course Evaluation Matrix:** The course teacher has to decide and use the appropriate assessment strategy and its weightage in theory, laboratory and Term work for ensuring CO attainment. The response/performance of the student in each of these designed activities is to be used to calculate **CO attainment**.

| COs         | Course Evaluation Matrix                                  |                             |                                     |                |                   |                                  |                                 |
|-------------|-----------------------------------------------------------|-----------------------------|-------------------------------------|----------------|-------------------|----------------------------------|---------------------------------|
|             | Theory Assessment (TA)**                                  |                             | Term Work Assessment (TWA)          |                |                   | Lab Assessment (LA)#             |                                 |
|             | Progressive Theory Assessment (PTA)<br>Class/Mid Sem Test | End Theory Assessment (ETA) | Term Work& Self Learning Assessment |                |                   | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |
|             |                                                           |                             | Assignments                         | Micro Projects | Other Activities* |                                  |                                 |
| CO-1        | 15%                                                       | 15%                         | 15%                                 | 20%            | 20%               | 10%                              | 10%                             |
| CO-2        | 20%                                                       | 20%                         | 20%                                 | 20%            | 20%               | 20%                              | 20%                             |
| CO-3        | 20%                                                       | 20%                         | 20%                                 | 20%            | 20%               | 20%                              | 20%                             |
| CO-4        | 25%                                                       | 25%                         | 25%                                 | 20%            | 20%               | 30%                              | 30%                             |
| CO-5        | 20%                                                       | 20%                         | 20%                                 | 20%            | 20%               | 20%                              | 20%                             |
| Total Marks | 30                                                        | 70                          | 20                                  | 20             | 10                | 20                               | 30                              |
|             |                                                           |                             | 50                                  |                |                   |                                  |                                 |

**Legend:**

\*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

\*\*: Mentioned under point- (N)

#: Mentioned under point- (O)

**Note:**

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

**N) Suggested Specification Table for End Semester Theory Assessment:** Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

| Unit Title and Number                             | Total Classroom Instruction (CI) Hours | Relevant COs Number(s) | Total Marks | ETA (Marks)  |                   |                         |
|---------------------------------------------------|----------------------------------------|------------------------|-------------|--------------|-------------------|-------------------------|
|                                                   |                                        |                        |             | Remember (R) | Understanding (U) | Application & above (A) |
| <b>Unit-1.0</b> Introduction to Computer Networks | 5                                      | CO-1                   | 10          | 3            | 5                 | 2                       |
| <b>Unit-2.0</b> Transmission media and mode       | 5                                      | CO-2                   | 14          | 4            | 6                 | 4                       |
| <b>Unit-3.0</b> Network Models and Network Layer  | 18                                     | CO-3                   | 14          | 4            | 2                 | 8                       |
| <b>Unit-4.0</b> Networking in Linux               | 12                                     | CO-4                   | 18          | 5            | 6                 | 7                       |
| <b>Unit-5.0</b> Networking in Windows             | 8                                      | CO-5                   | 14          | 4            | 6                 | 4                       |
| <b>Total</b>                                      | <b>48</b>                              | <b>-</b>               | <b>70</b>   | <b>20</b>    | <b>25</b>         | <b>25</b>               |

**Note:** Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

**O) Suggested Assessment Table for Laboratory (Practical):**

| S. No. | Laboratory Practical Titles                                                                                   | Relevant COs Number(s) | PLA #/ELA # (Marks) |          |               |
|--------|---------------------------------------------------------------------------------------------------------------|------------------------|---------------------|----------|---------------|
|        |                                                                                                               |                        | Performance         |          | Viva-Voce (%) |
|        |                                                                                                               |                        | PRA* (%)            | PDA* (%) |               |
| 1.     | Share Files/Folders, Devices, and Printers in the Network and access the shared resource from the other node. | CO-1                   | 50                  | 40       | 10            |
| 2.     | Prepare and test straight UTP cable for data transfer                                                         | CO-2                   | 50                  | 40       | 10            |
| 3.     | Prepare and test cross UTP cable for data transfer                                                            | CO-2                   | 50                  | 40       | 10            |
| 4.     | Create wi-fi environment                                                                                      | CO-2                   | 50                  | 40       | 10            |
| 5.     | Configure and test Repeater in network                                                                        | CO-2                   | 50                  | 40       | 10            |
| 6.     | Configure and test Layer-2 Switch in a network                                                                | CO-2                   | 50                  | 40       | 10            |
| 7.     | Configure static IP addresses in network and internet settings                                                | CO-3                   | 50                  | 40       | 10            |
| 8.     | Run Wireshark to analyze IP packets                                                                           | CO-3                   | 50                  | 40       | 10            |
| 9.     | Configure NAT to enable devices on a private network to access the internet using a single public IP address  | CO-3                   | 50                  | 40       | 10            |
| 10.    | Configure the network interface using the Linux command                                                       | CO-3                   | 50                  | 40       | 10            |
| 11.    | Configure a DHCP server to dynamically assign IP addresses in the Linux system.                               | CO-4                   | 50                  | 40       | 10            |
| 12.    | Create an FTP server for file transfer in Linux system.                                                       | CO-4                   | 50                  | 40       | 10            |

| S. No. | Laboratory Practical Titles                                                       | Relevant COs Number(s) | PLA #/ELA # (Marks) |          |               |
|--------|-----------------------------------------------------------------------------------|------------------------|---------------------|----------|---------------|
|        |                                                                                   |                        | Performance         |          | Viva-Voce (%) |
|        |                                                                                   |                        | PRA* (%)            | PDA* (%) |               |
| 13.    | Set up a web server for hosting websites in Linux system.                         | CO-4                   | 50                  | 40       | 10            |
| 14.    | Configure bridge interfaces on Linux systems                                      | CO-4                   | 50                  | 40       | 10            |
| 15.    | Troubleshoot the network issues using Linux command in the Linux system           | CO-4                   | 50                  | 40       | 10            |
| 16.    | Configure a DHCP server to dynamically assign IP addresses on the Windows system. | CO-5                   | 50                  | 40       | 10            |
| 17.    | Create an FTP server for file transfer on the Windows system.                     | CO-5                   | 50                  | 40       | 10            |
| 18.    | Set up a web server for hosting websites on the Windows system.                   | CO-5                   | 50                  | 40       | 10            |
| 19.    | Troubleshoot the network issues using Windows command in Windows system           | CO-5                   | 50                  | 40       | 10            |

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

**Note:** This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

- P) Suggested Instructional/Implementation Strategies:** Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Field Trips, Portfolio Based, Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field Information and Communications Technology (ICT)Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Session, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

**Q) List of Major Laboratory Equipment, Tools and Software:**

| S. No. | Name of Equipment, Tools and Software           | Broad Specifications                                                                             | Relevant Experiment/Practical Number |
|--------|-------------------------------------------------|--------------------------------------------------------------------------------------------------|--------------------------------------|
| 1.     | Computer System                                 | Processor Intel Core i7 with RAM 16 GB, DDR3/DDR4, HDD 500 GB OS Windows 11                      | All                                  |
| 2.     | Computer System                                 | Processor Intel Core i7 with RAM 16 GB, DDR3/DDR4, HDD 500 GB OS Linux                           | All                                  |
| 3.     | Cable and connectors                            | UTP Cable CAT 6, RJ45 Connectors                                                                 | 2,3                                  |
| 4.     | Crimping Tool, Punch Tool, Network Cable Tester | -                                                                                                | 2,3                                  |
| 5.     | Layer2 switch                                   | 16 Port 100/1000 Mbps with min. 2 Combo SFP ports (optical fiber cable and copper cable support) | All                                  |
| 6.     | Repeater                                        | Rj45 connection por, extendibility up to 100 meters                                              | 5                                    |
| 7.     | Wi-fi router                                    | 500 Mbps, dual band, Wireless Encryption using WPA™ or WPA2™   Fast Ethernet ports (WAN/LAN)     | 4                                    |
|        | Wi-fi Access point                              | Dual Band Wi-Fi, 1200 Mbps Wi-Fi Gigabit Port, Multiple Modes   MU-MIMO                          | 4                                    |
| 8.     | Printer                                         | Any type of printer (for demonstration of device sharing)                                        | 1                                    |

**R) Suggested Learning Resources:****(a) Books:**

| S. No. | Titles                                   | Author(s)                         | Publisher and Edition with ISBN                                      |
|--------|------------------------------------------|-----------------------------------|----------------------------------------------------------------------|
| 1      | Computer Network                         | Andrew S Tanenbum                 | Prentice Hall,<br>ISBN-13: 978-0-13-212695-3, ISBN-10: 0-13-212695-8 |
| 2      | Data Communication and Networking        | Behrouz, Forouzan                 | Mcgraw Hill,<br>ISBN-10: 9780070634145,<br>ISBN-13: 978-0070634145   |
| 3      | Computer Networking: A Top-Down Approach | James F. Kurose and Keith W. Ross | Pearson, ISBN-10: 9780133594140,<br>ISBN-13: 978-0133594140          |
| 4      | Linux Networking Cookbook                | Carla Schroder                    | Wiley Publishing,<br>ISBN: 9780596102487                             |

**(b) Online Educational Resources (OER):**

1. <https://www.geeksforgeeks.org/computer-network-tutorials/>
2. <https://www.netacad.com/>
3. <https://www.udemy.com/topic/networking/>
4. <https://www.edx.org/learn/networking>

**Note:** Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational resources before use by the students.

**(c) Others:**

1. Lab Manuals

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- A) **Course Code** : 2418603A(T2418603A/P2418603A/S2418603A)
- B) **Course Title** : Introduction to Machine Learning (AIML, CSE)
- C) **Pre-requisite Course(s)** : Introduction to Artificial Intelligence
- D) **Rationale** :

Machine Learning is one of the most important technology these days due to its ability to automate tasks, detect patterns and learn from the data. Machine learning has emerged as a fundamental technology which have diverse applications in all fields of engineering and other diversified area.

This course introduces students to the principles and techniques of machine learning, which built-up a strong foundation in data analysis, pattern recognition, and predictive modeling thus enabling them to leverage its potential in their professional careers.

- E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

**After completion of the course, the students will be able to-**

- CO-1** Prepare data by performing cleaning, testing training operation for better analysis and judgment.
- CO-2** Classify the nature of real-world machine learning problems such as supervised learning, unsupervised learning, and reinforcement learning to solve problems.
- CO-3** Apply different classification and regression models on a given dataset on the basis of evaluation matrices.
- CO-4** Apply different unsupervised learning models on the basis of evaluation matrices on a given datasets.
- CO-5** Implement different dimensionality reduction techniques of machine learning to solve a given problem.

**F) Suggested Course Articulation Matrix (CAM):**

| Course Outcomes (COs) | Programme Outcomes (POs)                        |                          |                                          |                           |                                                                           |                            |                            | Programme Specific Outcomes* (PSOs) |       |
|-----------------------|-------------------------------------------------|--------------------------|------------------------------------------|---------------------------|---------------------------------------------------------------------------|----------------------------|----------------------------|-------------------------------------|-------|
|                       | PO-1<br>Basic and Discipline Specific Knowledge | PO-2<br>Problem Analysis | PO-3<br>Design/ Development of Solutions | PO-4<br>Engineering Tools | PO-5<br>Engineering Practices for Society, Sustainability and Environment | PO-6<br>Project Management | PO-7<br>Life Long Learning | PSO-1                               | PSO-2 |
| CO-1                  | 2                                               | 1                        | -                                        | 1                         | -                                                                         | -                          | -                          |                                     |       |
| CO-2                  | 2                                               | 2                        |                                          | 2                         | -                                                                         | -                          | -                          |                                     |       |
| CO-3                  | 2                                               | 2                        | 2                                        | 2                         | -                                                                         | 1                          | 1                          |                                     |       |
| CO-4                  | 2                                               | 2                        | 2                                        | 2                         | -                                                                         | 1                          | 1                          |                                     |       |
| CO-5                  | 2                                               | 2                        | -                                        | 2                         | -                                                                         | -                          | 1                          |                                     |       |

**Legend:** High (3), Medium (2), Low (1) and No mapping (-)

\* PSOs will be developed by the respective program coordinator at the institute level. As per the latest NBA guidelines, formulating PSOs is optional

**G) Teaching and Learning Scheme:**

| Course Code     | Course Title                     | Scheme of Studies<br>(Hours/Week) |   |                      |                         |                           |                   |
|-----------------|----------------------------------|-----------------------------------|---|----------------------|-------------------------|---------------------------|-------------------|
|                 |                                  | Classroom Instruction (CI)        |   | Lab Instruction (LI) | Notional Hours (TW+ SL) | Total Hours (CI+LI+SW+SL) | Total Credits (C) |
|                 |                                  | L                                 | T |                      |                         |                           |                   |
| <b>2418603A</b> | Introduction to Machine learning | 03                                | - | 04                   | 02                      | 09                        | 06                |

**Legend:**

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

**Note:** TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

**H) Assessment Scheme:**

| Course Code | Course Title                     | Assessment Scheme (Marks)           |                             |                                            |          |                                  |                                 | Total Marks (TA+TWA+LA) |
|-------------|----------------------------------|-------------------------------------|-----------------------------|--------------------------------------------|----------|----------------------------------|---------------------------------|-------------------------|
|             |                                  | Theory Assessment (TA)              |                             | Term Work & Self-Learning Assessment (TWA) |          | Lab Assessment (LA)              |                                 |                         |
|             |                                  | Progressive Theory Assessment (PTA) | End Theory Assessment (ETA) | Internal                                   | External | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |                         |
| 2418603A    | Introduction to Machine Learning | 30                                  | 70                          | 20                                         | 30       | 20                               | 30                              | 200                     |

**Legend:**

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.)

**Note:**

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

I) **Course Curriculum Detailing:** This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

J) **Theory Session Outcomes (TSOs) and Units: T2418603A**

| Major Theory Session Outcomes (TSOs)                                                                                                                                                                                                                                                                                                | Units                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Relevant COs Number(s) |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| TSO 1a. Differentiate Artificial intelligence and machine learning<br>TSO 2a. Classify given dataset<br>TSO 3a. Explain preprocessing processes of data<br>TSO 4a. Explain technique of data normalization<br>TSO 5a. Split dataset into train, test and validation sets.                                                           | <b>Unit-1.0 Introduction to Machine Learning (ML)</b><br>1.1 Overview of Artificial Intelligence (AI)<br>Introduction to ML, Relationship between AI & ML, Difference between AI & ML<br>1.2 Datasets<br>Type of datasets, Text Datasets, Image Datasets, Time Series Datasets, Spatial Datasets, Graph Datasets<br>1.3 Preprocessing and normalization<br>Data Cleaning, Data Transformation, Feature Encoding, Dimensionality Reduction, Feature Selection, Data Normalization<br>1.4 Dataset division<br>test, train, and validation sets, Cross-validation. | CO-1                   |
| TSO 2a. Explain machine learning process<br>TSO 2b. Discriminate supervised, unsupervised, and reinforcement learning<br>TSO 2c. Describe the real-life machine learning examples.                                                                                                                                                  | <b>Unit-2.0 Fundamental Elements of Machine Learning</b><br>2.1 Applications of Machine Learning, processes involved in Machine Learning.<br>2.2 Machine Learning Techniques<br>Supervised Learning, Unsupervised Learning, Reinforcement Learning<br>2.3 Real life examples of Machine Learning.                                                                                                                                                                                                                                                               | CO-2                   |
| TSO 3a. Explain the advantages and challenges related to K-nearest neighbor classifier.<br>TSO 3b. Differentiate between linear and logistic regression.<br>TSO 3c. Use different evaluation measures to quantify the variation of data points from a regression line<br>TSO 3d. Evaluate the performance of classification models. | <b>Unit-3.0 Supervised Learning</b><br>3.1 Classification and Regression, K-Nearest Neighbor, Linear Regression, Logistic Regression<br>3.2 Evaluation Measures, Sum of squares error (SSE), Mean squares error (MME), R-square, confusion matrix, precision, recall, F-Score, ROC-Curve                                                                                                                                                                                                                                                                        | CO-3                   |
| TSO 4a. Explain clustering and its challenges.<br>TSO 4b. Differentiate between hierarchical, agglomerative, and divisive clustering.<br>TSO 4c. Differentiate Extrinsic Measures and Intrinsic Measures                                                                                                                            | <b>Unit 4.0 Unsupervised Learning</b><br>4.1 Introduction to Clustering<br>Types of Clustering, Hierarchical, Agglomerative Clustering, Divisive clustering<br>4.2 Evaluation measures for clustering:<br>Extrinsic Measures, Intrinsic Measures                                                                                                                                                                                                                                                                                                                | CO-4                   |
| TSO 5a. Explain the need of dimensionality reduction techniques with example.<br>TSO 5b. Differentiate between PCA, LDA, and ICA.                                                                                                                                                                                                   | <b>Unit-5.0 Dimensionality Reduction Techniques</b><br>5.1 Principal component Analysis (PCA), Linear discriminant Analysis (LDA), Independent component Analysis (ICA)                                                                                                                                                                                                                                                                                                                                                                                         | CO-5                   |

**Note:** One major TSO may require more than one Theory session/Period.

**K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2418603A**

| Practical/Lab Session Outcomes (LSOs)                                                                                                                                                                                                                                                                     | S. No. | Laboratory Experiment/Practical Titles                                                                                                                                                                                                                               | Relevant COs Number(s)       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|
| LSO 1.1. Use pandas library for data analysis.<br>LSO 1.2. Apply normalization techniques on a given dataset.<br>LSO 1.3. Use scikit-learn to split datasets into train, test, and validation sets<br>LSO 1.4. Apply train, test, and validation technique on given dataset                               | 1.     | a. Import and export data using Pandas library functions.<br>b. Use standard scalar and minimax normalization techniques on a given dataset.<br>c. Split datasets into train, test, and validation sets.<br>d. Apply k-fold validation technique on a given dataset. | CO-1                         |
| LSO 2.1. Write, execute python program to implement k-nearest neighbor classifier.<br>LSO 2.2. Write, execute python program to implement linear regression.<br>LSO 2.3. Write, execute python program to implement logistic regression.<br>LSO 2.4. Apply different performance measures used in python. | 2.     | a. Implement k-nearest neighbor Classifier using python.<br>b. Implement linear regression using python.<br>c. Implement logistic regression using python.<br>d. Implement various evaluation measures using python.                                                 | CO-2, CO-3                   |
| LSO 3.1. Write and execute python program to implement K-mean clustering technique.<br>LSO 3.2. Write and execute python program to implement fuzzy C-mean clustering technique.                                                                                                                          | 3.     | a. Implement K-mean clustering using python.<br>b. Implement fuzzy C-mean clustering using python.                                                                                                                                                                   | CO-1, CO-4                   |
| LSO 4.1. Write and execute python program to implement Principle Component Analysis (PCA) method.<br>LSO 4.2. Write and execute Python program to implement Linear discriminative analysis (LDA) method.                                                                                                  | 4.     | a. Implement Dimensionality reduction using Principle Component Analysis (PCA) method.<br>b. Implement Dimensionality reduction using the Linear discriminative analysis (LDA) method.                                                                               | CO-1, CO-5<br><br>CO-1, CO-5 |

**L) Suggested Term Work and Self-Learning: S2418603A** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

**a. Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

**b. Micro Projects:**

1. Prepare a report on recent classifiers (supervised learning) used in the research/real-time project.
2. Prepare a report on recent clustering techniques (unsupervised learning) used in the research/real-time project.
3. Make a small project on Loan Prediction using Machine Learning on a Kaggle dataset named "Loan Prediction Problem Dataset". The link to the dataset is- <https://www.kaggle.com/datasets/altruistdelhite04/loan-prediction-problem-dataset>.
4. Prepare a presentation on different datasets with their salient points used in classification and clustering from UCI and Kaggle repositories.

**c. Other Activities:**

1. Seminar Topics:
  - Future of Machine Learning
  - Support vector machine
  - Artificial neural network
  - Deep learning
  - Pros and cons of Machine learning

**M) Suggested Course Evaluation Matrix:** The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term work for ensuring CO attainment. The response/performance of the student in each of these designed activities is to be used to calculate **CO attainment**.

| COs         | Course Evaluation Matrix                                  |                             |                                      |                |                   |                                  |                                 |
|-------------|-----------------------------------------------------------|-----------------------------|--------------------------------------|----------------|-------------------|----------------------------------|---------------------------------|
|             | Theory Assessment (TA)**                                  |                             | Term Work Assessment (TWA)           |                |                   | Lab Assessment (LA)#             |                                 |
|             | Progressive Theory Assessment (PTA)<br>Class/Mid Sem Test | End Theory Assessment (ETA) | Term Work & Self Learning Assessment |                |                   | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |
|             |                                                           |                             | Assignments                          | Micro Projects | Other Activities* |                                  |                                 |
| CO-1        | 20%                                                       | 20%                         | 20%                                  | 20%            | 20%               | 20%                              | 20%                             |
| CO-2        | 15%                                                       | 15%                         | 15%                                  | 20%            | 20%               | 15%                              | 20%                             |
| CO-3        | 25%                                                       | 25%                         | 25%                                  | 20%            | 20%               | 25%                              | 20%                             |
| CO-4        | 25%                                                       | 25%                         | 25%                                  | 20%            | 20%               | 25%                              | 20%                             |
| CO-5        | 15%                                                       | 15%                         | 15%                                  | 20%            | 20%               | 15%                              | 20%                             |
| Total Marks | 30                                                        | 70                          | 20                                   | 20             | 10                | 20                               | 30                              |
|             |                                                           |                             | 50                                   |                |                   |                                  |                                 |

**Legend:**

\*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

\*\* : Mentioned under point- (N)

# : Mentioned under point- (O)

**Note:**

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

**N) Suggested Specification Table for End Semester Theory Assessment:** Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

| Unit Title and Number                             | Total Classroom Instruction (CI) Hours | Relevant COs Number(s) | Total Marks | ETA (Marks)  |                   |                         |
|---------------------------------------------------|----------------------------------------|------------------------|-------------|--------------|-------------------|-------------------------|
|                                                   |                                        |                        |             | Remember (R) | Understanding (U) | Application & above (A) |
| Unit-1.0 Introduction to Machine Learning (ML)    | 10                                     | CO1                    | 14          | 3            | 5                 | 6                       |
| Unit 2.0 Fundamental Elements of Machine Learning | 8                                      | CO1, CO2               | 10          | 3            | 2                 | 5                       |
| Unit 3.0 Supervised Learning                      | 12                                     | CO3, CO4               | 18          | 5            | 4                 | 9                       |
| Unit 4.0 Unsupervised Learning                    | 12                                     | CO3, CO4               | 18          | 5            | 4                 | 9                       |
| Unit 5.0 Dimensionality Reduction Techniques      | 6                                      | CO4, CO5               | 10          | 4            | 2                 | 4                       |
| <b>Total</b>                                      | <b>48</b>                              | <b>-</b>               | <b>70</b>   | <b>20</b>    | <b>17</b>         | <b>33</b>               |

**Note:** Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

**O) Suggested Assessment Table for Laboratory (Practical):**

| S. No. | Laboratory Practical Titles                                                                  | Relevant COs Number(s) | PLA/ELA (Marks) |           |               |
|--------|----------------------------------------------------------------------------------------------|------------------------|-----------------|-----------|---------------|
|        |                                                                                              |                        | Performance     |           | Viva-Voce (%) |
|        |                                                                                              |                        | PRA* (%)        | PDA** (%) |               |
| 1.     | a. Import and export data using Pandas library functions.                                    | CO-1                   | 45              | 45        | 10            |
|        | b. Use standard scalar and minimax normalization techniques on a given dataset.              | CO-1                   | 40              | 50        | 10            |
|        | c. Split datasets into train, test, and validation sets.                                     | CO-1                   | 40              | 50        | 10            |
|        | d. Apply k-fold validation technique on a given dataset.                                     | CO-1                   | 40              | 50        | 10            |
| 2.     | a. Implement k-nearest neighbor Classifier using python.                                     | CO-2, CO-3             | 40              | 50        | 10            |
|        | b. Implement linear regression using python.                                                 | CO-2, CO-3             | 40              | 50        | 10            |
|        | c. Implement logistic regression using python.                                               | CO-2, CO-3             | 40              | 50        | 10            |
|        | a. Implement various evaluation measures using python.                                       | CO-2, CO-3             | 40              | 50        | 10            |
| 3.     | a. Implement K-mean clustering using python.                                                 | CO-1, CO-4             | 40              | 50        | 10            |
|        | b. Implement fuzzy C-mean clustering using python.                                           | CO-1, CO-4             | 40              | 50        | 10            |
| 4.     | a. Implement Dimensionality reduction using Principle Component Analysis (PCA) method.       | CO-1, CO-5             | 40              | 50        | 10            |
|        | b. Implement Dimensionality reduction using the Linear discriminative analysis (LDA) method. | CO-1, CO-4             | 40              | 50        | 10            |

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

**Note:** This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

**P) Suggested Instructional/Implementation Strategies:** Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Field Trips, Portfolio Based, Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field Information and Communications Technology (ICT)Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Session, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

**Q) List of Major Laboratory Equipment, Tools and Software:**

| S. No. | Name of Equipment, Tools and Software          | Broad Specifications                                                                                                                 | Relevant Experiment/Practical Number |
|--------|------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|
| 1      | Computer system                                | Multi core (4/8) CPU, 16 GB RAM, 1 TB HD, A Graphics Processing Unit with 4 GB or more of video RAM is desirable for large data set. | 1-12                                 |
| 2      | Python                                         | Version 3.10 or above                                                                                                                | 1-12                                 |
| 3      | Anaconda                                       | Generic                                                                                                                              | 1-12                                 |
| 4      | scikit-learn, scipy, numpy, pandas, tensorflow | Generic                                                                                                                              | 1-12                                 |

**R) Suggested Learning Resources:****(a) Books:**

| S. No. | Titles                                                                                                                           | Author(s)                              | Publisher and Edition with ISBN                                 |
|--------|----------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|-----------------------------------------------------------------|
| 1      | Machine Learning for Beginners                                                                                                   | Harsh Bhasin                           | BPB Publications, 1st Edition, ISBN-13978-9389845426            |
| 2      | Understanding Machine Learning: From Theory to Algorithms                                                                        | Shai Shalev-Shwartz and Shai Ben-David | Cambridge University Press, 1st Edition, ISBN-13:978-1107057135 |
| 3      | Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems | Aurélien Géron                         | O'Reilly Media, 3rd Edition<br>ISBN-13:978-9355421982           |
| 4      | Machine Learning: A Probabilistic Perspective                                                                                    | Kevin P. Murphy                        | The MIT Press, Illustrated edition,<br>ISBN-13: 978-0262018029  |
| 5      | Pattern Recognition and Machine Learning                                                                                         | Christopher M. Bishop                  | Springer New York, NY, 1st Edition<br>ISBN-13: 9780387310732    |

**(b) Online Educational Resources:**

1. <https://www.coursera.org/articles/machine-learning-books>
2. <https://www.javatpoint.com/machine-learning>
3. <https://nptel.ac.in/courses/106106139>

**Note:** Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational resources before use by the students.

**(c) Others:**

1. Lab Manuals

\*\*\*\*\*

- A) **Course Code** : 2418603B(T2418603B/P2418603B/S2418603B)
- B) **Course Title** : Mobile Application Development
- C) **Pre- requisite Course(s)** : JAVA Programming
- D) **Rationale** :

Android application development is one of the growing and rising trend in the industry of mobile. Mobile app development fosters innovation and creativity. It encourages individuals to think critically, solve problems, and design user-friendly interfaces. Since majority of the mobile devices are android based, this course examines the principles of mobile application design and covers the necessary concept which are required to understand mobile based applications and develop android-based application.

- E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

**After completion of the course, the students will be able to-**

- CO-1** Explain key architectural components of mobile applications for Variety of operating systems.
- CO-2** Explain the process of data management and retrieval in mobile applications.
- CO-3** Develop rich user interfaces by using layout and interfaces.
- CO-4** Use user interface components for mobile application development.
- CO-5** Create mobile applications using database.

**F) Suggested Course Articulation Matrix (CAM):**

| Course Outcomes (COs) | Programme Outcomes (POs)                        |                          |                                          |                           |                                                                           |                            |                            | Programme Specific Outcomes* (PSOs) |       |
|-----------------------|-------------------------------------------------|--------------------------|------------------------------------------|---------------------------|---------------------------------------------------------------------------|----------------------------|----------------------------|-------------------------------------|-------|
|                       | PO-1<br>Basic and Discipline Specific Knowledge | PO-2<br>Problem Analysis | PO-3<br>Design/ Development of Solutions | PO-4<br>Engineering Tools | PO-5<br>Engineering Practices for Society, Sustainability and Environment | PO-6<br>Project Management | PO-7<br>Life Long Learning | PSO-1                               | PSO-2 |
| CO-1                  | 1                                               | -                        | -                                        | -                         | -                                                                         | -                          | 1                          |                                     |       |
| CO-2                  | 2                                               | 2                        | 2                                        | 1                         | -                                                                         | -                          | 1                          |                                     |       |
| CO-3                  | 2                                               | 2                        | 2                                        | 1                         | -                                                                         | 2                          | -                          |                                     |       |
| CO-4                  | 2                                               | 3                        | 3                                        | 1                         | 1                                                                         | 2                          | -                          |                                     |       |
| CO-5                  | 2                                               | 3                        | 3                                        | 1                         | 1                                                                         | 2                          | -                          |                                     |       |

**Legend:** High (3), Medium (2), Low (1) and No mapping (-)

\* PSOs will be developed by the respective program coordinator at the institute level. As per the latest NBA guidelines, formulating PSOs is optional

**G) Teaching & Learning Scheme:**

| Course Code     | Course Title                   | Scheme of Study (Hours/Week) |   |                      |                         |                           |                   |
|-----------------|--------------------------------|------------------------------|---|----------------------|-------------------------|---------------------------|-------------------|
|                 |                                | Classroom Instruction (CI)   |   | Lab Instruction (LI) | Notional Hours (TW+ SL) | Total Hours (CI+LI+TW+SL) | Total Credits (C) |
|                 |                                | L                            | T |                      |                         |                           |                   |
| <b>2418603B</b> | Mobile Application Development | 03                           | - | 04                   | 02                      | 09                        | 06                |

**Legend:**

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

**Note:** TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

**H) Assessment Scheme:**

| Course Code | Course Title                   | Assessment Scheme (Marks)           |                             |                                            |          |                                  |                                 | Total Marks (TA+TWA+LA) |
|-------------|--------------------------------|-------------------------------------|-----------------------------|--------------------------------------------|----------|----------------------------------|---------------------------------|-------------------------|
|             |                                | Theory Assessment (TA)              |                             | Term Work & Self-Learning Assessment (TWA) |          | Lab Assessment (LA)              |                                 |                         |
|             |                                | Progressive Theory Assessment (PTA) | End Theory Assessment (ETA) | Internal                                   | External | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |                         |
| 2418603B    | Mobile Application Development | 30                                  | 70                          | 20                                         | 30       | 20                               | 30                              | 200                     |

**Legend:**

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.)

**Note:**

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

**I) Course Curriculum Detailing:** This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Indian Knowledge System (IKS) and others must be integrated appropriately.

**J) Theory Session Outcomes (TSOs) and Units: T2418603B**

| Major Theory Session Outcomes (TSOs)                                                                                                                                                                                                                                                                                                                                                                                                 | Units                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Relevant Cos Number(s) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| TSO 1a. Explain the differences and similarities between major mobile application ecosystems<br>TSO 1b. Highlighting the key capabilities introduced with each generation.<br>TSO 1c. Explain different connection types in mobile app development.<br>TSO 1d. Explain mobile application development Life Cycle.                                                                                                                    | <b>Unit-1.0 Basics of Mobile Application Architecture</b><br>1.1 Overview of mobile applications and ecosystems (iOS, Android, etc.)<br>1.2 Introduction to mobile phone generations – 1G to 5G<br>1.3 Mobile OS Architectures<br>1.4 Smart phone architecture-ARM (Advance RISC Machine)<br>1.4.1 Kernel structure<br>1.4.2 Intel architectures<br>1.4.3 iOS and Windows<br>1.5 Mobile Application Architectures: Client-Server<br>1.5.1 Connection Types<br>1.6 The Mobile Application Development Lifecycle<br>1.7 Android Stack<br>1.8 Android Applications Structure                                                                                                                                                                                                                                                                                                  | <b>CO-1</b>            |
| TSO 2a. Explain how to work with Shared Preferences for lightweight data storage.<br>TSO 2b. Describe the importance of persistent data storage for complex data management.<br>TSO 2c. Explain the role of Content Provider classes in Android for sharing data between applications.<br>TSO 2d. Classify layout in various categories.<br>TSO 2e. Highlight the importance of persistent data storage for complex data management. | <b>Unit-2.0 Content Providers and Data Sharing</b><br>2.1. Using preferences<br>2.1.1. Working with Shared Preferences<br>2.1.2. Preference access permissions<br>2.2. Using the filesystem<br>2.2.1. Creating files<br>2.2.2. Accessing files<br>2.2.3. Files as raw resources<br>2.2.4. XML file resources<br>2.2.5. External storage via an SD card<br>2.3. Persisting data to a database<br>2.3.1. Building and accessing a database<br>2.3.2. Using the sqlite3 tool<br>2.4. Working with Content Provider classes<br>2.4.1. Using an existing Content Provider<br>2.4.2. Creating a Content Provider<br>2.5 Overview of Android Layouts<br>2.5.1 Introduction to Layouts<br>2.5.2 Understanding the purpose of layouts Android apps.<br>2.6 Types of Layouts: Linear Layout, Relative Layout, Constraint Layout, Frame Layout<br>2.7 Adaptive Layouts with Fragments | <b>CO-2</b>            |
| TSO 3a. Explain method to create an Activity class in Android.                                                                                                                                                                                                                                                                                                                                                                       | <b>Unit-3.0 Interface and Layout in Android</b><br>3.1. Creating the Activity<br>3.1.1 Creating an Activity class                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>CO-3</b>            |

| Major Theory Session Outcomes (TSOs)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Units                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Relevant Cos Number(s) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| <p>TSO 3b. Comprehend the role and usage of common views in Android.</p> <p>TSO 3c. Explain method to create views that are defined through XML.</p> <p>TSO 3d. Explain method to efficiently use resources and animations to create responsive and visually appealing applications.</p>                                                                                                                                                                                                                                 | <p>3.1.2 Exploring the Activity lifecycle</p> <p>3.2 Working with views</p> <p>3.2.1 Exploring common views</p> <p>3.2.2 Using a List View</p> <p>3.2.3 Multitasking with Handler and Message</p> <p>3.2.4 Creating custom views</p> <p>3.2.5 Understanding layout</p> <p>3.2.6 Handling focus</p> <p>3.2.7 Grasping events</p> <p>3.3 Using Resources</p> <p>3.3.1 Supported resource types</p> <p>3.3.2 Referencing resources in Java</p> <p>3.3.3 Defining views and layouts through XML resources</p> <p>3.3.4 Externalizing values</p> <p>3.3.5 Providing animations</p> <p>3.4 Exploring the Android Manifest File</p>                                                                                                                                                                                                                                                                                                                               |                        |
| <p>TSO 4a. Explain the foundational components of Android UI.</p> <p>TSO 4b. Explain the method to create UI elements that are used to build the structure of Android applications.</p> <p>TSO 4c. Explain the function of Advanced UI Components for Enhanced User Experiences</p> <p>TSO 4d. Apply menu and dialogs to Create Engaging and Interactive Android Applications</p> <p>TSO 4e. Explain methods to create effectively use different UI components to improve the user experience and app functionality.</p> | <p><b>Unit-4.0 Android User Interface Components</b></p> <p>4.1 Basics of Android UI Components</p> <p>4.1.1 Introduction to Android UI Components: Overview of Views and View Groups.</p> <p>4.1.2 Understanding Android XML Layout Files: Structure and usage of XML for defining UIs.</p> <p>4.2 Commonly Used UI Components</p> <p>4.2.1 Text Views and Edit Texts: Displaying and editing text.</p> <p>4.2.2 Buttons and Image Buttons: Handling clicks and actions.</p> <p>4.2.3 Image Views: Displaying images.</p> <p>4.3 Advanced UI Components</p> <p>4.3.1 RecyclerView: Displaying lists and grids efficiently.</p> <p>4.3.2 Card View: Presenting information in a card format.</p> <p>4.3.3 Navigation View: Implementing navigation drawers.</p> <p>4.4 Menu and Dialogs</p> <p>4.4.1 Menus and Context Menus: Adding options and context menus.</p> <p>4.4.2 Dialogs and Toasts: Displaying alerts, confirmations, and quick messages.</p> | <b>CO-4</b>            |
| <p>TSO 5a. Explain the basics of SQLite database.</p> <p>TSO 5b. Contrast SQLite with other database solutions.</p> <p>TSO 5c. Integrate the database within the user interface of an Android application.</p> <p>TSO 5d. Apply Practical Skills in SQLite Database Integration and Management</p>                                                                                                                                                                                                                       | <p><b>Unit-5.0 Design and Implementation of Database-Driven Applications</b></p> <p>5.1 Introduction to SQLite Database</p> <p>5.1.1 Creating and opening a database,</p> <p>5.1.2 Creating tables</p> <p>5.1.3 Inserting retrieving and deleting data</p> <p>5.1.4 Choosing the Right Database</p> <p>5.1.5 Comparison of SQLite, Room, Firebase Realtime Database, and other NoSQL databases.</p> <p>5.1.6 SQLite Database Integration</p> <p>5.2. Registering Content Providers</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>CO-5</b>            |

| Major Theory Session Outcomes (TSOs) | Units                                                                                                                                                                                                                                                                                                                                                     | Relevant Cos Number(s) |
|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
|                                      | 5.2.1 Using content Providers (Insert, delete, retrieve and update).<br>5.3 Understanding SQLite:<br>5.3.1 Basics of SQLite database<br>5.3.2 Role and integration in Android applications.<br>5.4 Implementing a Database-Driven Application<br>5.4.1 Designing the Database Schema:<br>5.4.2 Integrating the Database with UI<br>5.4.3 Database Testing |                        |

**Note:** One major TSO may require more than one Theory session/Period.

**K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2418603B**

| Practical/Lab Session Outcomes (LSOs)                                                                                                                                                                                                                                                              | S. No. | Laboratory Experiment/Practical Titles                                                                                                                                                                                                                                                                                                                                                                 | Relevant COs Number(s) |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| LSO 1.1 Explain mobile ecosystems.<br>LSO 1.2 Explain the evolution of mobile technologies and the architectural differences among major mobile operating systems.<br>LSO 1.3 Comprehend the significance of smartphone architecture in application development.                                   | 1.     | 1.1 Research and present the unique features and development environments of iOS and Android.<br>1.2 Create a timeline charting the evolution from 1G to 5G, highlighting key technological advancements.<br>1.3 Compare the architectures of Android, iOS, and Windows mobile OS.<br>1.4 Use software simulation tools to visualize ARM and Intel architectures in smartphones.                       | CO-1                   |
| LSO 2.1. Store user settings using shared preferences for Android App development<br>LSO 2.2. Performing file operation on internal and external storage.<br>LSO 2.3. Implement CRUD operations using SQLite for mobile app development.<br>LSO 2.4. Share data in different Android applications. | 2.     | 2.1 Develop a simple Android app utilizing Shared Preferences to store user settings.<br>2.2 Create an app that performs file creation, reading, and writing operations on both internal and external storage.<br>2.3 Build a basic app that demonstrates CRUD operations using SQLite.<br>2.4 Develop an app that uses a custom Content Provider for data sharing between two different applications. | CO-2                   |
| LSO 3.1. Create Android activities.<br>LSO 3.2. Use views and resources effectively.<br>LSO 3.3. Manipulate the Android Manifest file to configure application settings and permissions.                                                                                                           | 3.     | 1.1 Create an app that logs and displays each callback of the Activity lifecycle.<br>1.2 Create an app that uses a List View to display a list of items and includes at least one custom view.<br>1.3 Develop an app that dynamically utilizes different types of resources like strings, images, and animations.                                                                                      | CO-3                   |

| Practical/Lab Session Outcomes (LSOs)                                                                                                                                                                                                               | S. No. | Laboratory Experiment/Practical Titles                                                                                                                                                                                                                                                                                                                                                                                                           | Relevant COs Number(s) |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
|                                                                                                                                                                                                                                                     |        | 1.4 Modify the Android Manifest file to change app permissions, define activities, and set the application's theme.                                                                                                                                                                                                                                                                                                                              |                        |
| <i>LSO 4.1.</i> Customize of Android UI components<br><i>LSO 4.2.</i> Use advanced elements like RecyclerView and Navigation View in their applications.                                                                                            | 4.     | 1.1 Create an app showcasing the use of Text Views, Buttons, and Image Views with various styles and actions.<br>1.2 Develop an app that uses RecyclerView to display a list of items efficiently.<br>1.3 Implement an app that uses menus, context menus, and dialogs to interact with the user.<br>1.4 Build an app with a Navigation View that implements a sliding navigation menu.                                                          | CO-4                   |
| <i>LSO 5.1.</i> Integrate databases within Android applications.<br><i>LSO 5.2.</i> Utilize SQLite and Content Providers for robust data management.<br><i>LSO 5.3.</i> Establish seamless interaction between the database and the user interface. | 5.     | 1.1 Develop an app that creates an SQLite database, performs CRUD operations, and displays the data.<br>1.2 Build an app that shares data with another app using a custom Content Provider.<br>1.3 Design and implement a complex database schema within an app, demonstrating normalization and indexing.<br>1.4 Create an app that integrates database operations with the user interface, displaying database content dynamically in the app. | CO-5                   |

**Note:** in addition to above listed practical, students are suggested to practice all the examples covered by the teacher during theory sessions.

**L) Suggested Term Work and Self Learning: S2418603B**

- a. **Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.
- b. **Micro Projects:**
  1. Develop a personal finance tracking app that allows users to record their income and expenses. The app should use SQLite for data persistence, allowing users to add, view, edit, and delete financial records. Implement charts or graphs using external libraries to visualize spending patterns over time.
  2. Create a custom contacts application that allows users to save and manage their contacts independently of the phone's default contacts app. Use a custom Content Provider to handle data storage, and implement features for adding, viewing, updating, and deleting contacts.
  3. Build a simple fitness tracking app that allows users to log workouts, track progress, and set goals. Use various Android views and resources to create an interactive and user-friendly interface, including custom views for visualizing workout data.
  4. Develop a local tourist guide app that provides information about tourist attractions, restaurants, and hotels in a selected area. The app should use the mobile device's GPS to offer personalized recommendations. Implement client-server architecture to fetch data from a server and cache it locally for offline access.

## c. Other Activities:

## 1. UI/UX Design Workshop

Objective: Conduct workshops focusing on the principles of UI/UX design specific to mobile applications. Encourage students to design mockups for their micro projects before implementation, focusing on user flow, aesthetics, and functionality.

## 2. Hackathon or App Development Contest

Objective: Organize a hackathon or app development contest where students can form teams and develop applications based on certain themes or problems within a limited time frame. This encourages creativity, teamwork, and practical application of learned skills. Join online CTF challenges related to network security.

## 3. Exploration of Advanced Topics

Objective: Encourage students to explore advanced topics in mobile app development, such as augmented reality, machine learning integration, or blockchain in apps, through research presentations or mini-projects.

## i. Self-Learning Topics:

1. Mobile App Security Learn best practices for securing mobile applications, including secure communication, data encryption, OAuth2 authentication, and protecting against common vulnerabilities.

## 2. Augmented Reality (AR) in Mobile Apps

Discover: How to integrate AR features into mobile apps using ARKit for iOS and AR Core for Android. Explore use cases in gaming, education, and retail.

## 3. Machine Learning in Mobile Apps

Investigate: Implementing machine learning models in mobile applications, utilizing frameworks like TensorFlow Lite and Core ML for tasks such as image recognition, natural language processing, and predictive analytics.

**M) Suggested Course Evaluation Matrix:** course teacher has to decide and use the appropriate assessment strategy and its weight age in theory, laboratory and Term work for ensuring CO attainment. The response/performance of the student in each of these designed activities is to be used to calculate **CO attainment**.

| COs         | Course Evaluation Matrix                                  |                             |                                     |                |                   |                                  |                                 |
|-------------|-----------------------------------------------------------|-----------------------------|-------------------------------------|----------------|-------------------|----------------------------------|---------------------------------|
|             | Theory Assessment (TA)**                                  |                             | Term Work Assessment (TWA)          |                |                   | Lab Assessment (LA)#             |                                 |
|             | Progressive Theory Assessment (PTA)<br>Class/Mid Sem Test | End Theory Assessment (ETA) | Term Work& Self Learning Assessment |                |                   | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |
|             |                                                           |                             | Assignments                         | Micro Projects | Other Activities* |                                  |                                 |
| CO-1        | 20%                                                       | 20%                         | 20%                                 | 20%            | 20%               | 10%                              | 16%                             |
| CO-2        | 15%                                                       | 15%                         | 20%                                 | 20%            | 20%               | 15%                              | 18%                             |
| CO-3        | 25%                                                       | 25%                         | 20%                                 | 20%            | 20%               | 25%                              | 18%                             |
| CO-4        | 25%                                                       | 25%                         | 20%                                 | 20%            | 20%               | 25%                              | 25%                             |
| CO-5        | 15%                                                       | 15%                         | 20%                                 | 20%            | 20%               | 25%                              | 23%                             |
| Total Marks | 30                                                        | 70                          | 20                                  | 20             | 10                | 20                               | 30                              |
|             |                                                           |                             | 50                                  |                |                   |                                  |                                 |

## Legend:

\*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

\*\*: Mentioned under point- (N)

#: Mentioned under point- (O)

**Note:**

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

**N) Suggested Specification Table for End Semester Theory Assessment:** Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

| Unit Title and Number                                                     | Total Classroom Instruction (CI) Hours | Relevant COs Number(s) | Total Marks | ETA (Marks)  |                   |                         |
|---------------------------------------------------------------------------|----------------------------------------|------------------------|-------------|--------------|-------------------|-------------------------|
|                                                                           |                                        |                        |             | Remember (R) | Understanding (U) | Application & above (A) |
| <b>Unit-1.0</b> Basics of Android Architecture                            | 12                                     | CO-1                   | 14          | 5            | 5                 | 4                       |
| <b>Unit 2.0</b> Content Providers and Data Sharing                        | 10                                     | CO-2                   | 10          | 2            | 4                 | 4                       |
| <b>Unit3.0</b> Interface and Layout in Android                            | 10                                     | CO-3                   | 18          | 5            | 6                 | 7                       |
| <b>Unit 4.0</b> Android User Interface Components                         | 8                                      | CO-4                   | 18          | 5            | 6                 | 7                       |
| <b>Unit 5.0</b> Design and Implementation of Database-Driven Applications | 8                                      | CO-5                   | 10          | 3            | 3                 | 4                       |
| <b>Total</b>                                                              | <b>48</b>                              | <b>-</b>               | <b>70</b>   | <b>20</b>    | <b>24</b>         | <b>26</b>               |

**Note:** Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

**O) Suggested Specification Table for Laboratory (Practical):**

| S. No. | Laboratory Practical Titles           | Relevant COs Number(s) | PLA/ELA     |           |               |
|--------|---------------------------------------|------------------------|-------------|-----------|---------------|
|        |                                       |                        | Performance |           | Viva-Voce (%) |
|        |                                       |                        | PRA* (%)    | PDA** (%) |               |
| 1.     | Explore Mobile Ecosystems.            | CO-1                   | 40          | 50        | 10            |
| 2.     | Smartphone Architecture Simulation    | CO-1                   | 40          | 50        | 10            |
| 3.     | Shared Preferences Implementation     | CO-2                   | 40          | 50        | 10            |
| 4.     | Content Provider Usage                | CO-2                   | 30          | 60        | 10            |
| 5.     | List View and Custom Views            | CO-3                   | 40          | 50        | 10            |
| 6.     | Android Manifest Exploration          | CO-3                   | 50          | 40        | 10            |
| 7.     | Interactive UI with Dialogs and Menus | CO-4                   | 50          | 40        | 10            |
| 8.     | Navigation Drawer Application         | CO-4                   | 50          | 40        | 10            |
| 9.     | Content Provider for Data Sharing     | CO-5                   | 70          | 20        | 10            |
| 10.    | Database Integration with UI          | CO-5                   | 50          | 40        | 10            |

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

**Note:** This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

**P) Suggested Instructional/Implementation Strategies:** Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Field Trips, Portfolio Based, Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field Information and Communications Technology (ICT)Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Session, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

**Q) List of Major Laboratory Equipment, Tools and Software:**

| S. No. | Name of Equipment, Tools and Software                  | Broad Specifications            | Relevant Experiment/Practical Number |
|--------|--------------------------------------------------------|---------------------------------|--------------------------------------|
| 1      | Computer System                                        | Any General-purpose Computer    | All                                  |
| 2      | Integrated Development Environments (IDEs) and Editors | Android Studio, X code, VS Code | All                                  |
| 3      | Cross-Platform Development Frameworks                  | Flutter, React Native           | All                                  |
| 4      | Version Control                                        | Git, GitHub                     | All                                  |

**R) Suggested Learning Resources:**

**(a) Books:**

| S. No. | Titles                                                            | Author(s)                      | Publisher and Edition with ISBN                                                   |
|--------|-------------------------------------------------------------------|--------------------------------|-----------------------------------------------------------------------------------|
| 1.     | Beginning Android Programming with Android Studio, Fourth Edition | Jerome F. DiMarzio             | Wrox<br>ISBN: 9781118705599                                                       |
| 2.     | Android Studio 3.0 Development Essentials - Android 8 Edition     | Smyth Neil                     | Create space Independent Publishing Platform<br>ISBN-9781977540096, 9781977540096 |
| 3.     | Designing Mobile Interfaces, 1st Edition                          | Steven Hooper and Eric Berkman | Addison-Wesley Professional.<br>ISBN- 978-1449394639                              |

**(b) Open Educational Resources (OER):**

1. <https://developer.android.com/>
2. <https://material.io/design>
3. <https://xd.adobe.com/ideas/principles/mobile-design/>
4. <https://www.coursera.org/learn/introduction-to-android-mobile-application-development>
5. <https://www.udemy.com/course/complete-android-n-developer-course/>

**(c) Others:**

1. Learning Header files
2. Lab Manuals

\*\*\*\*\*

- A) **Course Code** : 2400604B(T2400604B/P2400604B/S2400604B)
- B) **Course Title** : Artificial Intelligence (Advanced)
- C) **Pre- requisite Course(s)** : Artificial Intelligence (Basic)
- D) **Rationale** :

In Artificial Intelligence (Basic) course, students have learned the basics for Artificial Intelligence problem solving techniques, data analytics and articulates the different dimensions of these areas. This Artificial Intelligence (Advanced) course offers the students the comprehension of Machine learning which is a subset of artificial intelligence in the field of computer. The course also exposes students to Tens or flow a Python-based open source library for numerical computation used in machine learning and developing neural networks. After completing the course students will be able to implement various techniques used in machine learning and neural networks using open source tools.

- E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/laboratory/workshop/field/ industry.

**After completion of the course, the students will be able to-**

- CO-1** Elaborate the use of Machine learning in Artificial Intelligence.
- CO-2** Implement various supervised and unsupervised learning models and methods.
- CO-3** Illustrate Artificial neural networks and its applications.
- CO-4** Implement various Neural network models and Learning Methods.
- CO-5** Solve machine learning and artificial neural network problems using Tens or flow.

- F) **Suggested Course Articulation Matrix (CAM):**

| Course Outcomes (COs) | Programme Outcomes(POs)                         |                          |                                         |                           |                                                                           |                            |                            | Programme Specific Outcomes* (PSOs) |       |
|-----------------------|-------------------------------------------------|--------------------------|-----------------------------------------|---------------------------|---------------------------------------------------------------------------|----------------------------|----------------------------|-------------------------------------|-------|
|                       | PO-1<br>Basic and Discipline Specific Knowledge | PO-2<br>Problem Analysis | PO-3<br>Design/Development of Solutions | PO-4<br>Engineering Tools | PO-5<br>Engineering Practices for Society, Sustainability and Environment | PO-6<br>Project Management | PO-7<br>Life Long Learning | PSO-1                               | PSO-2 |
| CO-1                  | -                                               | 2                        | 2                                       | -                         | -                                                                         | -                          | 1                          |                                     |       |
| CO-2                  | 3                                               | 3                        | 3                                       | 3                         | -                                                                         | -                          | 2                          |                                     |       |
| CO-3                  | -                                               | 3                        | 3                                       | 3                         | -                                                                         | -                          | 2                          |                                     |       |
| CO-4                  | 3                                               | 1                        | 3                                       | 3                         | -                                                                         | -                          | 2                          |                                     |       |
| CO-5                  | 3                                               | 3                        | 3                                       | 3                         | -                                                                         | -                          | 2                          |                                     |       |

**Legend:** High (3), Medium (2), Low (1) and No mapping (-)

\*: PSOs will be developed by respective programme Coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

- G) **Teaching & Learning Scheme:**

| Course Code | Course Title                       | Scheme of Study (Hours/Week) |   |                      |                         |                           |                  |
|-------------|------------------------------------|------------------------------|---|----------------------|-------------------------|---------------------------|------------------|
|             |                                    | Classroom Instruction (CI)   |   | Lab Instruction (LI) | Notional Hours (TW+ SL) | Total Hours (CI+LI+TW+SL) | Total Credit (C) |
|             |                                    | L                            | T |                      |                         |                           |                  |
| 2400604B    | Artificial intelligence (Advanced) | 03                           | - | 04                   | 02                      | 09                        | 06               |

**Legend:**

- CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)
- LI: Laboratory Instruction (Includes experiments/practical performances/ problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)
- Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.
- TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)
- SL: Self Learning, MOOCS, spoken tutorials, online educational resources etc.
- C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)
- Note:** TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

**H) Assessment Scheme:**

| Course Code | Course Title                       | Assessment Scheme (Marks)           |                             |                                            |          |                                  |                                 | Total Marks (TA+TWA+LA) |
|-------------|------------------------------------|-------------------------------------|-----------------------------|--------------------------------------------|----------|----------------------------------|---------------------------------|-------------------------|
|             |                                    | Theory Assessment (TA)              |                             | Term Work & Self-Learning Assessment (TWA) |          | Lab Assessment (LA)              |                                 |                         |
|             |                                    | Progressive Theory Assessment (PTA) | End Theory Assessment (ETA) | Internal                                   | External | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |                         |
| 2400604B    | Artificial Intelligence (Advanced) | 30                                  | 70                          | 20                                         | 30       | 20                               | 30                              | 200                     |

**Legend:**

- PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)
- PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)
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**Note:**

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

- I) Course Curriculum Detailing:** This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

## J) Theory Session Outcomes (TSOs) and Units: T2400604B

| Major Theory Session Outcomes (TSOs)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Units                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Relevant Cos Number (s) |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| TSO 1a. Describe the basic terminology of Machine learning<br>TSO 1b. Explain the concept of dataset and ways to handle them<br>TSO 1c. illustrate the process of dataset division<br>TSO 1d. Explain process involved in machine learning                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Unit – 1.0: Introduction to Machine Learning</b><br><br>Concept of Machine Learning, Define Learning, Learn the Network, Evaluate the Network, datasets and ways to handle them, Feature sets, Dataset division: test, train and validation sets, cross validation. Applications of Machine Learning, processes involved in Machine Learning                                                                                                                                                                                                                                                                                             | <b>CO-1</b>             |
| TSO 2a. Identify the category or class of a particular dataset using KNN algorithm<br>TSO 2b. Use Linear regression for predictive analysis<br>TSO 2c. Predict the categorical dependent variable using Logistic Regression<br>TSO 2d. Use SVM for classification problems in Machine Learning<br>TSO 2e. determine the performance of the classification models<br>TSO 2f. evaluate the performance of the classification model using ROC-curve<br>TSO 2g Explain characteristics of Unsupervised learning.<br>TSO 2h. Explain different clustering methods<br>TSO 2i. Implement K-means clustering algorithm to group the unlabeled dataset | <b>Unit 2.0: Supervised and Unsupervised Learning</b><br><br><b>Supervised Learning:</b><br>Introduction to Supervised Learning, K-Nearest Neighbor, Linear Regression, Logistic Regression, Support Vector Machine (SVM), Evaluation Measures: confusion matrix, precision, precision and recall, ROC-Curve (Receiver Operating Characteristic curve)<br><br><b>Unsupervised Learning:</b><br>Introduction to Unsupervised Learning, Introduction to clustering, Types of Clustering: Hierarchical, Agglomerative Clustering and Divisive clustering; Partitional Clustering - K-means clustering. Expectation-Maximization (EM) Algorithm | <b>CO-2</b>             |
| TSO 3a. Explain Structure and working of Biological Neural Network.<br>TSO 3b. differentiate between Artificial Neural Network and Biological Neural Network<br>TSO 3c. State key historical points in development of ANN<br>TSO 3d. Explain the architecture of an artificial neural network                                                                                                                                                                                                                                                                                                                                                 | <b>Unit 3.0: Introduction to Neural Networks</b><br><br>Structure and working of Biological Neural Network, Fundamentals of Artificial Neural Networks & Applications, Characteristics of Artificial Neural Networks, History of neural network research, characteristics of neural networks terminology.                                                                                                                                                                                                                                                                                                                                   | <b>CO-3</b>             |
| TSO 4a. Use neuron McCulloch – Pitts model in designing logical operations<br>TSO 4b. Apply Rosenblatt's Perceptron to solve linear classification problems<br>TSO 4c. Implement Adaptive Linear Neuron (Adaline) training algorithm in neural network<br>TSO 4d. Use Backpropagation neural training algorithm<br>TSO 4e. Use ART (Adaptive Resonance Theory) learning model<br>TSO 4f: Implement Bidirectional Associative Memory (BAM) model in Artificial Neural Network                                                                                                                                                                  | <b>Unit 4.0: Neural Networks Models and Learning Methods</b><br><br>Models of neuron McCulloch – Pitts model, Rosenblatt's Perceptron, Adaline model, Basic learning laws, Topology of neural network architecture, Multilayer Neural Networks, Learning Methods, Backpropagation, Counter propagation, Adaptive Resonance Theory (ART), Associative memories, BAM.                                                                                                                                                                                                                                                                         | <b>CO-4</b>             |
| TSO 5a. Illustrate the features of Tens or flow<br>TSO 5b. Manipulate tensors<br>TSO 5c. Explain features of Tens or Board visualization<br>TSO 5d Explain the concept and features of Tens or                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>Unit-5.0: Tensor flow</b><br><br>features of TensorFlow, Tensor Data structure- Rank, shape, type, one dimension and two-dimension tensor, Tensor handling                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>CO-5</b>             |

| Major Theory Session Outcomes (TSOs) | Units                                                                                                                                                                                                                                                                                                                                                   | Relevant Cos Number (s) |
|--------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| flow playground                      | and manipulations, Tensor board visualization- symbols<br>Tensors, Variables, Automatic differentiation, Graphs and function, modules layers and models, training loops, features of Tens or flow playground- data ,the ration of train and test data, features, hidden layers, Epoch, learning rate, activation function, regularization, problem type |                         |

**Note:** One major TSO may require more than one Theory session/Period.

#### K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical:P2400604B

| Practical/Lab Session Outcomes (LSOs)                                                                     | S. No. | Laboratory Experiment/Practical Titles                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Relevant COs Number(s) |
|-----------------------------------------------------------------------------------------------------------|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| LSO 1.1 Implement data classification algorithms                                                          | 1      | Write a program to implement k-Nearest Neighbor algorithm to classify the iris data set. Print both correct and wrong predictions. Python ML library classes can be used for this problem.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | CO-2                   |
| LSO 2.1 Implement Machine learning algorithms<br>LSO 2.2 Evaluate the performance of classification model | 2      | (a) Implement SVM for Iris Dataset- download the dataset from ( <a href="https://gist.github.com/netj/8836201">https://gist.github.com/netj/8836201</a> )<br><br>(b) Find confusion matrix and evaluation matrix for SVM<br>Hint: SVM model can be constructed using sklearn command,<br>import pandas as pd<br>from sklearn.svm import SVC<br>from sklearn.model_selection import train_test_split<br>from sklearn.metrics import confusion_matrix<br>from sklearn.metrics import classification_report<br>from sklearn.metrics import accuracy_score<br>1. Read the csv Iris dataset file<br>2. Condition the data<br>3. Condition the training and Testing data<br>4. Construct the Linear model<br>5. Test the model with Linear kernel<br>6. Prepare confusion matrix<br>7. prepare Classification Report | CO-2                   |
| LSO 3.1 Perform clustering operations using k-means algorithm                                             | 3      | a) Explore k-means algorithm for the small sample dataset.<br><br>b) Explore k-means algorithm for Iris Dataset                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | CO-2                   |
| LSO 4.1 Perform clustering operations using EM algorithm                                                  | 4      | Apply EM algorithm to cluster a set of data stored in a .CSV file. Use the same data set for clustering using k-Means algorithm. Compare the results of these two algorithms and comment on the quality of clustering. You can add Python ML library classes/API in the program.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | CO-2                   |
| LSO 5.1 Build artificial neural network<br>LSO 5.2 Test artificial neural network                         | 5      | Build an Artificial Neural Network by implementing the Backpropagation algorithm and test the same using appropriate data sets.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | CO-4                   |

| Practical/Lab Session Outcomes (LSOs)                                                                                                                                                        | S. No. | Laboratory Experiment/Practical Titles                                                                                                                                                  | Relevant COs Number(s) |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| LSO 6.1 Detect features or business intelligence in the input data using perceptron                                                                                                          | 6      | Implement the perceptron algorithm from scratch in python.                                                                                                                              | CO-4                   |
| LSO 7.1 Use Tensors for given problems                                                                                                                                                       | 7      | Write a programme to implement two dimension and three-dimension Tensor.                                                                                                                | CO5                    |
| LSO 8.1 Use basic features for tensor handling and manipulations                                                                                                                             | 8      | Write a programme to add and multiply two 4x4 matrix, you can Import "tens or flow" and "numpy".                                                                                        | CO5                    |
| LSO 9.1 Test artificial intelligence (AI) algorithms through the use of Google's TensorFlow machine learning libraries.                                                                      | 9      | Solve a classification problem on the Tens or flow playground.<br>Hint: refer <a href="https://www.educba.com/tensorflow-playground/">https://www.educba.com/tensorflow-playground/</a> | CO5                    |
| LSO 10.1 Implement artificial intelligence (AI) algorithms through the use of Google's TensorFlow machine learning libraries<br>LSO 10.2 perform predictive analysis using linear regression | 10     | Implement algorithm for linear regression in tens or flow                                                                                                                               | CO5, CO2               |

**L) Suggested Term Work and Self Learning:S2400604B** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

**a. Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

**b. Micro Projects:**

Use python programming for the solutions of Microproject problems

- (a) Create a Bar plot to get the frequency of the three species of the Iris data.
  - (b) Create a Pie plot to get the frequency of the three species of the Iris data.
  - (c) Write a Python program to create a graph to find relationship between the sepal length and width.
- (a) Write a Python program to split the iris dataset into its attributes (X) and labels (y). The X variable contains the first four columns (i.e. attributes) and y contains the labels of the dataset.
  - (b) Write a Python program using Scikit-learn to split the iris dataset into 70% train data and 30% test data. Out of total 150 records, the training set will contain 120 records and the test set contains 30 of those records. Print both datasets.
- Conduct performance analysis of Classification Algorithms (any 2) on a specific dataset.

**M) Suggested Course Evaluation Matrix:** The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of the student in each of these designed activities is to be assessed to calculate CO attainment.

| COs  | Course Evaluation Matrix                                  |                            |                                      |                |                   |                                  |                                 |
|------|-----------------------------------------------------------|----------------------------|--------------------------------------|----------------|-------------------|----------------------------------|---------------------------------|
|      | Theory Assessment (TA)**                                  |                            | Term Work Assessment (TWA)           |                |                   | Lab Assessment (LA)#             |                                 |
|      | Progressive Theory Assessment (PTA)<br>Class/Mid Sem Test | End Theory Assessment(ETA) | Term Work & Self-Learning Assessment |                |                   | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |
|      |                                                           |                            | Assignments                          | Micro Projects | Other Activities* |                                  |                                 |
| CO-1 | 20%                                                       | 15%                        | 30%                                  | 20%            | 30%               | --                               | --                              |

|             |     |     |     |     |     |     |     |
|-------------|-----|-----|-----|-----|-----|-----|-----|
| CO-2        | 10% | 25% | 20% | 20% | 20% | 30% | 33% |
| CO-3        | 30% | 25% | 30% | 20% | 20% | --  | --  |
| CO-4        | 20% | 20% | 20% | 20% | 30% | 30% | 33% |
| CO-5        | 20% | 15% | 10% | 20% | --  | 40% | 34% |
| Total Marks | 30  | 70  | 20  | 20  | 10  | 20  | 30  |
|             |     |     | 50  |     |     |     |     |

**Legend:**

- \* : Other Activities include self-learning, seminar, visits, surveys, product development, software development etc.  
 \*\* : Mentioned under point- (N)  
 # : Mentioned under point- (O)

**Note:**

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

**N) Suggested Specification Table for End Semester Theory Assessment:** Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

| Unit Title and Number                                 | Total Classroom Instruction (CI) Hours | Relevant COs Number (s) | Total Marks | ETA (Marks)  |                   |                         |
|-------------------------------------------------------|----------------------------------------|-------------------------|-------------|--------------|-------------------|-------------------------|
|                                                       |                                        |                         |             | Remember (R) | Understanding (U) | Application & above (A) |
| Unit-1.0. Introduction to Machine Learning            | 8                                      | CO1                     | 11          | 5            | 4                 | 2                       |
| Unit-2.0. Supervised and Unsupervised Learning        | 10                                     | CO2                     | 18          | 5            | 6                 | 7                       |
| Unit-3.0. Introduction to Neural Networks             | 10                                     | CO3                     | 17          | 5            | 7                 | 5                       |
| Unit-4.0. Neural Networks Models and Learning Methods | 10                                     | CO4                     | 14          | 3            | 3                 | 8                       |
| Unit-5.0. Tensor Flow                                 | 10                                     | CO5                     | 10          | 2            | 6                 | 2                       |
| <b>Total Marks</b>                                    | <b>48</b>                              |                         | <b>70</b>   | <b>20</b>    | <b>26</b>         | <b>24</b>               |

**Note:** Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

**O) Suggested Assessment Table for Laboratory (Practical):**

| S. No. | Laboratory Practical Titles                                                                                                                                                                                                                          | Relevant COs Number(s) | PLA/ELA     |           |               |
|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|-------------|-----------|---------------|
|        |                                                                                                                                                                                                                                                      |                        | Performance |           | Viva-Voce (%) |
|        |                                                                                                                                                                                                                                                      |                        | PRA* (%)    | PDA** (%) |               |
| 1.     | Write a program to implement k-Nearest Neighbor algorithm to classify the iris data set. Print both correct and wrong predictions. Python ML library classes can be used for this problem.                                                           | CO-2                   | -           | 90        | 10            |
| 2.     | (a) Implement SVM for Iris Dataset- download the dataset from ( <a href="https://gist.github.com/netj/8836201">https://gist.github.com/netj/8836201</a> )<br>(b) Find confusion matrix and evaluation matrix for SVM                                 | CO-2                   | -           | 90        | 10            |
| 3.     | a) Explore k-means algorithm for the small sample dataset.<br>b) Explore k-means algorithm for Iris Dataset                                                                                                                                          | CO-2                   | 20          | 70        | 10            |
| 4.     | Apply EM algorithm to cluster a set of data stored in a .CSV file. Use the same data set for clustering using k-Means algorithm. Compare the results of these two algorithms and comment on the quality of clustering. You can add Python ML library | CO-2                   | -           | 90        | 10            |

| S. No. | Laboratory Practical Titles                                                                                                     | Relevant COs Number(s) | PLA/ELA     |           |               |
|--------|---------------------------------------------------------------------------------------------------------------------------------|------------------------|-------------|-----------|---------------|
|        |                                                                                                                                 |                        | Performance |           | Viva-Voce (%) |
|        |                                                                                                                                 |                        | PRA* (%)    | PDA** (%) |               |
|        | classes/API in the program.                                                                                                     |                        |             |           |               |
| 5.     | Build an Artificial Neural Network by implementing the Backpropagation algorithm and test the same using appropriate data sets. | CO-4                   | 10          | 80        | 10            |
| 6.     | Implement the perceptron algorithm from scratch in python.                                                                      | CO-4                   | 10          | 80        | 10            |
| 7.     | Write a programme to implement two dimension and three-dimension Tensor.                                                        | CO-5                   | -           | 90        | 10            |
| 8.     | Write a programme to add and multiply two 4x4 matrix, you can Import "tens or flow" and "numpy".                                | CO-5                   | -           | 90        | 10            |
| 9.     | Solve a classification problem on the Tens or flow playground.                                                                  | CO-5                   | 20          | 70        | 10            |
| 10.    | Implement algorithm for linear regression in tens or flow                                                                       | CO-2, CO-5             | 10          | 80        | 10            |

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

**Note:** This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

**P) Suggested Instructional/Implementation Strategies:** Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Group Discussion, Portfolio Based Learning, Live Demonstrations in Classrooms, Lab, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

**Q) List of Major Laboratory Equipment, Tools and Software:**

| S. No. | Name of Equipment, Tools and Software   | Broad Specifications                                                                                                                                                                                                                                                                        | Relevant Experiment/Practical Number |
|--------|-----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|
| 1.     | Computer Systems                        | Desktop Computers with i3 processor, 16 GB RAM, 512 GBHDD                                                                                                                                                                                                                                   | S. No. 1 to 10                       |
| 2.     | Online Python IDE                       | <a href="https://www.online-python.com/">https://www.online-python.com/</a>                                                                                                                                                                                                                 | S. No. 1 to 10                       |
| 3.     | Jupyter Notebook                        | Download from <a href="https://jupyter.org/">https://jupyter.org/</a>                                                                                                                                                                                                                       | S. No. 1 to 10                       |
| 4.     | Pip Python package manager              | Download Pip 22.3 From <a href="https://pypi.org/project/pip/">https://pypi.org/project/pip/</a>                                                                                                                                                                                            | S. No. 1 to 10                       |
| 5.     | Google colab                            | <a href="https://colab.research.google.com/github/tensorflow/docs/blob/master/site/en/tutorials/quickstart/beginner.ipynb#scrollTo=DUNzJc4jTj6G">https://colab.research.google.com/github/tensorflow/docs/blob/master/site/en/tutorials/quickstart/beginner.ipynb#scrollTo=DUNzJc4jTj6G</a> | S. No. 1 to 10                       |
| 6.     | Various modules, Libraries and Packages | Tens or flow, NumPy, Pandas, package                                                                                                                                                                                                                                                        | S. No. 1 to 10                       |

**R) Suggested Learning Resources:****(a) Books:**

| S. No. | Titles                                                                                      | Author(s)                                               | Publisher and Edition with ISBN                                                             |
|--------|---------------------------------------------------------------------------------------------|---------------------------------------------------------|---------------------------------------------------------------------------------------------|
| 1.     | Machine Learning using Python                                                               | Manaranjan Pradhan,<br>U Dinesh Kumar                   | Wiley, ISBN-10: 8126579900<br>ISBN-13: 978-8126579907                                       |
| 2.     | Introduction to Machine Learning                                                            | Jeeva Jose                                              | Khanna Book Publishing Co. (P) Ltd, 2020.<br>ISBN-10: 9389139066<br>ISBN-13: 978-9389139068 |
| 3.     | Machine Learning for Dummies                                                                | John Paul Mueller and<br>Luca Massaron, For<br>Dummies, | For Dummies; 2nd edition,<br>ISBN-10: 1119724015<br>ISBN-13: 978-1119724018                 |
| 4.     | Machine Learning                                                                            | Rajeev Chopra                                           | Khanna Book Publishing Co., 2021<br>ISBN-10: 9789386173423<br>ISBN-13: 978-9386173423       |
| 6.     | Learn TensorFlow 2.0: Implement<br>Machine Learning and Deep Learning<br>Models with Python | Pramod Singh, Avinash<br>manure                         | Apress, 978-1484255605<br>ISBN-10: 1484255607<br>ISBN-13: 978-1484255605                    |

**(b) Online Educational Resources:**

1. NPTEL Course: Introduction to Machine Learning, Prof. Balaraman Ravindran, IIT Madras
2. <https://www.tensorflow.org/resources/learn-ml>
3. <https://www.tutorialspoint.com/tensorflow/index.htm>
4. <https://www.javatpoint.com/tensorflow>
5. <https://developers.google.com/machine-learning/crash-course/exercises>

**Note:** Teachers are requested to check the creative commons license status/ financial implications of the suggested OER, before use by the students.

**(c) Others:****Data Source:**

- <https://archive.ics.uci.edu/ml/machine-learning-databases/auto-mpg/>
- <https://archive.ics.uci.edu/ml/machine-learning-databases/iris/iris.data>
- <https://www.kaggle.com/arshid/iris-flower-dataset>
- <https://www.kaggle.com/rohankayan/years-of-experience-and-salary-dataset>

\*\*\*\*\*

- A) **Course Code** : 2400604C(T2400604C/P2400604CS2400604C)
- B) **Course Title** : Internet of Things (Advanced)
- C) **Pre- requisite Course(s)** : IoT (Basics), Computer Networks
- D) **Rationale** :

The rise and rise of IoT technologies is redefining business opportunities and process. This has led to a growing need to learn advance skills to remain competitive in the market. Put together, these are a potent combination of technologies that will dictate how our future is written, which is a strong indicator of rewarding job opportunities in those domains. Introduction of the Advanced IoT follows a rigorous curriculum which blends the academic excellence and industry-relevant applications.

This course will be exposed to a breadth of skills which will help students to become multi-faceted software engineers with a deeper understanding of these modern technologies, their applications, and interdependence.

- E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

**After completion of the course, the students will be able to-**

- CO-1 Use basic Python features in Programming.
- CO-2 Use advance Python features in Programming.
- CO-3 Explain features of Cloud and IoT data storage on it.
- CO-4 Explain IoT Networking and its application.
- CO-5 Develop IoT App for the given problem

- F) **Suggested Course Articulation Matrix (CAM):**

| Course Outcomes (COs) | Programme Outcomes (POs)                        |                          |                                         |                           |                                                                           |                            |                            | Programme Specific Outcomes* (PSOs) |       |
|-----------------------|-------------------------------------------------|--------------------------|-----------------------------------------|---------------------------|---------------------------------------------------------------------------|----------------------------|----------------------------|-------------------------------------|-------|
|                       | PO-1<br>Basic and Discipline Specific Knowledge | PO-2<br>Problem Analysis | PO-3<br>Design/Development of Solutions | PO-4<br>Engineering Tools | PO-5<br>Engineering Practices for Society, Sustainability and Environment | PO-6<br>Project Management | PO-7<br>Life Long Learning | PSO-1                               | PSO-2 |
| CO-1                  | 3                                               | 3                        | 2                                       | 2                         | -                                                                         | 2                          | -                          |                                     |       |
| CO-2                  | 3                                               | 3                        | 2                                       | 2                         | -                                                                         | 2                          | -                          |                                     |       |
| CO-3                  | 1                                               | -                        | 3                                       | 2                         | 2                                                                         | 2                          | 2                          |                                     |       |
| CO-4                  | 1                                               | -                        | 2                                       | 3                         | -                                                                         | 2                          | 2                          |                                     |       |
| CO-5                  | 3                                               | 3                        | 3                                       | 2                         | 2                                                                         | 3                          | 3                          |                                     |       |

**Legend:** High (3), Medium (2), Low (1) and No mapping (-)

\* PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

- G) **Teaching & Learning Scheme:**

| Course Code | Course Title   | Scheme of Study (Hours/Week) |   |                      |                         |                           |                   |
|-------------|----------------|------------------------------|---|----------------------|-------------------------|---------------------------|-------------------|
|             |                | Classroom Instruction (CI)   |   | Lab Instruction (LI) | Notional Hours (TW+ SL) | Total Hours (CI+LI+TW+SL) | Total Credits (C) |
|             |                | L                            | T |                      |                         |                           |                   |
| 2400604C    | IoT (Advanced) | 03                           | - | 04                   | 02                      | 09                        | 06                |

**Legend:**

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances/ problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCS, spoken tutorials, Online educational resources etc.

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

**Note:** TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

**H) Assessment Scheme:**

| Course Code | Course Title  | Assessment Scheme (Marks)           |                             |                                            |          |                                  |                                 | Total Marks (TA+TWA+LA) |
|-------------|---------------|-------------------------------------|-----------------------------|--------------------------------------------|----------|----------------------------------|---------------------------------|-------------------------|
|             |               | Theory Assessment (TA)              |                             | Term Work & Self-Learning Assessment (TWA) |          | Lab Assessment (LA)              |                                 |                         |
|             |               | Progressive Theory Assessment (PTA) | End Theory Assessment (ETA) | Internal                                   | External | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |                         |
| 2400604C    | IoT Advanced) | 30                                  | 70                          | 20                                         | 30       | 20                               | 30                              | 200                     |

**Legend:**

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.)

**Note:**

- ETA & ELA are to be carried out at the end of the term/ semester.
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**J) Theory Session Outcomes (TSOs) and Units:T2400604C**

| Major Theory Session Outcomes (TSOs)                                                                                                                                                                                                 | Units                                                                                                                                                    | Relevant COs Number(s) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| TSO.1. a. Write the steps to install Python.<br>TSO.1. b. Explain given types of variables in python.<br>TSO.1. c. Explain use and importance of Tuple, Dictionary, operators in python<br>TSO.1. d. Explain use of array in python. | <b>Unit-1.0 Python Basics: -</b><br><br>1.1 Installation of Python<br>1.2 Variables, Print () function, Escape character sequence and run python Program | CO-1 and CO-5          |

| Major Theory Session Outcomes (TSOs)                                                                                                                                                                                                                                                                                                                                                                                           | Units                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Relevant COs Number(s) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| TSO.1. e. Explain use of 2-Dimensional Array in python<br>TSO.1. f Explain uses of given type of Conditional statement in python.                                                                                                                                                                                                                                                                                              | 1.3 Python Tuple, Dictionary, operators<br>1.4 Python arrays, create, reverse and append data into it.<br>1.5 Python 2 Dimensional arrays.<br>1.6 Python Conditional statement.                                                                                                                                                                                                                                                                                |                        |
| TSO.2. a. Explain uses of given type of do & while loops in python<br>TSO.2. b. Explain working of break, continue and pass statement in python<br>TSO.2. c. Write the benefits of using OOP methodology in python.<br>TSO.2. d. Explain given type of string operation related to python.<br>TSO.2. e. Explain given function in python<br>TSO.2. f Explain use of Lambda function in python.                                 | <b>Unit 2.0 Python Advance: -</b><br><br>2.1 Python Do & while loops<br>2.2 Python break, continue, pass statements<br>2.3 Python OOPs Class, Object, Inheritance and Constructor<br>2.4 Python Strings Replace, Join, Split, Reverse, Uppercase, Lowercase, count, find, split and length<br>2.5 Python Functions, Built-in functions and user defined functions<br>2.6 Lambda function and uses                                                              | CO-1 and CO5           |
| TSO.3. a. Differentiate between Cloud and IoT cloud.<br>TSO.3. b. Explain features of Cloud in IoT environment<br>TSO.3. c. List features of various types of Cloud<br>TSO.3. d. List features of cloud services like SaaS, PaaS and IaaS<br>TSO.3. f List advantages of cloud data storage.<br>TSO.3. g Explain Arduino architecture and its applications.<br>TSO.3.h Explain Raspberry pi architecture and its applications. | <b>Unit-3.0 Cloud Features: -</b><br><br>3.1 Cloud computing and IoT cloud<br>3.2 Benefits of cloud in IoT<br>3.3 Types of Cloud public, private and hybrid<br>3.4 Cloud services like SaaS, PaaS and IaaS<br>3.5 Cloud connectivity and Data storage on Cloud.<br>3.6 Arduino: Architecture, Programming, and Applications<br>3.7 Raspberry Pi Architecture, Programming, and Application basic level for IoT applications                                    | CO-1, CO-2 and CO-5    |
| TSO.4. a. Explain wired network<br>TSO.4. b. Explain short range wireless network<br>TSO.4. c. Explain M2M communication<br>TSO.4. d. Explain various generation of wireless network<br>TSO.4. e. Explain the importance of LWPAN in IoT<br>TSO.4. f Differentiate between SigFox & LoRaWAN<br>TSO.4. g Explain use of NB-IOT (Narrow Band IOT)<br>TSO.4.h Create heterogenous network using RFID.                             | <b>Unit.4.0 IoT Networking and Application: -</b><br><br>4.1 Wired and short-range wireless network<br>4.2 M2M – 2G, 3G, 4G & 5G networks<br>4.3 LPWAN – Low Power Wide Area Networks<br>4.4 SigFox & LoRaWAN.<br>4.5 NB-IOT (Narrow Band IOT)<br>4.6 RFID and Bar code basics- Components of an RFID system-Data -Tags-Antennas- Connectors- Cables- Readers- encoder/ printers for smart labels- Controllers software<br>4.7 RFID advantages over Bar codes. | CO-1 and CO-4          |
| TSO.5. a. Identify suitable framework for IoT app development<br>TSO.5. b. Identify various stages of selected app<br>TSO.5. c. Develop the app.<br>TSO.5. d. Implement and deploy the app<br>TSO.5. e Maintain and improve the app based on the feedback                                                                                                                                                                      | <b>Unit. 5.0 IoT App Development: -</b><br><br>5.1 Framework selection for IoT app development<br>5.2 Identify stages of app to be developed.<br>5.3 Develop, Implement, and Deploy the App<br>5.4 Testing and Integration<br>5.5 Maintain and improve                                                                                                                                                                                                         | CO-4 and CO-5          |

**Note:** One major TSO may require more than one Theory session/Period.

**K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical:P2400604C**

| Practical/Lab Session Outcomes (LSOs)                                                                                                                                                                                                                                                                    | S. No. | Laboratory Experiment/Practical Titles                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Relevant COs Number(s) |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| LSO 1.1 Python installation<br>LSO 1.2 Prepare and run python program on given problem<br>LSO 1.3 Prepare python program on Dictionary, Tuple and operators.<br>LSO 1.4 Prepare program on arrays<br>LSO 1.5 Prepare a program on 2-dimensional array<br>LSO 1.6 Create program on conditional statement | 1.     | 1.1 Install given version of Python on the computer system.<br>1.2 Prepare a python program using print() function and run it.<br>1.3 Access given value from the tuple<br>1.4 Print the given value of key from the dict.<br>1.5 Write a Python program to create an array of 5 integers and display the array items. Access individual element through indexes<br>1.6 Write a Python program which takes two digits m (row) and n (column) as input and generates a two-dimensional array.<br>1.7 Write a python program to check whether person is eligible for voting or not. (accept age from the user)<br>1.8 Write a python program to check whether the entered number is even or odd.<br>1.9 Write a python program to check whether entered number is divisible by another entered number.<br>1.10 Write a python program to display "Yes" is entered number is divisible by 5 otherwise display "No"                                                                                                                                                                                                       | CO-1                   |
| LSO 2.1 Prepare python program on Do & while loops<br>LSO 2.2 Prepare python program on break and continue statement.<br>LSO 2.3 Prepare Python program using break and continue statements<br>LSO 2.4 prepare python program using OOP<br>LSO 2.5 Prepare Python program using functions                | 2.     | 2.1 Prepare a python program which can print first 10 even and odd numbers using while statement<br>2.2 Write a python program which can print first 10 integers and its square using while/for loop.<br>2.3 Write a python program which can print sum of first 10 natural numbers using while/for loop.<br>2.4 Write a python program which can identify the prime number between the range given using while/for loop.<br>2.5 Consider a situation where you want to iterate over a string and want to print all the characters until a letter 'e' or 's' is encountered. It is specified that you have to do this using loop and only one loop is allowed to use.<br>2.6 Consider the situation when you need to write a program which prints the number from 1 to 10 and but not 6. It is specified that you have to do this using loop and only one loop is allowed to use.<br>2.7 Create a Class with instance attributes<br>2.8 Create a Vehicle class without any variables and methods<br>2.9 Write a Python function to find the Max of three numbers.<br>2.10 Write a Python program to reverse a string. | CO-2                   |
| LSO 3.1 Signup for free cloud storage                                                                                                                                                                                                                                                                    | 3.     | 3.1 Create a free cloud account<br>3.2 Store data on cloud and retrieve it                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | CO-3                   |

| Practical/Lab Session Outcomes (LSOs)                                                                                                                                                                                                                                                               | S. No. | Laboratory Experiment/Practical Titles                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Relevant COs Number(s) |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| LSO 3.2 Store data into cloud and retrieve it.                                                                                                                                                                                                                                                      |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                        |
| LSO 4.1 Design various types of network cables<br>LSO 4.2 Connect computer in LAN.<br>LSO 4.3 Connect devices using wireless network<br>LSO 4.4 Connect machine with machine<br>LSO 4.5 Connect devices using IEEE 802<br>LSO 4.6 Connect devices using LPWAN<br>LSO 4.7 Connect devices using RFID | 4      | 4.1 Study of different types of Network cables and Practically implement the cross-wired cable and straight through cable using clamping tool.<br>4.2 Connect the computers in Local Area Network<br>4.3 Connect 2 or more devices using Bluetooth<br>4.4 Connect 2 or more devices using infrared<br>4.5 Connect 2 more machine using m2m<br>4.6 Connect 2 or more different devices using access point<br>4.7 Connect 2 devices using LPWAN (Smart Meter)<br>4.8 Connect 2 or more devices using RFID | CO-4                   |
| LSO 5.1 Develop a IoT app<br>LSO 5.2 Develop IoT applications using smartphones.                                                                                                                                                                                                                    | 5.     | 5.1 Identify a problem and develop an app<br>5.2 Building a temperature monitoring system using sensors and Smartphone                                                                                                                                                                                                                                                                                                                                                                                  | CO-5                   |

**L) Suggested Term Work and Self Learning: S2400604C** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

**a. Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

**b. Micro Projects:**

1. Prepare a report on Python programming language.
2. Develop a small software in python to solve a IoT data analysis.
3. Create a id on free cloud storage and share data on it for others.
4. Create a heterogenous network and connect different dives.
5. Create a an IoT app for the identified problem

**c. Other Activities:**

1. Seminar Topics: - "Future of wireless network."
2. "Smart electricity billing ", "Cloud computing and IoT"
3. Visit to industry for IoT implementation in industrial process.
4. Reading RFID cards using 8051- RFID in the supply chain- Vehicles parking using RFID- library management system- electronic toll payment- smart shipping containers fleet monitoring and management.
5. Building IoT Applications like pressure, air quality, temperature and motion detector using Arduino and raspberry-pi Universal boards.
6. Surveys of market for availability of various types of network devices and its pricing.
7. Product Development: Development of projects for real life problem solution app.
8. Software Development: Using Python

**d. Self-Learning Topics:**

1. Deeper knowledge in Python features
2. Network devices and its capabilities
3. Advantages of IoT implementations

**M) Suggested Course Evaluation Matrix:** The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

| COs         | Course Evaluation Matrix                                  |                             |                                      |                |                   |                                  |                                 |
|-------------|-----------------------------------------------------------|-----------------------------|--------------------------------------|----------------|-------------------|----------------------------------|---------------------------------|
|             | Theory Assessment (TA)**                                  |                             | Term Work Assessment (TWA)           |                |                   | Lab Assessment (LA)#             |                                 |
|             | Progressive Theory Assessment (PTA)<br>Class/Mid Sem Test | End Theory Assessment (ETA) | Term Work & Self-Learning Assessment |                |                   | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |
|             |                                                           |                             | Assignments                          | Micro Projects | Other Activities* |                                  |                                 |
| CO-1        | 10%                                                       | 10%                         | 20%                                  | --             | 33%               | 10%                              | 20%                             |
| CO-2        | 15%                                                       | 10%                         | 20%                                  | --             | 33%               | 15%                              | 20%                             |
| CO-3        | 30%                                                       | 30%                         | 20%                                  | --             | 34%               | 15%                              | 20%                             |
| CO-4        | 20%                                                       | 30%                         | 20%                                  | 50%            | --                | 30%                              | 20%                             |
| CO-5        | 25%                                                       | 20%                         | 20%                                  | 50%            | --                | 30%                              | 20%                             |
| Total Marks | 30                                                        | 70                          | 20                                   | 20             | 10                | 20                               | 30                              |
|             |                                                           |                             | 50                                   |                |                   |                                  |                                 |

**Legend:**

\*: Other Activities include self-learning, seminar, visits, surveys, product development, software development etc.

\*\*: Mentioned under point- (N)

#: Mentioned under point-(O)

**Note:**

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

**N) Suggested Specification Table for End Semester Theory Assessment:** Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

| Unit Title and Number               | Total Classroom Instruction (CI) Hours | Relevant COs Number (s) | Total Marks | ETA (Marks)  |                   |                         |
|-------------------------------------|----------------------------------------|-------------------------|-------------|--------------|-------------------|-------------------------|
|                                     |                                        |                         |             | Remember (R) | Understanding (U) | Application & above (A) |
| Unit-1.0 Python basics              | 5                                      | CO1                     | 7           | 2            | 2                 | 3                       |
| Unit-2.0 Python Advance             | 5                                      | Co1, CO2                | 7           | 2            | 2                 | 3                       |
| Unit-3.0 Cloud features             | 14                                     | CO3                     | 21          | 8            | 8                 | 5                       |
| Unit-4.0 Networking and Application | 14                                     | CO4, CO3                | 21          | 5            | 7                 | 9                       |
| Unit-5.0 IoT Applications           | 10                                     | CO5, CO3 and CO4        | 14          | 3            | 6                 | 5                       |
| Total Marks                         | 48                                     |                         | 70          | 20           | 25                | 25                      |

**Note:** Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

**O) Suggested Assessment Table for Laboratory (Practical):**

| S. No. | Laboratory Practical Titles                                                                                                                                                                                                          | Relevant COs Number(s) | PLA/ELA     |           |               |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|-------------|-----------|---------------|
|        |                                                                                                                                                                                                                                      |                        | Performance |           | Viva-Voce (%) |
|        |                                                                                                                                                                                                                                      |                        | PRA* (%)    | PDA** (%) |               |
| 1.     | Install given version of Python the computer system.                                                                                                                                                                                 | CO-1                   | 70          | 20        | 10            |
| 2.     | Prepare a python program using print() function and run it.                                                                                                                                                                          | CO-1                   | 60          | 30        | 10            |
| 3.     | Access given value from the tuple                                                                                                                                                                                                    | CO-1                   | 60          | 30        | 10            |
| 4.     | Print the given value of key from the dict.                                                                                                                                                                                          | CO-1                   | 60          | 30        | 10            |
| 5.     | Write a Python program to create an array of 5 integers and display the array items. Access individual element through indexes                                                                                                       | CO-1                   | 60          | 30        | 10            |
| 6.     | Write a Python program which takes two digits m (row) and n (column) as input and generates a two-dimensional array.                                                                                                                 | CO-1                   | 60          | 30        | 10            |
| 7.     | Write a python program to check whether person is eligible for voting or not. (accept age from the user)                                                                                                                             | CO-1                   | 60          | 30        | 10            |
| 8.     | Write a python program to check whether the entered number is even or odd.                                                                                                                                                           | CO-1                   | 60          | 30        | 10            |
| 9.     | Write a python program to check whether entered number is divisible by another entered number.                                                                                                                                       | CO-1                   | 60          | 30        | 10            |
| 10.    | Write a python program to display "Yes" is entered number is divisible by 5 otherwise display "No"                                                                                                                                   | CO-1                   | 60          | 30        | 10            |
| 11.    | Prepare a python program which can print first 10 even and odd numbers using while statement                                                                                                                                         | CO-2                   | 60          | 30        | 10            |
| 12.    | Write a python program which can print first 10 integers and its square using while/for loop.                                                                                                                                        | CO-2                   | 60          | 30        | 10            |
| 13.    | Write a python program which can print sum of first 10 natural numbers using while/for loop.                                                                                                                                         | CO-2                   | 60          | 30        | 10            |
| 14.    | Write a python program which can identify the prime number between the range given using while/for loop.                                                                                                                             | CO-2                   | 60          | 30        | 10            |
| 15.    | Consider a situation where you want to iterate over a string and want to print all the characters until a letter 'e' or 's' is encountered. It is specified that you have to do this using loop and only one loop is allowed to use. | CO-2                   | 60          | 30        | 10            |
| 16.    | Consider the situation when you need to write a program which prints the number from 1 to 10 and but not 6. It is specified that you have to do this using loop and only one loop is allowed to use.                                 | CO-2                   | 60          | 30        | 10            |
| 17.    | Create a Class with instance attributes                                                                                                                                                                                              | CO-2                   | 60          | 30        | 10            |
| 18.    | Create a Vehicle class without any variables and methods                                                                                                                                                                             | CO-2                   | 60          | 30        | 10            |
| 19.    | Write a Python function to find the Max of three numbers.                                                                                                                                                                            | CO-2                   | 60          | 30        | 10            |
| 20.    | Write a Python program to reverse a string.                                                                                                                                                                                          | CO-2                   | 60          | 30        | 10            |
| 21.    | Create a free cloud account                                                                                                                                                                                                          | CO-3                   | 70          | 20        | 10            |

| S. No. | Laboratory Practical Titles                                                                                                                | Relevant COs Number(s) | PLA/ELA     |           |               |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------|------------------------|-------------|-----------|---------------|
|        |                                                                                                                                            |                        | Performance |           | Viva-Voce (%) |
|        |                                                                                                                                            |                        | PRA* (%)    | PDA** (%) |               |
| 22.    | Store data on cloud and retrieve it.                                                                                                       | CO-3                   | 60          | 30        | 10            |
| 23.    | Study of different types of Network cables and Practically implement the cross-wired cable and straight through cable using clamping tool. | CO-4                   | 70          | 20        | 10            |
| 24.    | Connect the computers in Local Area Network                                                                                                | CO-4                   | 70          | 20        | 10            |
| 25.    | Connect 2 or more devices using Bluetooth                                                                                                  | CO-4                   | 70          | 20        | 10            |
| 26.    | Connect 2 or more devices using infrared                                                                                                   | CO-4                   | 70          | 20        | 10            |
| 27.    | Connect 2 more machine using m2m                                                                                                           | CO-4                   | 70          | 20        | 10            |
| 28.    | Connect 2 or more different devices using access point                                                                                     | CO-4                   | 70          | 20        | 10            |
| 29.    | Connect 2 devices suing LPWAN (Smart Meter)                                                                                                | CO-4                   | 70          | 20        | 10            |
| 30.    | Connect 2 or more devices using RFID                                                                                                       | CO-4                   | 70          | 20        | 10            |
| 31.    | Identify a problem and develop an app                                                                                                      | CO-5                   | 70          | 20        | 10            |

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

**Note:** This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

**P) Suggested Instructional/ Implementation Strategies:** Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

**Q) List of Major Laboratory Equipment, Tools and Software:**

| S. No. | Name of Equipment, Tools and Software | Broad Specifications                             | Relevant Experiment/Practical Number |
|--------|---------------------------------------|--------------------------------------------------|--------------------------------------|
| 1      | Python software                       | Openly available as per instruction              | As mentioned above list              |
| 2      | Cables connectors and crimping tools  | Cat 6e cable, RJ-45 connectors and Crimping Tool |                                      |
| 3      | Bluetooth and infrared devices        | Any mobile and wireless keyboard and mouse       |                                      |
| 4      | IoT free cloud                        | Free available                                   |                                      |
| 5      | Smart devices                         | Like meters, bulbs etc.                          |                                      |
| 6      | Wireless access point                 | Wireless router or access point                  | -                                    |

| S. No. | Name of Equipment, Tools and Software | Broad Specifications                           | Relevant Experiment/Practical Number |
|--------|---------------------------------------|------------------------------------------------|--------------------------------------|
| 7      | Arduino development board             | Arduino Uno and Arduino Nano.                  | -                                    |
| 8      | Raspberry Pi                          | Raspberry Pi 4/ Raspberry Pi 3/ Raspberry Pi 2 | -                                    |

## R) Suggested Learning Resources:

### (a) Books:

| S. No. | Titles                                                               | Author(s)          | Publisher and Edition with ISBN                                                                    |
|--------|----------------------------------------------------------------------|--------------------|----------------------------------------------------------------------------------------------------|
| 1      | Let Us Python                                                        | Kanetkar Yashavant | BPB Publications<br>ISBN: 9789388511568, 9789388511568                                             |
| 2      | IOT (Internet of things) and Its Application                         | P K Pandey         | T Balaji Publication (1 January 2020) ISBN-10: 8194136385 ISBN-13: 978-8194136385                  |
| 3      | Raspberry Pi Cookbook: Software and Hardware Problems and Solutions  | Simon Monk         | Shroff/O'Reilly; Third edition (4 October 2019)<br>ISBN-10: 9352139267 ISBN-13: 978-9352139262     |
| 4      | Raspberry Pi Cookbook: Software and Hardware Problems and Solutions, | Simon Monk         | Shroff/O'Reilly; Third edition (4 October 2019)<br>ISBN-10: 9352139267 ISBN-13: 978-9352139262     |
| 5      | Cloud Computing: Concepts, Technology & Architecture                 | Erl                | Pearson Education India; 1st edition (1 January 2014), ISBN-10: 9332535922 ISBN-13: 978-9332535923 |

### (b) Online Educational Resources:

1. [nptel.iitm.ac.in/courses/.../IIT.../lecture%2023%20and%2024.htm](https://nptel.iitm.ac.in/courses/.../IIT.../lecture%2023%20and%2024.htm)
2. [en.wikipedia.org/wiki/Shear\\_and\\_moment\\_diagram](https://en.wikipedia.org/wiki/Shear_and_moment_diagram)
3. [www.freestudy.co.uk/mech%20prin%20h2/stress.pdf](https://www.freestudy.co.uk/mech%20prin%20h2/stress.pdf)
4. [www.engineerstudent.co.uk/stress\\_and\\_strain.html](https://www.engineerstudent.co.uk/stress_and_strain.html)
5. [https://www.iit.edu/arc/workshops/pdfs/Moment\\_Inertia.pdf](https://www.iit.edu/arc/workshops/pdfs/Moment_Inertia.pdf)
6. <https://www.veritis.com/blog/aws-vs-azure-vs-gcp-the-cloud-platform-of-your-choice/>
7. <https://wiki.python.org/moin/TimeComplexity>
8. [www.engineerstudent.co.uk/stress\\_and\\_strain.html](https://www.engineerstudent.co.uk/stress_and_strain.html)
9. [https://www.iit.edu/arc/workshops/pdfs/Moment\\_Inertia.pdf](https://www.iit.edu/arc/workshops/pdfs/Moment_Inertia.pdf)  
Amini, P. (2014). Sulley: Pure Python fully automated and unattended fuzzing frame- work.  
<https://github.com/OpenRCE/sulley>

**Note:** Teachers are requested to check the creative commons license status/ financial implications of the suggested OER, before use by the students.

### (c) Others:

1. Learning Packages
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

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- A) **Course Code** : 2400604D(T2400604D/P2400604D/S2400604D)
- B) **Course Title** : Drone Technology (Advanced)
- C) **Pre- requisite Course(s)** : Drone Technology (Basics)
- D) **Rationale** :

In previous semester, a course in drone technology broadly discussed about basic principles, functions and interface of different components and design simple drone structure. In order to understand the successive development of drones / UAVs in terms of their geometric structure, working methodology and navigation control etc., so it is important to study the advanced course on Drone Technology. This course includes the study of Static and dynamic force analysis on drone, advance flying features, navigation control, maintenance and advance applications of different types of drone.

- E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

**After completion of the course, the students will be able to-**

- CO-1** Apply the concept of engineering mechanics for stability of drone.
- CO-2** Design the structure of drone using GPS module and thermal Image camera.
- CO-3** Operate drone using advance flight controller board.
- CO-4** Perform drone maintenance and assembly.
- CO-5** Use drone in advance applications like precision agriculture, security, IoT, etc.

- F) **Suggested Course Articulation Matrix (CAM):**

| Course Outcomes (COs) | Programme Outcomes (POs)                        |                          |                                          |                           |                                                                           |                            |                            | Programme Specific Outcomes* (PSOs) |       |
|-----------------------|-------------------------------------------------|--------------------------|------------------------------------------|---------------------------|---------------------------------------------------------------------------|----------------------------|----------------------------|-------------------------------------|-------|
|                       | PO-1<br>Basic and Discipline Specific Knowledge | PO-2<br>Problem Analysis | PO-3<br>Design/ Development of Solutions | PO-4<br>Engineering Tools | PO-5<br>Engineering Practices for Society, Sustainability and Environment | PO-6<br>Project Management | PO-7<br>Life Long Learning | PSO-1                               | PSO-2 |
| CO-1                  | 3                                               | -                        | -                                        | -                         | -                                                                         | -                          | -                          |                                     |       |
| CO-2                  | 2                                               | 2                        | -                                        | 3                         | 3                                                                         | -                          | -                          |                                     |       |
| CO-3                  | 2                                               | 2                        | 3                                        | 3                         | -                                                                         | -                          | -                          |                                     |       |
| CO-4                  | 3                                               | -                        | -                                        | 3                         | -                                                                         | -                          | -                          |                                     |       |
| CO-5                  | -                                               | 2                        | 2                                        | -                         | -                                                                         | 3                          | 2                          |                                     |       |

Legend: High (3), Medium (2), Low (1) and No mapping (-)

\* PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

- G) **Teaching & Learning Scheme:**

| Course Code | Course Title                | Scheme of Study (Hours/Week) |   |                      |                         |                           |                   |
|-------------|-----------------------------|------------------------------|---|----------------------|-------------------------|---------------------------|-------------------|
|             |                             | Classroom Instruction (CI)   |   | Lab Instruction (LI) | Notional Hours (TW+ SL) | Total Hours (CI+LI+TW+SL) | Total Credits (C) |
|             |                             | L                            | T |                      |                         |                           |                   |
| 2400604D    | Drone Technology (Advanced) | 03                           | - | 04                   | 02                      | 09                        | 06                |

**Legend:**

- CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)
- LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)
- Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.
- TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)
- SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.
- C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)
- Note:** TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

**H) Assessment Scheme:**

| Course Code | Course Title                | Assessment Scheme (Marks)           |                             |                                            |          |                                  |                                 | Total Marks (TA+TWA+LA) |
|-------------|-----------------------------|-------------------------------------|-----------------------------|--------------------------------------------|----------|----------------------------------|---------------------------------|-------------------------|
|             |                             | Theory Assessment (TA)              |                             | Term Work & Self-Learning Assessment (TWA) |          | Lab Assessment (LA)              |                                 |                         |
|             |                             | Progressive Theory Assessment (PTA) | End Theory Assessment (ETA) | Internal                                   | External | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |                         |
| 2400604D    | Drone Technology (Advanced) | 30                                  | 70                          | 20                                         | 30       | 20                               | 30                              | 200                     |

**Legend:**

- PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)
- PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)
- TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.)

**Note:**

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

**I) Course Curriculum Detailing:** This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

**J) Theory Session Outcomes (TSOs) and Units:T2400604D**

| Major Theory Session Outcomes (TSOs) |                                              | Units                                                                                                                                                                                                                   | Relevant COs Number (s) |
|--------------------------------------|----------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| TSO 1a.                              | Draw free body diagram of quadcopter drone.  | <b>Unit-1.0 Engineering mechanics for Drone Technology</b><br><br>1.1 Drone Mechanics <ul style="list-style-type: none"> <li>Free body diagram of drone</li> <li>Method of finding resultant of force system</li> </ul> | <b>CO-1</b>             |
| TSO 1b.                              | Determine centroid of given drone structure. |                                                                                                                                                                                                                         |                         |

| Major Theory Session Outcomes (TSOs)                                                                                                                                                                                                                                                                                                                                                                                                                                             | Units                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Relevant COs Number (s) |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| TSO 1c. Determine center of gravity of different drone structure.<br>TSO 1d. Analyze different types of force acting drone system.<br>TSO 1e. Differentiate between static and dynamic force analysis.<br>TSO 1f. Explain how gyroscopic motion keeps drone balanced and hovering.                                                                                                                                                                                               | <ul style="list-style-type: none"> <li>Equilibrium of coplanar force system</li> </ul> 1.2 Center of Gravity <ul style="list-style-type: none"> <li>Centroid of plane figure</li> <li>Center of gravity of solid bodies</li> </ul> 1.3 Force analysis in drone <ul style="list-style-type: none"> <li>Force analysis in drone</li> <li>Forces of flight</li> <li>Principle axes and rotation of aerial systems</li> </ul> 1.4 Dynamics of machine <ul style="list-style-type: none"> <li>Static and dynamic force analysis</li> <li>Gyroscopic motions</li> </ul>                                                                                                                  |                         |
| TSO 2a. Describe properties and application of smart materials use in UAV frame.<br>TSO 2b. Calculate the diameter of the propeller for given drone frame size.<br>TSO 2c. Determine size of quadcopter frame and diameter of propeller of drone<br>TSO 2d. Describe working of GPS and its hardware interfacing.<br>TSO 2e. Write steps to interface GPS module for drone navigation.<br>TSO 2f. Describe different RF blocks and antennas used in RF transmitter and receiver. | <b>Unit-2.0 Drone Frame and Components</b><br><br>2.1 Drone frame design <ul style="list-style-type: none"> <li>Calculation principle for drone frame sizes</li> <li>Quadcopter frame design</li> <li>Smart materials for UAV frame</li> </ul> Green material uses in drone<br><br>2.2 Advance Drones component <ul style="list-style-type: none"> <li>GPS, Interfacing of GPS hardware</li> <li>Thermal and chemical sensor</li> <li>Tilt and LiDAR sensor</li> </ul> 2.3 RF transmitter and receiver <ul style="list-style-type: none"> <li>RF blocks</li> <li>RF antennas</li> </ul> 2.4 Micro-electromechanical systems (MEMS) based sensor<br>2.5 HD and thermal Image camera | <b>CO-2</b>             |
| TSO 3a. Identify features and specifications of FCB use in different application<br>TSO 3b. Explain ports of any given advance flight controller board.<br>TSO 3c. Write steps of software installation of flight controller board.<br>TSO 3d. Describe installation and calibration steps of radio telemetry with FCB.<br>TSO 3e. Write steps of calibration of accelerometer and ESC with FCB.<br>TSO 3f. Describe interfacing of GPS with FCB.                                | <b>Unit-3.0 Advance flight controller Board (FCB)</b><br><br>3.1 Specification and ports of FCB<br>3.2 Software for FCB <ul style="list-style-type: none"> <li>Software installation</li> </ul> 3.3 Radio Communication with FCB <ul style="list-style-type: none"> <li>Installation of Radio Telemetry</li> <li>Radio Calibration with FCB</li> </ul> 3.4 Calibration of accelerometer<br>3.5 Calibration of ESC<br>3.6 Interface of motor with FCB using ESC<br>3.7 GPS interface with FCB<br>3.8 Safety features of advance FCB                                                                                                                                                 | <b>CO-3</b>             |
| TSO 4a. Describe challenges comes in drone maintenance.                                                                                                                                                                                                                                                                                                                                                                                                                          | <b>Unit-4.0 Maintenance and Assembling of Drone</b><br><br>4.1 Need and scope of drone maintenance<br>4.2 Types of maintenance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>CO-4</b>             |

| Major Theory Session Outcomes (TSOs)                                                                                                                                                                                                       | Units                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Relevant COs Number (s) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| TSO 4b. Describe measuring devices and instrument use in drone maintenance.<br>TSO 4c. Describe measuring instrument used to measure electrical parameters in drone.<br>TSO 4d. Write sequence of steps use in assembling of drone.        | 4.3 Routine drone maintenance and its checklist <ul style="list-style-type: none"> <li>Recording basic details</li> <li>Structural inspection</li> <li>Battery check</li> <li>Software/firmware</li> </ul> 4.4 Types of measuring instrument use in drone maintenance<br>4.5 Measurement of different electrical parameters related with drone hardware<br>4.6 Assembly of drones <ul style="list-style-type: none"> <li>Concept of interchangeability</li> <li>Principle of gauging and their applicability in drone assembly</li> <li>Parameters and profile measurements of standard propellers</li> <li>Concepts of drone assembly using 3D modeling</li> </ul> |                         |
| TSO 5a. Describe function of autonomous drone using AI.<br>TSO 5b. Describe IoT enable UAV for surveillance and data gathering.<br>TSO 5c. Explain drone applications based on cost saving, enhanced efficiency and profitability aspects. | <b>Unit-5.0 Advance Drone Application</b><br>5.1 Application of AI in Drone Technology<br>5.2 IoT and Computer vision integrated Drone<br>5.3 Drone interface with smart-phone<br>5.4 Drone Applications in <ul style="list-style-type: none"> <li>Military</li> <li>Precision Agriculture</li> </ul>                                                                                                                                                                                                                                                                                                                                                               | <b>CO-5</b>             |

**Note:** One major TSO may require more than one theory session/period.

#### K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400604D

| Practical/Lab Session Outcomes (LSOs)                                                                                                                                                                                                | S. No. | Laboratory Experiment/Practical Titles                                                                                                           | Relevant COs Number(s) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| LSO 1.1 Use the force of gravity to compute the centre of gravity for a given drone structure.                                                                                                                                       | 1.     | Determine Centre of gravity of different drone structure.                                                                                        | CO-1                   |
| LSO 2.1 Develop skills of observation and interpreting phenomenal changes on Drone model for stability and hovering.                                                                                                                 | 2.     | Demonstrate gyroscopic effect on a drone model                                                                                                   | CO-1                   |
| LSO 3.1 Draw various frame to be required in designing drone structure.<br>LSO 3.2 Use Measuring instrument in designing drone frame.<br>LSO 3.3 Choose suitable materials for making drone frame                                    | 3.     | Compare different types of airframe structure like quadcopter frame (plus shape, cross shape and H-shape), hexacopter frame (hexa + and hexa S). | CO-2, CO-4             |
| LSO 4.1 Identify and measure the condition of sensors.<br>LSO 4.2 Interface Tilt and LiDAR sensors in drone.                                                                                                                         | 4.     | Test Tilt and LiDAR sensors and their characteristics with Microcontroller based Flight controller board.                                        | CO-2                   |
| LSO 5.1 Identify different component of GPS module<br>LSO 5.2 Measure and use signals from GPS module to determine latitude & longitude.<br>LSO 5.3 Diagnose problems using appropriate instruments/tools related to GPS navigation. | 5.     | Demonstrate the interfacing of GPS module to drone navigation.                                                                                   | CO-2, CO-3             |

| Practical/Lab Session Outcomes (LSOs)                                                                                                                                                                                                                     | S. No. | Laboratory Experiment/Practical Titles                                              | Relevant COs Number(s) |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------------------------------------------------------------------------------------|------------------------|
| LSO 6.1 Measure characteristics of HD and thermal Image camera.<br>LSO 6.2 Diagnose common problems related to HD and thermal Image camera.                                                                                                               | 6.     | Test HD and thermal Image camera and their characteristics.                         | CO-2                   |
| LSO 7.1 Identify the characteristics of RF circuit blocks like amplifier, and filters.<br>LSO 7.2 Identity different antennas used.<br>LSO 7.3 Operate drone using RC transmitter and receiver.                                                           | 7.     | Identify, configure and operate 433MHz and 2.4 GHz RC transmitter and receiver.     | CO-2                   |
| LSO 8.1 Test the different peripheral interconnections with FCB<br>LSO 8.2 Troubleshoot advance Flight control board (FCB)                                                                                                                                | 8.     | Programming and configure of parameters in flight control board (FCB).              | CO-3                   |
| LSO 9.1 Configure radio communication device to control drones.<br>LSO 9.2 Operate drone using RC transmitter and receiver.                                                                                                                               | 9.     | Test and perform communication of advance Flight control board with RF transceiver. | CO-3, CO-2             |
| LSO 10.1 Measure various parameters of GPS system<br>LSO 10.2 Interface GPS system with flight controller board.                                                                                                                                          | 10.    | Test and perform communication of Flight control board (FCB) with GPS               | CO-3, CO-2             |
| LSO 11.1 Configure HD and thermal image camera with drone.<br>LSO 11.2 Demonstrate use of HD and thermal image camera with FCB                                                                                                                            | 11.    | Test and troubleshoot HD and thermal image camera with advance FCB in drone.        | CO-3, CO-2             |
| LSO 12.1 Measure voltage, current frequency using Digital Multimeter<br>LSO 12.2 Measure peak to peak voltage, time period, and duty cycle using DSO and waveform generator.<br>LSO 12.3 Measure unknown frequency and its level using spectrum analyzer. | 12.    | Measure various electric parameters in drone hardware                               | CO-4                   |
| LSO 13.1 Inspect drone as per the given checklist<br>LSO 13.2 Diagnose drone problems after flying of 50 and 100hrs                                                                                                                                       | 13.    | Perform preventive maintenance of drone components                                  | CO-4                   |
| LSO 14.1 Perform dismantle process of drone.<br>LSO 14.2 perform services need for operation<br>LSO 14.3 Check and Install different parts of the drone system.<br>LSO 14.4 Assemble drone component.                                                     | 14.    | Dismantle and service of different parts of drone system                            | CO-4                   |

**L) Suggested Term Work and Self Learning: S2400604D** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

**a. Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

**b. Micro Projects:**

1. Prepare maintenance report for small UAV.
2. Survey nearby electronics shop and Prepare report on types of drone frames and drone sensors available and its specification.
3. Prepare report of surveying & mapping of our institute using drone with HD and thermal image camera.
4. Prepare report on land and crops quality of nearby agriculture field using drone.

5. Prepare report on Identify and select different application drones like agriculture, Surveillance, Inspections and gathering Information for disaster management.
6. Download 5 videos on advance FCB of drone design. Watch them and write report on it.
7. Market survey on different types of FCB, its specification and specific application and prepare report.
8. Develop mission completion drone with the help of GPS based Advance FCB.

**c. Other Activities:**

1. Seminar Topics-Drone stability using gyroscopic motion, Quadcopter frame, Green material use in drone design, GPS based drones, types of HD and thermal Image camera, Safety features in advance drone, Drone Assembling, Military drone.
2. Visits: Visit nearby small industry, Drone institute facilities. Prepare report of visit with special comments of advance drone technology used, material used, cost of printed component.
3. Surveys: Survey nearby electronics shop and Prepare report of list of advance drone components and its specification.
4. Product Development
5. Software Development

**d. Self-Learning Topics:**

1. Different types Drones frame
2. Overview of GPS technology
3. Different types of HD and thermal Image camera
4. Safety features in Drone
5. Advance drone application

**M) Suggested Course Evaluation Matrix:** The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

| COs         | Course Evaluation Matrix                                  |                             |                                      |                |                   |                                  |                                 |
|-------------|-----------------------------------------------------------|-----------------------------|--------------------------------------|----------------|-------------------|----------------------------------|---------------------------------|
|             | Theory Assessment (TA)**                                  |                             | Term Work Assessment (TWA)           |                |                   | Lab Assessment (LA)#             |                                 |
|             | Progressive Theory Assessment (PTA)<br>Class/Mid Sem Test | End Theory Assessment (ETA) | Term Work & Self-Learning Assessment |                |                   | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |
|             |                                                           |                             | Assignments                          | Micro Projects | Other Activities* |                                  |                                 |
| CO-1        | 15%                                                       | 15%                         | 20%                                  | 20%            | 20%               | 25%                              | 25%                             |
| CO-2        | 20%                                                       | 20%                         | 20%                                  | 20%            | 20%               | 25%                              | 25%                             |
| CO-3        | 25%                                                       | 25%                         | 20%                                  | 20%            | 20%               | 25%                              | 25%                             |
| CO-4        | 25%                                                       | 25%                         | 20%                                  | 20%            | 20%               | 25%                              | 25%                             |
| CO-5        | 15%                                                       | 15%                         | 20%                                  | 20%            | 20%               | -                                | -                               |
| Total Marks | 30                                                        | 70                          | 20                                   | 20             | 10                | 20                               | 30                              |
|             |                                                           |                             | 50                                   |                |                   |                                  |                                 |

**Legend:**

\*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

\*\*: Mentioned under point- (N)

#: Mentioned under point-(O)

**Note:**

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

**N) Suggested Specification Table for End Semester Theory Assessment:** Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

| Unit Title and Number                                      | Total Classroom Instruction (CI) Hours | Relevant COs Number (s) | Total Marks | ETA (Marks)  |                   |                         |
|------------------------------------------------------------|----------------------------------------|-------------------------|-------------|--------------|-------------------|-------------------------|
|                                                            |                                        |                         |             | Remember (R) | Understanding (U) | Application & above (A) |
| <b>Unit 1.0</b> Engineering mechanics for Drone Technology | 8                                      | CO-1                    | 12          | 04           | 04                | 04                      |
| <b>Unit 2.0</b> Drone frame and components                 | 10                                     | CO-2                    | 14          | 04           | 04                | 06                      |
| <b>Unit 3.0</b> Advance Flight Controller Board            | 12                                     | CO-3                    | 16          | 04           | 06                | 06                      |
| <b>Unit 4.0</b> Maintenance and assembling of drone        | 10                                     | CO-4                    | 16          | 04           | 06                | 06                      |
| <b>Unit 5.0</b> Advance Drone Application                  | 8                                      | CO-5                    | 12          | 04           | 04                | 04                      |
| <b>Total Marks</b>                                         | <b>48</b>                              |                         | <b>70</b>   | <b>20</b>    | <b>24</b>         | <b>26</b>               |

**Note:** Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

**O) Suggested Assessment Table for Laboratory (Practical):**

| S. No. | Laboratory Practical Titles                                                                                                                      | Relevant COs Number(s) | PLA /ELA    |           |               |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|-------------|-----------|---------------|
|        |                                                                                                                                                  |                        | Performance |           | Viva-Voce (%) |
|        |                                                                                                                                                  |                        | PRA* (%)    | PDA** (%) |               |
| 1.     | Determine Centre of gravity of different drone structure.                                                                                        | CO-1                   | 50          | 40        | 10            |
| 2.     | Demonstrate gyroscopic effect on a drone model                                                                                                   | CO-1                   | 40          | 50        | 10            |
| 3.     | Compare different types of airframe structure like quadcopter frame (plus shape, cross shape and H-shape), hexacopter frame (hexa + and hexa S). | CO-2                   | 50          | 40        | 10            |
| 4.     | Test Tilt and LiDAR sensors and their characteristics with Microcontroller based Flight controller board.                                        | CO-2                   | 50          | 40        | 10            |
| 5.     | Demonstrate the interfacing of GPS module to drone navigation.                                                                                   | CO-2, CO-3             | 50          | 40        | 10            |
| 6.     | Test HD and thermal Image camera and their characteristics.                                                                                      | CO-2                   | 50          | 40        | 10            |
| 7.     | Identify, configure and operate 433MHz and 2.4 GHz RC transmitter and receiver.                                                                  | CO-2                   | 60          | 30        | 10            |
| 8.     | Programming and configuration of parameters in flight control board (FCB).                                                                       | CO-3                   | 60          | 30        | 10            |
| 9.     | Test and perform communication of advance Flight control board with RF transceiver.                                                              | CO-3, CO-2             | 60          | 30        | 10            |
| 10.    | Test and perform communication of Flight control board (FCB) with GPS                                                                            | CO-3, CO-2             | 60          | 30        | 10            |
| 11.    | Test and troubleshoot HD and thermal image camera with advance FCB in drone.                                                                     | CO-3, CO-2             | 60          | 30        | 10            |
| 12.    | Measure various electric parameters in drone hardware                                                                                            | CO-4                   | 40          | 50        | 10            |

| S. No. | Laboratory Practical Titles                              | Relevant COs Number(s) | PLA /ELA    |           |               |
|--------|----------------------------------------------------------|------------------------|-------------|-----------|---------------|
|        |                                                          |                        | Performance |           | Viva-Voce (%) |
|        |                                                          |                        | PRA* (%)    | PDA** (%) |               |
| 13.    | Perform preventive maintenance of drone components       | CO-4                   | 60          | 30        | 10            |
| 14.    | Dismantle and service of different parts of drone system | CO-4                   | 60          | 30        | 10            |

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

**Note:** This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

**P) Suggested Instructional/Implementation Strategies:** Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

**Q) List of Major Laboratory Equipment, Tools and Software:**

| S. No. | Name of Equipment, Tools and Software     | Broad Specifications                       | Relevant Experiment/Practical Number |
|--------|-------------------------------------------|--------------------------------------------|--------------------------------------|
| 1.     | Drone Frame                               | Tricopter/Quadcopter/Hexacopter            | 1-15                                 |
| 2.     | Propellers                                | 15 X 5.5 CW/Others                         | 1-15                                 |
| 3.     | GPS module                                | M8N Series                                 | 1-15                                 |
| 4.     | Drone Camera                              | 15-20 Megapixel                            | 1-15                                 |
| 5.     | Camera Gimble                             | 3 Axis feature, 360 Degree movement        | 1-15                                 |
| 6.     | Tilt Sensor                               | 8-30 volt                                  | 1-15                                 |
| 7.     | LiDER sensor                              | Range 75m to 200m                          | 1-15                                 |
| 8.     | Battery                                   | Lithium Polymer Battery, 8000 to 10000 mAh | 1-15                                 |
| 9.     | Motor                                     | BLDC, 370kv                                | 1-15                                 |
| 10.    | Electronic speed Controller (ESC)         | 40 Amp                                     | 1-15                                 |
| 11.    | Flight Controller Board                   | CC3D/Pixhawk/Others                        | 1-15                                 |
| 12.    | Transmitter and Receiver for radio signal | 10 Channels and more, 2.4 GHz & 5.8 GHz    | 1-15                                 |
| 13.    | Embedded system for AI application on UAV | Open Source Jetson Baseboard /Others       | 1-15                                 |

**R) Suggested Learning Resources:****(a) Books:**

| S. No. | Titles                                                                                                   | Author (s)                  | Publisher and Edition with ISBN                                          |
|--------|----------------------------------------------------------------------------------------------------------|-----------------------------|--------------------------------------------------------------------------|
| 1.     | Make: DIY Drone and Quadcopter Projects: A Collection of Drone-Based Essays, Tutorials, and Projects     | Editors of Make             | Shroff/Maker Media, First edition 2016, ISBN-978-9352133994              |
| 2.     | Make: Getting Started with Drones: Build and Customize Your Own Quadcopter                               | Terry Kilby & Belinda Kilby | Shroff/Maker Media, First edition 2016, ISBN-978-9352133147              |
| 3.     | Agricultural Drones: A Peaceful Pursuit                                                                  | K R Krishna                 | Apple Academic Press, 1st edition 2018, ISBN-978-1771885959              |
| 4.     | Building Multicopter Video Drones: Build and fly multicopter drones to gather breathtaking video footage | Ty Audronis                 | Packt Publishing Limited; Illustrated edition, 2014, ISBN-978-1782175438 |
| 5.     | The Complete Guide to Drones                                                                             | Adam Juniper                | Ilex Press, Extended 2nd Edition, 2018 ISBN-9781781575383                |
| 6.     | Unmanned Aircraft Systems - UAVS Design, Development and Deployment (Aerospace Series)                   | R Austin                    | John Wiley & Sons Inc, 1st edition, 2010, ISBN-978-0470058190            |

**(b) Online Educational Resources:**

1. <https://archive.nptel.ac.in/courses/101/104/101104083/>
2. [https://onlinecourses.nptel.ac.in/noc21\\_ae14/preview](https://onlinecourses.nptel.ac.in/noc21_ae14/preview)
3. [https://en.wikipedia.org/wiki/Unmanned\\_aerial\\_vehicle](https://en.wikipedia.org/wiki/Unmanned_aerial_vehicle)
4. <https://fusion.engineering/>
5. <https://robocraze.com/blogs/post/best-flight-controller-for-drone>
6. <https://www.youtube.com/watch?v=lrkFG7GiIPQ>
7. <https://www.youtube.com/watch?v=KjG6FKCNCbM>
8. <https://ardupilot.org/>
9. <https://px4.io/>

**Note:** Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational resources before use by the students.

**(c) Others:**

1. Development of an Autonomous IoT-Based Drone for Campus Security, Abdelrahman Mahmoud Gaber, Rozeha A. Rashid, Nazri Nasir, Ruzairi Abdul Rahim, M. Adib Sarijari, A. Shahidan Abdullah, Omar A. Aziz, Siti Zaleha A. Hamid, Samura Ali, 2021
2. IoT based UAV platform for emergency services; S. K. Datta, J. L. Dugelay, & C. Bonnet, 2018
3. Development of an Autonomous Drone for Surveillance Application; M. A. Dinesh, S. Santhosh Kumar, J. Sanath, K. N. Akarsh & K. M. Manoj Gowda, 2018
4. Autonomous cloud-based drone system for disaster response and mitigation; C. Alex & A. Vijaychandra, 2016
5. <https://www.geeetech.com/Documents/CC3D%20flight%20control%20board.pdf>
6. [https://www.bhphotovideo.com/lit\\_files/201146.pdf](https://www.bhphotovideo.com/lit_files/201146.pdf)
7. [http://tricopter.hu/docs/cc3d\\_manual.pdf](http://tricopter.hu/docs/cc3d_manual.pdf)

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- A) **Course Code** : 2400604E(T2400604E/P2400604E/S2400604E)
- B) **Course Title** : 3D Printing and Design (Advanced)
- C) **Pre- requisite Course(s)** : 3D Printing and Design (Basic)
- D) **Rationale** :

This advanced course on 3D Printing tries to develop understanding of the process of making real complex objects from digital models in the students using various 3D printing processes and materials (Plastics, Ceramics and Metals). It also covers the post processing required and details about various printing process and parameters to make a quality 3D printed component. This course can only be taken up after completing 3D Printing and Design (Basic) course offered in previous semester.

- E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

**After completion of the course, the students will be able to-**

- CO-1** Select newer 3D Printing material for various applications.
- CO-2** Use solid based 3D Printing processes to develop products.
- CO-3** Use liquid-based 3D Printing processes to develop products.
- CO-4** Use powder-based 3D Printing processes to develop products.
- CO-5** Apply post processing techniques and quality checks on 3D printed components.

- F) **Suggested Course Articulation Matrix (CAM):**

| Course Outcomes (COs) | Programme Outcomes (POs)                        |                          |                                          |                           |                                                                           |                            |                            | Programme Specific Outcomes* (PSOs) |       |
|-----------------------|-------------------------------------------------|--------------------------|------------------------------------------|---------------------------|---------------------------------------------------------------------------|----------------------------|----------------------------|-------------------------------------|-------|
|                       | PO-1<br>Basic and Discipline Specific Knowledge | PO-2<br>Problem Analysis | PO-3<br>Design/ Development of Solutions | PO-4<br>Engineering Tools | PO-5<br>Engineering Practices for Society, Sustainability and Environment | PO-6<br>Project Management | PO-7<br>Life Long Learning | PSO-1                               | PSO-2 |
| CO-1                  | 3                                               | -                        | -                                        | -                         | 2                                                                         | -                          | 2                          |                                     |       |
| CO-2                  | 3                                               | -                        | 2                                        | 2                         | -                                                                         | -                          | 2                          |                                     |       |
| CO-3                  | 3                                               | -                        | 2                                        | 2                         | -                                                                         | -                          | 2                          |                                     |       |
| CO-4                  | 3                                               | -                        | 2                                        | 2                         | -                                                                         | -                          | 2                          |                                     |       |
| CO-5                  | 3                                               | 2                        | -                                        | 3                         | 2                                                                         | -                          | 2                          |                                     |       |

**Legend:** High (3), Medium (2), Low (1) and No mapping (-)

\* PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

- G) **Teaching & Learning Scheme:**

| Course Code | Course Title                      | Scheme of Study (Hours/Week) |   |                      |                         |                           |                   |
|-------------|-----------------------------------|------------------------------|---|----------------------|-------------------------|---------------------------|-------------------|
|             |                                   | Classroom Instruction (CI)   |   | Lab Instruction (LI) | Notional Hours (TW+ SL) | Total Hours (CI+LI+TW+SL) | Total Credits (C) |
|             |                                   | L                            | T |                      |                         |                           |                   |
| 2400604E    | 3D Printing and Design (Advanced) | 03                           | - | 04                   | 02                      | 09                        | 06                |

**Legend:**

- CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)
- LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)
- Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.
- TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)
- SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.
- C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)
- Note:** TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

**H) Assessment Scheme:**

| Course Code | Course Title                      | Assessment Scheme (Marks)           |                             |                                            |          |                                  |                                 | Total Marks (TA+TWA+LA) |
|-------------|-----------------------------------|-------------------------------------|-----------------------------|--------------------------------------------|----------|----------------------------------|---------------------------------|-------------------------|
|             |                                   | Theory Assessment (TA)              |                             | Term Work & Self-Learning Assessment (TWA) |          | Lab Assessment (LA)              |                                 |                         |
|             |                                   | Progressive Theory Assessment (PTA) | End Theory Assessment (ETA) | Internal                                   | External | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |                         |
| 2400604E    | 3D Printing and Design (Advanced) | 30                                  | 70                          | 20                                         | 30       | 20                               | 30                              | 200                     |

**Legend:**

- PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)
- PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)
- TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.)

**Note:**

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

- I) Course Curriculum Detailing:** This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self-Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

**J) Theory Session Outcomes (TSOs) and Units:T2400604E**

| Major Theory Session Outcomes (TSOs)                                                    | Units                                                                       | Relevant COs Number(s) |
|-----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|------------------------|
| TSO 1a. Explain various forms of 3D printing raw material.                              | <b>Unit-1.0 3D Printing Materials</b>                                       | <b>CO1</b>             |
| TSO 1b. Select material for the given popular 3D printing processes with justification. | 1.1 Various forms of 3D printing raw material- Liquid, Solid, Wire, Powder. |                        |

| Major Theory Session Outcomes (TSOs)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Units                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Relevant COs Number(s)  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| <p><i>TSO 1c.</i> Select various Polymer based 3D printing raw materials with justification.</p> <p><i>TSO 1d.</i> Explain procedure of Powder preparation for the given 3D printing material.</p> <p><i>TSO 1e.</i> Explain properties of the given Metal/Ceramics 3D printing material.</p> <p><i>TSO 1f.</i> Choose suitable 3D printing material on the basis of Performance Requirements and Material Properties.</p>                                                                                                                                      | <p>1.2 Popular FDM, SLA, SLS, Binder Jetting, Material Jetting and Direct Energy deposition 3D printing materials.</p> <p>1.3 Polymers, Metals, Non-Metals, Ceramics.</p> <p>1.4 Polymers and their properties.</p> <p>1.5 Powder Preparation and their desired properties.</p> <p>1.6 Choosing the Right 3D Printing Material on the basis of Performance Requirements and Material Properties.</p>                                                                               |                         |
| <p><i>TSO 2a.</i> Explain working of a typical FDM based 3D Printer.</p> <p><i>TSO 2b.</i> Justify use of FDM based 3D printing process and material for the given component.</p> <p><i>TSO 2c.</i> Explain the Laminated Object Manufacturing process.</p> <p><i>TSO 2d.</i> Estimate the cost and time of the given FDM based 3D printed component.</p>                                                                                                                                                                                                       | <p><b>Unit-2.0 Solid based 3D Printing Processes</b></p> <p>2.1 Basic principle and working of fused deposition modeling (FDM) process.</p> <p>2.2 Liquefaction, solidification and bonding.</p> <p>2.3 Laminated Object Manufacturing process.</p> <p>2.4 Cost estimation of FDM 3D printed component.</p>                                                                                                                                                                        | CO1, CO2                |
| <p><i>TSO 3a.</i> Explain the phenomenon of Photo Polymerization.</p> <p><i>TSO 3b.</i> Explain the working of a typical Stereo Lithography based 3D Printer.</p> <p><i>TSO 3c.</i> Explain procedure of 3D Scanning of the given component.</p> <p><i>TSO 3d.</i> Justify use of SLA based 3D printing process and material for the given component.</p> <p><i>TSO 3e.</i> Estimate the cost and time of the given SLA based 3D printed component.</p> <p><i>TSO 3f.</i> Apply Curing process to SLA based 3D printed component.</p>                           | <p><b>Unit-3.0 Liquid based 3D Printing Processes</b></p> <p>3.1 Photo polymerization.</p> <p>3.2 Principle and working of stereo lithography apparatus.</p> <p>3.3 SLA based 3D printing processes.</p> <p>3.4 SLA based 3D printing process materials.</p> <p>3.5 Scanning techniques.</p> <p>3.6 Curing processes.</p> <p>3.7 Cost estimation of SLA 3D printed component.</p>                                                                                                  | CO1, CO3                |
| <p><i>TSO 4a.</i> Explain powder fusion mechanism.</p> <p><i>TSO 4b.</i> Explain working of a typical SLA based 3D Printer.</p> <p><i>TSO 4c.</i> Justify use of SLA based 3D printing process and material for the given component.</p> <p><i>TSO 4d.</i> Explain Net shape process.</p> <p><i>TSO 4e.</i> Explain Binder Jet 3D printing process.</p> <p><i>TSO 4f.</i> Justify use of Binder Jet 3D printing process and material for the given component.</p> <p><i>TSO 4g.</i> Estimate the cost and time of the given SLS based 3D printed component.</p> | <p><b>Unit-4.0 Powder based 3D Printing Processes</b></p> <p>4.1 Powder fusion mechanism.</p> <p>4.2 Principle and working of Selective Laser Sintering (SLS) process.</p> <p>4.3 SLS based 3D printers.</p> <p>4.4 Laser Engineering Net Shaping process.</p> <p>4.5 Electron Beam Melting.</p> <p>4.6 Binder Jet 3D Printing.</p> <p>4.7 Materials and Process parameters for SLS based 3D printing processes.</p> <p>4.8 Cost estimation of SLS based 3D printed component.</p> | CO1, CO4                |
| <p><i>TSO 5a.</i> Justify the need of post processing in the given 3D printed component.</p> <p><i>TSO 5b.</i> List the various post processing techniques.</p> <p><i>TSO 5c.</i> List the steps to perform post processing.</p>                                                                                                                                                                                                                                                                                                                                | <p><b>Unit-5.0 Post Processing and Quality</b></p> <p>5.1 Need of post processing: Functional and Aesthetic reasons.</p> <p>5.2 Steps of Post Processing: Cleaning/Support removal, Fixing, Curing or hardening, Surface finishing, Colouring.</p>                                                                                                                                                                                                                                 | CO1, CO2, CO3, CO4, CO5 |

| Major Theory Session Outcomes (TSOs)                                                                                                                                                                                                                                                                                                                                                                                             | Units                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Relevant COs Number(s) |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| <p><i>TSO 5d.</i> Explain the given Cleaning related post processing approach for 3D printed component.</p> <p><i>TSO 5e.</i> Explain the given Surface finishing related post processing approach for 3D printed component.</p> <p><i>TSO 5f.</i> Apply simple inspection and testing techniques on the given 3D printed component.</p> <p><i>TSO 5g.</i> Identify the type of defect(s) in the given 3D printed component.</p> | <p>5.3 Cleaning: Support Removal (FDM and Material Jetting); Powder Removal (SLS and Powder Bed Fusion); Washing (SLA and Photo polymerization).</p> <p>5.4 Fixing: Filling, Gluing, Welding.</p> <p>5.5 Surface finishing: Sanding, Polishing, Tumbling, Hydro dipping, Epoxy coating, Electro Plating, Vapor Smoothing-Acetone treatment.</p> <p>5.6 Colorings, Coating, Priming and Painting.</p> <p>5.7 Inspection and testing: Digital, Visual, Physical.</p> <p>5.8 Defects and their causes.</p> |                        |

**Note:** One major TSO may require more than one Theory session/Period.

**K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical:P2400604E**

| Practical/Lab Session Outcomes (LSOs)                                                                                                                                                                                                                                                                                                                                                            | S. No. | Laboratory Experiment/Practical Titles                                                                                                                                          | Relevant COs Number(s) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| <p><i>LSO 1.1.</i> Use the available 3D printing software.</p> <p><i>LSO 1.2.</i> Select printing process parameters based on the type/make of Printer and raw material</p> <p><i>LSO 1.3.</i> Set printing process parameters.</p> <p><i>LSO 1.4.</i> Produce a complex component using available FDM Printer.</p>                                                                              | 1.     | Develop the assigned digital single complex component using FDM based 3D Printer and available material.                                                                        | CO1, CO2               |
| <p><i>LSO 2.1.</i> Use the available 3D printing software.</p> <p><i>LSO 2.2.</i> Select printing process parameters based on the type/make of Printer and raw material</p> <p><i>LSO 2.3.</i> Set printing process parameters.</p> <p><i>LSO 2.4.</i> Produce a complex component using available SLA Printer.</p> <p><i>LSO 2.5.</i> Perform curing of the SLA based 3D printed component.</p> | 2.     | Develop the assigned digital single complex component using SLA based 3D Printer and available material.                                                                        | CO1, CO3               |
| <p><i>LSO 3.1.</i> Use the available 3D printing software.</p> <p><i>LSO 3.2.</i> Select printing process parameters based on the type/make of Printer and raw material</p> <p><i>LSO 3.3.</i> Set printing process parameters.</p> <p><i>LSO 3.4.</i> Produce a complex component using available SLS Printer.</p>                                                                              | 3.     | Develop the assigned digital single complex component using SLS based 3D Printer and available material.                                                                        | CO1, CO4               |
| <p><i>LSO 4.1.</i> Use the available 3D printing software.</p> <p><i>LSO 4.2.</i> Select printing process parameters based on the type/make of Printer and raw material</p> <p><i>LSO 4.3.</i> Set printing process parameters.</p> <p><i>LSO 4.4.</i> Produce a complex component using available FDM, SLA and SLS Printer.</p>                                                                 | 4.     | Develop same digital single complex component using FDM, SLA and SLS based 3D Printers and compare the printed components on the basis of Cost, Time, Surface finish, Strength. | CO1, CO2, CO3, CO4     |

| Practical/Lab Session Outcomes (LSOs)                                                                                                                                                                                                                                                                                          | S. No. | Laboratory Experiment/Practical Titles                                                                                       | Relevant COs Number(s) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------------------------------------------------------------------------------------------------------------------------------|------------------------|
| <i>LSO 4.5.</i> Perform Cost, Time, Surface finish and Strength estimations related to 3D printed components.                                                                                                                                                                                                                  |        |                                                                                                                              |                        |
| <i>LSO 5.1.</i> Use the available 3D printing software.<br><i>LSO 5.2.</i> Select printing process parameters based on the type/make of Printer and raw material<br><i>LSO 5.3.</i> Select appropriate tolerance, fit and printing process parameters.<br><i>LSO 5.4.</i> Produce an assembly using available SLA/SLS Printer. | 5.     | Print one digital assembly on SLA/SLS based 3D Printer.                                                                      | CO2/CO3/CO4            |
| <i>LSO 6.1.</i> Use of available 3D scanner.<br><i>LSO 6.2.</i> Develop 3D digital model using scanning approach.<br><i>LSO 6.3.</i> Use the available 3D printing software.<br><i>LSO 6.4.</i> Produce a complex component using available SLA Printer.                                                                       | 6.     | Scan the given real complex component and print it using FDM/SLA/SLS based 3D Printer.                                       | CO2, CO3, CO4          |
| <i>LSO 7.1.</i> Identify tools/devices/chemicals for post processing<br><i>LSO 7.2.</i> Perform post processing operations on printed component.                                                                                                                                                                               | 7.     | Apply post processing techniques on the 3D printed component of experiment number 1 and/or 2 and/or 3.                       | CO5                    |
| <i>LSO 8.1.</i> Identify tools/devices/techniques for inspection and testing.<br><i>LSO 8.2.</i> Identify the defects in 3D printed components<br><i>LSO 8.3.</i> Apply remedial measures to bring soundness in the defective 3D printed component.                                                                            | 8.     | Check the soundness of the 3D printed component of experiment number 1 and/or 2 and/or 3 using available devices/techniques. | CO5                    |

**L) Suggested Term Work and Self Learning: S2400604E** Some sample suggested assignments, micro project and other activities are mentioned here for reference

**a. Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

**b. Micro Projects:**

1. Prepare a list of solid, liquid and powder form 3D printing raw materials stating their cost, colour opacity, flexibility and weight per unit volume.
2. Download 5 videos of 3D printing of different components using FDM, SLA and SLS each. Watch them and write a report to detail out the steps involved, 3D Printer used, 3D Printing software used, material used, complexity involved, printing time, post processing steps used.
3. Prepare a report on post processing steps and techniques used for 3D printed components using FDM, SLA, SLS.
4. Prepare a report to compare FDM, SLA, SLS based 3D printing process on the basis of cost, surface finish, printer setting time, printing time and post processing time and cost involved.

5. Download 5 videos of 3D printing processes **other than** FDM, SLA and SLS. Watch them and write a report to detail out the steps involved, 3D Printer used, 3D Printing software used, material used, complexity involved, printing time, post processing steps used.
6. Download 1 video related to inspection and testing of 3D printed components using different techniques like Visual inspection, Scanning Electron Microscopy (SEM), CT system, X-ray, Penetration testing, Infrared thermography, Leak or pressure testing for complex structures, Eddy current, Mechanical property inspection to measure tensile, yield, shear, fatigue, hardness, density, impact strength, Metallography (Microstructure testing). Watch them and write a report to detail out the steps involved and equipment used.

**c. Other Activities:**

1. Seminar Topics:

- Newer 3D printing raw materials
- Direct energy 3D printing process
- Material jetting 3D printing process
- Micro 3D printing process
- Metal and Ceramic 3D printing
- 3D printing of Jewelry
- 3D printing of Bio implants
- Printing of flexible plastic components

2. Visits: Visit nearby tool room/industry with 3D Printing facilities. Prepare report of visit with special comments of 3D printing technique used, material used, single component/batch production/mass production and cost of printed component.

3. Self-Learning Topics:

- 3D printing of transparent, soft and flexible plastic components
- 3D printing of metal components
- 3D printing of ceramic components
- 3D scanning process.
- Chemical post processing techniques

**M) Suggested Course Evaluation Matrix:** The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

| COs         | Course Evaluation Matrix                                  |                             |                                      |                |                   |                                  |                                 |
|-------------|-----------------------------------------------------------|-----------------------------|--------------------------------------|----------------|-------------------|----------------------------------|---------------------------------|
|             | Theory Assessment (TA)**                                  |                             | Term Work Assessment (TWA)           |                |                   | Lab Assessment (LA)#             |                                 |
|             | Progressive Theory Assessment (PTA)<br>Class/Mid Sem Test | End Theory Assessment (ETA) | Term Work & Self Learning Assessment |                |                   | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |
|             |                                                           |                             | Assignments                          | Micro Projects | Other Activities* |                                  |                                 |
| CO-1        | 15%                                                       | 15%                         | 15%                                  | -              | -                 | 10%                              | 20%                             |
| CO-2        | 20%                                                       | 20%                         | 20%                                  | 25%            | 25%               | 25%                              | 20%                             |
| CO-3        | 20%                                                       | 20%                         | 20%                                  | 25%            | 25%               | 25%                              | 20%                             |
| CO-4        | 20%                                                       | 20%                         | 20%                                  | 25%            | 25%               | 25%                              | 20%                             |
| CO-5        | 25%                                                       | 25%                         | 25%                                  | 25%            | 25%               | 15%                              | 20%                             |
| Total Marks | 30                                                        | 70                          | 20                                   | 20             | 10                | 20                               | 30                              |
|             |                                                           |                             | 50                                   |                |                   |                                  |                                 |

**Legend:**

\*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

\*\*: Mentioned under point- (N)

#: Mentioned under point-(O)

**Note:**

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

**N) Suggested Specification Table for End Semester Theory Assessment:** Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

| Unit Title and Number                              | Total Classroom Instruction (CI) Hours | Relevant COs Number(s)  | Total Marks | ETA (Marks)  |                   |                         |
|----------------------------------------------------|----------------------------------------|-------------------------|-------------|--------------|-------------------|-------------------------|
|                                                    |                                        |                         |             | Remember (R) | Understanding (U) | Application & above (A) |
| <b>Unit-1.0</b> 3D Printing Materials              | 6                                      | CO1                     | 10          | 3            | 2                 | 5                       |
| <b>Unit-2.0</b> Solid based 3D Printing Processes  | 10                                     | CO1, CO2                | 14          | 4            | 5                 | 5                       |
| <b>Unit-3.0</b> Liquid based 3D Printing Processes | 10                                     | CO1, CO3                | 14          | 4            | 5                 | 5                       |
| <b>Unit-4.0</b> Powder based 3D Printing Processes | 10                                     | CO1, CO4                | 14          | 4            | 5                 | 5                       |
| <b>Unit-5.0</b> Post Processing and Quality        | 12                                     | CO1, CO2, CO3, CO4, CO5 | 18          | 5            | 5                 | 8                       |
| <b>Total</b>                                       | <b>48</b>                              | <b>-</b>                | <b>70</b>   | <b>20</b>    | <b>22</b>         | <b>28</b>               |

**Note:** Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

**O) Suggested Assessment Table for Laboratory (Practical):**

| S. No. | Laboratory Practical Titles                                                                                                                                                     | Relevant COs Number(s) | PLA/ELA     |           |               |
|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|-------------|-----------|---------------|
|        |                                                                                                                                                                                 |                        | Performance |           | Viva-Voce (%) |
|        |                                                                                                                                                                                 |                        | PRA* (%)    | PDA** (%) |               |
| 1.     | Develop the assigned digital single complex component using FDM based 3D Printer and available material.                                                                        | CO1, CO2               | 30          | 60        | 10            |
| 2.     | Develop the assigned digital single complex component using SLA based 3D Printer and available material.                                                                        | CO1, CO3               | 30          | 60        | 10            |
| 3.     | Develop the assigned digital single complex component using SLS based 3D Printer and available material.                                                                        | CO1, CO4               | 30          | 60        | 10            |
| 4.     | Develop same digital single complex component using FDM, SLA and SLS based 3D Printers and compare the printed components on the basis of Cost, Time, Surface finish, Strength. | CO1, CO2, CO3, CO4     | 30          | 60        | 10            |
| 5.     | Print one assembly on SLA/SLS based 3D Printer.                                                                                                                                 | CO2/CO3/ CO4           | 30          | 60        | 10            |
| 6.     | Scan the given real complex component and print it using FDM/SLA/SLS based 3D Printer.                                                                                          | CO2, CO3, CO4          | 40          | 50        | 10            |
| 7.     | Apply post processing techniques on the 3D printed component of experiment number 1 and/or 2 and/or 3.                                                                          | CO5                    | 40          | 50        | 10            |
| 8.     | Check the soundness of the 3D printed component of experiment number 1 and/or 2 and/or 3 using available devices/techniques.                                                    | CO5                    | 40          | 50        | 10            |

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

**Note:** This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

**P) Suggested Instructional/Implementation Strategies:** Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Field Trips, Portfolio Based, Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field Information and Communications Technology (ICT)Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Session, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

**Q) List of Major Laboratory Equipment, Tools and Software:**

| S. No. | Name of Equipment, Tools and Software     | Broad Specifications                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Relevant Experiment/Practical Number |
|--------|-------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|
| 1.     | High end computers                        | Processor Intel Core i7 with Open GL Graphics Card, RAM 32 GB, DDR3/DDR4, HDD 500 GB, Graphics Card NVIDIA OpenGL 4 GB, OS Windows 10                                                                                                                                                                                                                                                                                                                                        | All                                  |
| 2.     | Parametric Computer Aided Design software | CATIA/Solid works/NX/Creo <b>OR</b> Available with CoE                                                                                                                                                                                                                                                                                                                                                                                                                       | 1 to 5                               |
| 3.     | FDM based 3D printer                      | Fused Deposition Modelling system with complete accessories; Build Volume-300 x 300 x 300mm or Higher; Layer Thickness-0.1 – 0.4 <b>OR</b> Available with CoE                                                                                                                                                                                                                                                                                                                | 1,4,5,6                              |
| 4.     | SLA based 3D printer                      | Printing Technology: SLA, 145 x 145 x 175mm build volume, Common layer thickness 25–100 µm, Dimensional Accuracy ± 0.5% (lower limit: ±0.10 mm), cure time of only 1-3s per layer, Material type: UV-sensitive liquid resin, Curing unit.                                                                                                                                                                                                                                    | 2,4,5,6                              |
| 5.     | SLS based 3D printer                      | Printing Technology: SLS., Build Volume: 130 x 130 x 180 mm, Recommended min. wall thickness: 0.8 mm, Powder Diameter: 60 Microns, Material Type: Nylon, TPU, Light Source: Laser Diode                                                                                                                                                                                                                                                                                      | 3,4,5,6                              |
| 6.     | 3D Printing Material                      | ABS/PLA, Resin based Photosensitive material, Polymer/metal/ceramic powder <b>OR</b> Available with CoE                                                                                                                                                                                                                                                                                                                                                                      | 1,2,3,4,5,6                          |
| 7.     | 3D Printing software                      | Latest version of software like: Cura/PrusaSlicer/ideaMaker/Meshmixer/MeshLab <b>OR</b> Available with CoE                                                                                                                                                                                                                                                                                                                                                                   | 1 to 6                               |
| 8.     | 3D Scanner and Processing software        | Handheld 3D scanner, Accuracy up to 0.1 mm, Resolution up to 0.2 mm, Real time onscreen 3D model projection and processing, Wireless technology with an inbuilt touch screen and battery, Extended field of view for capturing both large and small objects, Processing Software <b>OR</b> Available with CoE                                                                                                                                                                | 6                                    |
| 9.     | Post processing equipments and tools      | Deburring tools (tool handle & deburring blades), Electronic Digital Caliper, Cleaning Needles, Art knife set, Long nose pliers, Flush cutters, Wire brush, Nozzle cleaning kit, Tube cutter, Print removal spatula, Needle file, Cutting mat, Glue stick, Wire stripper, Chemicals, Etching agents etc.                                                                                                                                                                     | 7                                    |
| 10.    | Inspection and Testing devices            | <ul style="list-style-type: none"> <li>Visual inspection, Devices related to:</li> <li>Scanning electron microscopy (SEM), CT system, X-ray,</li> <li>Penetration testing,</li> <li>Infrared thermography,</li> <li>Leak or pressure testing for complex structures,</li> <li>Eddy current,</li> <li>Mechanical property inspection to measure tensile, yield, shear, fatigue, hardness, density, impact strength</li> <li>Metallography (Microstructure testing)</li> </ul> | 8                                    |

**R) Suggested Learning Resources:****(a) Books:**

| S. No. | Titles                                                                                                                             | Author(s)                                 | Publisher and Edition with ISBN                               |
|--------|------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|---------------------------------------------------------------|
| 1.     | Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing                                             | Lan Gibson, David W. Rosen, Brent Stucker | Springer, 2010<br>ISBN: 9781493921133                         |
| 2.     | Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing                                        | Andreas Gebhardt,                         | Hanser Publisher, 2011<br>ISBN: 156990507X, 9781569905074     |
| 3.     | 3D Printing and Design                                                                                                             | Sabrie Soloman                            | Khanna Publishing House, Delhi<br>ISBN: 9789386173768         |
| 4.     | 3D Printing and Rapid Prototyping- Principles and Applications                                                                     | C.K. Chua, Kah Fai Leong                  | World Scientific, 2017<br>ISBN: 9789813146754                 |
| 5.     | Getting Started with 3D Printing: A Hands-on Guide to the Hardware, Software, and Services Behind the New Manufacturing Revolution | Liza Wallach Kloski, Nick Kloski          | Make Community, LLC; 2nd edition, 2021<br>ISBN: 9781680450200 |
| 6.     | Laser-Induced Materials and Processes for Rapid Prototyping                                                                        | L. Lu, J. Fuh, Y.S. Wong                  | Kulwer Academic Press, 2001<br>ISBN: 9781461514695            |

**(b) Online Educational Resources:**

1. [https://onlinecourses.nptel.ac.in/noc21\\_me115/preview](https://onlinecourses.nptel.ac.in/noc21_me115/preview)
2. <https://archive.nptel.ac.in/courses/112/104/112104265/>
3. <https://bigrep.com/post-processing/>
4. <https://www.mdpi.com/2227-7080/9/3/61>
5. <https://all3dp.com/2/best-3d-printing-books/>
6. <https://www.youtube.com/watch?v=TQY2IF-sFaI>
7. <https://www.youtube.com/watch?v=Oz0PoS5LPxg>
8. <https://www.youtube.com/watch?v=6ejjh0GdyDc>

**Note:** Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational resources before use by the students.

**(c) Others:**

1. 3D Printing Projects DK Children; Illustrated edition, 2017
2. The 3D Printing Handbook: Technologies, design and applications Ben Redwood, Filemon Schöffner, Brian Garret, 3D Hubs; 1st edition, 2017
3. <https://www.improrecision.com/inspection-method-for-3d-printed-parts/>
4. 3D Printer Users' Guide
5. 3D Printer Material Handbook
6. Lab Manuals

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- A) **Course Code** : 2400604F(T2400604F/P2400604F/S2400604F)  
 B) **Course Title** : Industrial Automation (Advanced)  
 C) **Pre- requisite Course(s)** : Industrial automation (Basic), Digital Electronics and Basic programming skills

D) **Rationale** :

This course on Advanced industrial automation offers students a hands-on approach to implement industrial control using modern controllers like Programmable Logic Controller (PLC), Distributed Control System (DCS) Supervisory Control and Data Acquisition (SCADA). Students will learn to identify and connect field inputs and outputs; communicate with, and program microprocessor-based controllers. Students will also connect, communicate with, and develop displays for computer-based operator interfaces. Process manufacturers typically employ Distributed Control System (DCS) Supervisory Control and Data Acquisition (SCADA) technologies to monitor and control the operations in their facilities. DCS and SCADA systems are now doing much more than simply monitoring and controlling. The course will enable the students to use of basic instructions and addressing, advanced PLC instructions in Ladder Logic and to identify and troubleshoot the faults in PLC system and do PLC maintenance. This course also introduces the students to industrial automation communications, PLC maintenance and troubleshooting also to become a successful automation engineer.

- E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

**After completion of the course, the students will be able to-**

- CO-1.** Apply the principles of communication for industrial automation.  
**CO-2.** Test the output of the PLC ladder logic programs for the given application  
**CO-3.** Maintain PLC systems  
**CO-4.** Use SCADA for supervisory control and for acquiring data from the field.  
**CO-5.** Develop simple automation systems

F) **Suggested Course Articulation Matrix (CAM):**

| Course Outcomes (COs) | Programme Outcomes (POs)                        |                          |                                          |                           |                                                                           |                            |                            | Programme Specific Outcomes* (PSOs) |       |
|-----------------------|-------------------------------------------------|--------------------------|------------------------------------------|---------------------------|---------------------------------------------------------------------------|----------------------------|----------------------------|-------------------------------------|-------|
|                       | PO-1<br>Basic and Discipline Specific Knowledge | PO-2<br>Problem Analysis | PO-3<br>Design/ Development of Solutions | PO-4<br>Engineering Tools | PO-5<br>Engineering Practices for Society, Sustainability and Environment | PO-6<br>Project Management | PO-7<br>Life Long Learning | PSO-1                               | PSO-2 |
| CO-1                  | 3                                               | 2                        | 2                                        | 2                         | 2                                                                         | -                          | 2                          |                                     |       |
| CO-2                  | 3                                               | 3                        | 3                                        | 3                         | -                                                                         | -                          | 2                          |                                     |       |
| CO-3                  | 3                                               | 3                        | 3                                        | 3                         | 2                                                                         | 2                          | 2                          |                                     |       |
| CO-4                  | 3                                               | 2                        | 2                                        | 2                         | 2                                                                         | 2                          | 2                          |                                     |       |
| CO-5                  | 3                                               | 2                        | 2                                        | 3                         | 2                                                                         | 2                          | 2                          |                                     |       |

**Legend:** High (3), Medium (2), Low (1) and No mapping (-)

\* PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

**G) Teaching & Learning Scheme:**

| Course Code     | Course Title                     | Scheme of Study (Hours/Week) |   |                      |                         |                           |                   |
|-----------------|----------------------------------|------------------------------|---|----------------------|-------------------------|---------------------------|-------------------|
|                 |                                  | Classroom Instruction (CI)   |   | Lab Instruction (LI) | Notional Hours (TW+ SL) | Total Hours (CI+LI+TW+SL) | Total Credits (C) |
|                 |                                  | L                            | T |                      |                         |                           |                   |
| <b>2400604F</b> | Industrial Automation (Advanced) | 03                           | - | 04                   | 02                      | 09                        | 06                |

**Legend:**

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances/ problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, Online educational resources etc.

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

**Note:** TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

**H) Assessment Scheme:**

| Course Code | Course Title                     | Assessment Scheme (Marks)           |                             |                                            |          |                                  |                                 | Total Marks (TA+TWA+LA) |
|-------------|----------------------------------|-------------------------------------|-----------------------------|--------------------------------------------|----------|----------------------------------|---------------------------------|-------------------------|
|             |                                  | Theory Assessment (TA)              |                             | Term Work & Self-Learning Assessment (TWA) |          | Lab Assessment (LA)              |                                 |                         |
|             |                                  | Progressive Theory Assessment (PTA) | End Theory Assessment (ETA) | Internal                                   | External | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |                         |
| 2400604F    | Industrial Automation (Advanced) | 30                                  | 70                          | 20                                         | 30       | 20                               | 30                              | 200                     |

**Legend:**

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self -learning, any other student activities etc.

**Note:**

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self - learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

**I) Course Curriculum Detailing:** This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

**J) Theory Session Outcomes (TSOs) and Units: T2400604F**

| Major Theory Session Outcomes (TSOs)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Units                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Relevant COs Number(s) |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| TSO.1a Describe how does a PLC communicate?<br>TSO.1b Differentiate between parallel and series communication<br>TSO.1c Describe the data transfer mechanism for the given communication protocols.<br>TSO.1d Describe the given communication protocol used in PLC communication.<br>TSO.1e Summarize PLC to PLC communication procedure<br>TSO.1f Describe the common procedure to interface the PLC with other given hardware.                                                                                                                                                                                                                                                                                                  | <b>Unit-1.0 Industrial automation communication and Interfacing</b><br><br>1.1 Analog and Digital Communications on Plant Floors<br>1.2 Introduction to Industrial Networking<br>1.3 RS232-422-485 standards for data communication<br>1.4 Industrial Ethernet<br>1.5 Concept of Fieldbus<br>1.6 MODBUS protocol<br>1.7 Highway Addressable Remote Transducer (HART) Protocol<br>1.8 Interfacing of Programmable Logic Controller with other hardware                                                                                                                                                                                                                                                                                                                                                                                                                                                 | <b>CO-1</b>            |
| TSO.2a Specify the proper I/O addressing format of the given PLC.<br>TSO.2b Explain the use of different relay type instructions for the given operation.<br>TSO.2c Describe how a program is executed with the help of Program Scan cycle<br>TSO.2d Develop ladder logic program using arithmetic functions to perform the given operation.<br>TSO.2e Develop ladder logic programs using logical and comparison instructions to perform the given operation<br>TSO.2f Develop ladder logic programs using on delay, off delay and reset/retentive timer in a given PLC to create a delay in operation.<br>TSO.2g Develop ladder logic programs using Up, Down and UP-down counter in a given PLC to count the number of products | <b>Unit-2.0 PLC Programming</b><br><br>2.1 PLC I/O addressing in ladder logic<br>2.2 PLC programming instructions using ladder logic and relay type instructions<br>2.3 Program Scan cycle<br>2.4 PLC arithmetic functions - Addition, subtraction, multiplication, division instructions, increment decrement, trigonometric<br>2.5 PLC logical functions - AND, OR, XOR, NOT functions, PLC compare and convert functions.<br>2.6 Programming Timer –Addressing a timer block, status bits, On delay, Off Delay and reset/retentive timer<br>2.7 Programming Counter- Addressing a counter block, status bits, Up and Down counter, up-down counter, counter examples, register basics<br>2.8 Develop ladder logic for various simple applications                                                                                                                                                  | <b>CO-2</b>            |
| TSO.3a Describe Requirements for PLC enclosure.<br>TSO.3b Describe Proper grounding techniques.<br>TSO.3c Describe noise reduction Techniques.<br>TSO.3d Explain preventive maintenance procedure associated with PLC system to reduce environmental impact<br>TSO.3e Identify faults in the given PLC system<br>TSO.3f Explain the procedure for Troubleshooting PLC system<br>TSO.3g Prepare preventive maintenance plan for the PLC system<br>TSO.3h Use safety equipment's.<br>TSO.3i Follow safe practices                                                                                                                                                                                                                    | <b>Unit-3.0 Installation and maintenance of PLC systems</b><br><br>3.1 PLC enclosure, grounding requirements, noise generating inductive devices, leaky inputs and outputs, techniques to reduce electrical noise and leakage.<br>3.2 Introduction to PLC Trouble shooting and maintenance, trouble shooting of hardware and software.<br>3.3 Diagnostic LED Indicators in PLCs<br>3.4 Common problems <ul style="list-style-type: none"> <li>Internal problems – Check for PLC Power Supply, Emergency Push Button, Power Supply Failure, Battery Failure, Electrical Noise Interference, Verify the PLC Program with the Master Program, Corrupted PLC Memory</li> <li>External problems - Power failure, faulty grounding and electrical noise interference (RFI or EMI), Status of the Output Modules and their associated Circuitry, Status of the Input Modules and their associated</li> </ul> | <b>CO-3</b>            |

| Major Theory Session Outcomes (TSOs)                                                                                                                                                                                                                                                                                                                                                                   | Units                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Relevant COs Number(s) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                        | <p>Circuitry, Field Input and Output Devices, Communication Issues.</p> <ul style="list-style-type: none"> <li>Environmental Conditions. Check for humidity, temperature, vibration, and noise-level limits specified by its manufacturer</li> </ul> <p>3.5 Troubleshooting of Specific Components of the PLC System</p> <ul style="list-style-type: none"> <li>Power Supply Troubleshooting</li> <li>I/O Modules Troubleshooting</li> <li>Troubleshooting PLC Program Errors</li> <li>Troubleshooting the Working Environment of a PLC</li> <li>Replacement of CPU</li> </ul> <p>3.6 PLC trouble shooting flowchart</p> <p>3.7 PLC maintenance – PLC maintenance checklist, preventive maintenance procedure, maintenance plan for the PLC system.</p> <p>3.8 Safety procedure and safety equipment's.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                        |
| <p>TSO.4.a Describe the function of given element of a SCADA system.</p> <p>TSO.4.b Interface the given PLC with SCADA system using the given Open Platform Communications (OPC).</p> <p>TSO.4.c Describe the steps to develop a simple SCADA screen for the given industrial application.</p> <p>TSO.4.d Describe the procedure to maintain the SCADA based PLC system for the given application.</p> | <p><b>Unit-4.0 SCADA and DCS</b></p> <p>4.1 Introduction, need, benefits and typical applications of SCADA and DCS</p> <p>4.2 SCADA Architecture - Remote Terminal Units (RTUs), Master Terminal Units, Various SCADA editors, Communication protocols for SCADA</p> <p>4.3 Comparison of SCADA with DCS</p> <p>4.4 Interfacing SCADA system with PLC- Typical connection diagram, Object Linking and Embedding for Process Control (OPC) architecture</p> <p>4.5 Creating SCADA Screen HMI for simple object, Steps for linking SCADA object (defining Tags and items, creating trends etc.,) with PLC ladder program using OPC, configuring simple applications using SCADA: Traffic light control, water distribution, pipeline control, Power generation, transmission and distribution etc.</p> <p>4.6 Procedure to maintain the SCADA based PLC system.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>CO-3</b>            |
| <p>TSO.5a Identify different components used for automation in the given system</p> <p>TSO.5b Select automation components for a given situation</p> <p>TSO.5c In the given manufacturing or service industry Identify the areas where automation is possible.</p> <p>TSO.5d Prepare plan for sustainable automation as per the requirement.</p>                                                       | <p><b>Unit-5.0 Applications of Industrial Automation</b></p> <p>5.1 <b>Manufacturing-</b> Industrial Robots- welding robots, pick and place robots, Cabot's, Machine monitoring system, supply chain, Automated assembly system, Flexible Automation and programmable Automation.</p> <p>5.2 <b>Health Care-</b> microscopic robots for medical diagnosis, automated medication dispensing devices, AESOP, ZEUS, RP_7(remote presence 7th generation), DaVinci</p> <p>5.3 <b>Defense- guided rockets and missiles,</b> counter measures, UAV drones, launcher, radar antenna, engagement control system</p> <p>5.4 <b>Automobile –Break</b> monitoring system, Vehicle tracking system, Rear-view alarm to detect obstacles behind, Four-wheel drive, Traction control system, Dynamic steering response, Anti-lock braking system (ABS) Adaptive cruise control, Adaptive headlamps, Intelligent Parking Assist System, Driverless/Autonomous Cars</p> <p>5.5 <b>Agriculture-</b> harvesters, irrigation systems, plowing machines, self-driving tractors, grain yield sensor</p> <p>5.6 <b>Mining-</b> Mine planning system, mine picture compilation, mine control system, seismic imaging, laser imaging, Rig control system, automated drilling, automated exploration, automated truck</p> | <b>CO-5</b>            |

**Note:** One major TSO may require more than one Theory session/Period.

**K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400604F**

| Practical/Lab Session Outcomes (LSOs)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | S. No. | Laboratory Experiment/Practical Titles                                                                                                                                              | Relevant COs Number(s) |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| <i>LSO 1.1</i> Data communication from PLC to PC and vice versa                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 1.     | Transfer the control data from PLC to PC and vice versa                                                                                                                             | CO1                    |
| <i>LSO 1.2</i> Establish Communication channels between PLC s.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 2.     | Transfer the control data from PLC to PLC                                                                                                                                           | CO1                    |
| <i>LSO 1.3</i> Transfer data from sensors to PLC and from PLC to PC.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 3.     | Transfer the sensor data from sensor to PLC to PLC and PC                                                                                                                           | CO1                    |
| <i>LSO 1.4</i> Interface the given PLC with a PC or a Laptop                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 4.     | Interface the given PLC with a PC or a Laptop                                                                                                                                       | CO1                    |
| <i>LSO 2.1</i> Identify Different parts and front panel indicators of a PLC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 5.     | Identify the various parts and front panel status indicators of the given PLC.                                                                                                      | CO2                    |
| <i>LSO 2.2</i> Develop Ladder logic program for different arithmetic operations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 6.     | Develop/Execute ladder logic program for different arithmetic operations such as Addition, subtraction, multiplication, division increment, decrement, trigonometric in a given PLC | CO2                    |
| <i>LSO 2.3</i> Develop Ladder logic program for different logical operations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 7.     | Develop/Execute ladder logic program for logical operations such as AND, OR, NOT, NAND, NOR, X-OR, X-NOR gate along with truth table                                                | CO2                    |
| <i>LSO 2.4</i> Program Latch and Unlatch circuit in a PLC for motor operation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 8.     | Program the given PLC to start run and stop the given motor using latch circuit                                                                                                     | CO2                    |
| <i>LSO 2.5</i> Create delay in operation using on delay, off delay and retentive timer function in a given PLC.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 9.     | Test the functionality of on delay, off delay and retentive timer for its correct operation in a given PLC.                                                                         | CO2                    |
| <i>LSO 2.6</i> Count the number of objects/events using Up counter, Down counter and UP/Down counter in a PLC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 10.    | Test the functionality of Up, Down and Up-down counter for its correct operation in a given PLC.                                                                                    | CO2                    |
| <i>LSO 2.7</i> Program PLC using ladder logic to control a LED/Lamp                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 11.    | Develop/Execute a ladder logic program to put LED/lamp in the blinking mode                                                                                                         | CO2                    |
| <i>LSO 2.8</i> Program PLC using ladder logic to control a simple traffic light system                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 12.    | Develop/Execute a ladder logic program to control a simple traffic light control system using PLC                                                                                   | CO2                    |
| <i>LSO 3.1</i> Use hygrometer to measure the humidity inside the panel<br><i>LSO 3.2</i> Use thermometer to measure ambient temperature inside the panel<br><i>LSO 3.3</i> Use tester to determine the voltage fluctuation at the power supply terminals is within specifications<br><i>LSO 3.4</i> Test the ground connections of the given PLC.<br><i>LSO 3.5</i> A given PLC is not working as per the logic instructions investigate the PLC to identify the cause of failure to show the desired output<br><i>LSO 3.6</i> Investigate the cause of Noise in the given PLC<br><i>LSO 3.7</i> PLC goes on blackout out by losing its operating power. Troubleshoot the cause of failure.<br><i>LSO 3.8</i> Troubleshoot the corrupted PLC memory. | 13.    | Troubleshooting of PLC system                                                                                                                                                       | CO3                    |

| Practical/Lab Session Outcomes (LSOs)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | S. No. | Laboratory Experiment/Practical Titles                                                                      | Relevant COs Number(s) |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-------------------------------------------------------------------------------------------------------------|------------------------|
| <i>LSO 3.9</i> Replace CPU and power supply fuses in a given PLC system.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |        |                                                                                                             |                        |
| <i>LSO 4.1</i> Download any open source SCADA software and install the same.<br><i>LSO 4.2</i> Interpret the available components in symbol factory of SCADA software<br><i>LSO 4.3</i> Create simple SCADA HMI applications and apply dynamic properties. (Select any Three from the given list)<br>i. Turn on and off a tube light using a Switch<br>ii. Apply filling and object size properties to a rectangle, square and round object<br>iii. Move the object, fill the object using slider and meter reading.<br>iv. Apply orientation property to a fan and control its direction using a slider.<br>v. Move a square object horizontally first, then vertically and again horizontally by applying visibility property.<br><i>LSO 4.4</i> Create historical and real time trends for the given automation                                                                                                                                                                                                                                                                             | 14.    | Develop simple SCADA HMI applications using any one open source SCADA software and apply dynamic properties | CO4                    |
| <i>LSO 5.1</i> Develop a smart irrigation device to detect the change in moisture level in the soil and controls the flow of water accordingly with a DC pump.<br><i>LSO 5.2</i> Build an electronic device that can remotely control home appliances with your Bluetooth-enabled smartphone and a special Android application<br><i>LSO 5.3</i> Develop a PLC program to control the robot in such a way that the robot can automatically pick and place components and works in sync with the conveyor belt system.<br><i>LSO 5.4</i> Develop a Automation system to Open and close the door in the shop<br><i>LSO 5.5</i> Develop a line following robot with RFID sensor for supplying materials and automating workflow.<br><i>LSO 5.6</i> Develop smart street light controlling mechanism which will Switch on/off the lights automatically depending on the intensity of the sunlight at that particular time of the day.<br><i>LSO 5.7</i> Develop smart automated railway crossing system to detect train arrival and departure and send appropriate signals to the microcontroller. | 15.    | Develop simple automation systems for the given requirement (Select any Three from the given list)          | CO5                    |

- L) Suggested Term Work and Self Learning: S2400604F** Some sample suggested assignments, micro project and other activities are mentioned here for reference.
- a. Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.
- State three advantages of using programmed PLC timer over mechanical timing relay.
  - It is required to have a pilot light glow, meeting all of the circuit requirements given below:
    - All four circuit pressure Switches must be closed.
    - At least two out of three circuit limit Switches must be closed.
    - The reset Switch must not be closed.
  - Using AND, OR, and NOT gates, design a logic circuit that will solve this hypothetical problem
  - Prepare a comparison chart of different types of PLC
  - Prepare a maintenance plan for a given PLC system.
- b. Micro Projects:**
- Troubleshoot the faulty equipment/kit available in automation laboratory
  - Select one industry and analyze the process and propose the automation strategies' that can be used for automation.
  - Develop a working model of a given application using given actuators and valves.
  - Develop a smart irrigation device to detect the change in moisture level in the soil and controls the flow of water accordingly with a DC pump.
  - Build an electronic device that can remotely control home appliances with your Bluetooth-enabled smartphone and a special Android application
  - Develop a PLC program to control the robot in such a way that the robot can automatically pick and place components and works in sync with the conveyor belt system.
- c. Other Activities:**
- Seminar Topics- PLC instructions, Timers and Counters used in a given PLC
  - Seminar Topics- Industrial Applications of PLC and SCADA, AGV, Application of automation in different area, trouble shooting of different types of PLC
  - Visits – Visit any industry with full or semi automation and prepare a report on industrial automation used by the industry in the given section, components used, power requirement, output achieved and maintenance activities required.
  - Surveys- Carry out a market/internet survey of PLC and prepare the comparative technical specifications of any one type of PLC (Micro or Mini) of different manufacturer.
  - Product Development- Develop a prototype automatic railway crossing system
  - Software Development- Download any open source software for PLC and install on your laptop/PC and carry out basic PLC programming
  - Also download any open source software for SCADA and install on your laptop/PC and carry out basic SCADA HMI programming
  - Surveys – Carry out a internet based survey to compare SCADA and DCS
- d. Self-Learning Topics:**
- Basic concepts of working of robot
  - Automated material handling.
  - Instrumentation systems for inspection and testing for quality of the product
  - Use of robots in different applications
  - Intelligent Transportation Systems
  - Communication standards and protocols used in PLC
  - Use of PLC for different industrial applications
  - Use of SCADA for different industrial applications
  - Interfacing of PLC

- M) Suggested Course Evaluation Matrix:** The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

| COs         | Course Evaluation Matrix                                  |                             |                                      |                |                   |                                  |                                 |
|-------------|-----------------------------------------------------------|-----------------------------|--------------------------------------|----------------|-------------------|----------------------------------|---------------------------------|
|             | Theory Assessment (TA)**                                  |                             | Term Work Assessment (TWA)           |                |                   | Lab Assessment (LA)#             |                                 |
|             | Progressive Theory Assessment (PTA)<br>Class/Mid Sem Test | End Theory Assessment (ETA) | Term Work & Self-Learning Assessment |                |                   | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |
|             |                                                           |                             | Assignments                          | Micro Projects | Other Activities* |                                  |                                 |
| CO-1        | 10%                                                       | 20%                         | 20%                                  | --             | 33%               | 10%                              | 20%                             |
| CO-2        | 15%                                                       | 25%                         | 20%                                  | --             | 33%               | 15%                              | 20%                             |
| CO-3        | 15%                                                       | 20%                         | 20%                                  | --             | 34%               | 15%                              | 20%                             |
| CO-4        | 30%                                                       | 20%                         | 20%                                  | 50%            | --                | 30%                              | 20%                             |
| CO-5        | 30%                                                       | 15%                         | 20%                                  | 50%            | --                | 30%                              | 20%                             |
| Total Marks | 30                                                        | 70                          | 20                                   | 20             | 10                | 20                               | 30                              |
|             |                                                           |                             | 50                                   |                |                   |                                  |                                 |

**Legend:**

\*: Other Activities include self-learning, seminar, visits, surveys, product development, software development etc.

\*\*: Mentioned under point- (N)

#: Mentioned under point- (O)

**Note:**

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

- N) Suggested Specification Table for End Semester Theory Assessment:** Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

| Unit Title and Number                                        | Total Classroom Instruction (CI) Hours | Relevant COs Number (s) | Total Marks | ETA (Marks)  |                   |                         |
|--------------------------------------------------------------|----------------------------------------|-------------------------|-------------|--------------|-------------------|-------------------------|
|                                                              |                                        |                         |             | Remember (R) | Understanding (U) | Application & above (A) |
| Unit-1.0 Industrial automation Communication and Interfacing | 9                                      | CO1                     | 14          | 5            | 4                 | 5                       |
| Unit-2.0 PLC Programming                                     | 12                                     | CO2                     | 17          | 5            | 6                 | 6                       |
| Unit-3.0 Installation and maintenance of PLC systems         | 10                                     | CO3                     | 14          | 4            | 5                 | 5                       |
| Unit-4.0 SCADA and DCS                                       | 9                                      | CO4                     | 14          | 4            | 5                 | 5                       |
| Unit-5.0 Applications of Industrial Automation               | 8                                      | CO5                     | 11          | 2            | 4                 | 5                       |
| Total Marks                                                  | 48                                     |                         | 70          | 20           | 24                | 26                      |

**Note:** Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

**O) Suggested Assessment Table for Laboratory (Practical):**

| S. No. | Laboratory Practical Titles                                                                                                              | Relevant COs Number(s) | PLA/ELA     |           |               |
|--------|------------------------------------------------------------------------------------------------------------------------------------------|------------------------|-------------|-----------|---------------|
|        |                                                                                                                                          |                        | Performance |           | Viva-Voce (%) |
|        |                                                                                                                                          |                        | PRA* (%)    | PDA** (%) |               |
| 1.     | Transfer the control data from PLC to PC and vice versa                                                                                  | CO1                    | 50          | 40        | 10            |
| 2.     | Transfer the control data from PLC to PLC                                                                                                | CO1                    | 50          | 40        | 10            |
| 3.     | Transfer the sensor data from sensor to PLC to PLC and PC                                                                                | CO1                    | 50          | 40        | 10            |
| 4.     | Interface the given PLC with a PC or a Laptop                                                                                            | CO1                    | 50          | 40        | 10            |
| 5.     | Identify Different parts and front panel indicators of a PLC                                                                             | CO2                    | 50          | 40        | 10            |
| 6.     | Develop Ladder logic program for different arithmetic operations                                                                         | CO2                    | 50          | 40        | 10            |
| 7.     | Develop Ladder logic program for different logical operations                                                                            | CO2                    | 50          | 40        | 10            |
| 8.     | Program Latch and Unlatch circuit in a PLC for motor operation                                                                           | CO2                    | 50          | 40        | 10            |
| 9.     | Create delay in operation using on delay, off delay and retentive timer function in a given PLC                                          | CO2                    | 50          | 40        | 10            |
| 10.    | Count the number of objects/events using Up counter, Down counter and UP/Down counter in a PLC                                           | CO2                    | 50          | 40        | 10            |
| 11.    | Program PLC using ladder logic to control a LED/Lamp                                                                                     | CO2                    | 50          | 40        | 10            |
| 12.    | Program PLC using ladder logic to control a simple traffic light system                                                                  | CO2                    | 50          | 40        | 10            |
| 13.    | Use hygrometer to measure the humidity inside the panel                                                                                  | CO3                    | 50          | 40        | 10            |
| 14.    | Use thermometer to measure ambient temperature inside the panel                                                                          | CO3                    | 50          | 40        | 10            |
| 15.    | Use tester to determine the voltage fluctuation at the power supply terminals is within specifications                                   | CO3                    | 50          | 40        | 10            |
| 16.    | A given PLC is not working as per the logic instructions investigate the PLC to identify the cause of failure to show the desired output | CO3                    | 50          | 40        | 10            |
| 17.    | Investigate the cause of Noise in the given PLC                                                                                          | CO3                    | 50          | 40        | 10            |
| 18.    | PLC goes on blackout out by losing its operating power. Troubleshoot the cause of failure.                                               | CO3                    | 50          | 40        | 10            |
| 19.    | Troubleshoot the corrupted PLC memory.                                                                                                   | CO3                    | 50          | 40        | 10            |
| 20.    | Replace CPU and power supply fuses in a given PLC system                                                                                 | CO3                    | 50          | 40        | 10            |
| 21.    | Download any open source SCADA software and install the same.                                                                            | CO4                    | 50          | 40        | 10            |
| 22.    | Interpret the available components in symbol factory in SCADA software                                                                   | CO4                    | 50          | 40        | 10            |

| S. No. | Laboratory Practical Titles                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Relevant COs Number(s) | PLA/ELA     |           |               |
|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|-------------|-----------|---------------|
|        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                        | Performance |           | Viva-Voce (%) |
|        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                        | PRA* (%)    | PDA** (%) |               |
| 23.    | Create simple SCADA HMI applications and apply dynamic properties (Any Three).<br>i. Turn on and off a tube light using a Switch<br>ii. Apply filling and object size properties to a rectangle, square and round object<br>iii. Move the object, fill the object using slider and meter reading.<br>iv. Apply orientation property to a fan and control its direction using a slider.<br>v. Move a square object horizontally first, then vertically and again horizontally by applying visibility property.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | CO4                    | 50          | 40        | 10            |
| 24.    | Create historical and real time trends for the given automation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | CO4                    | 50          | 40        | 10            |
| 25.    | <b>Select any three of the following: -</b><br>i. Develop a smart irrigation device to detect the change in moisture level in the soil and controls the flow of water accordingly with a DC pump.<br>ii. Build an electronic device that can remotely control home appliances with your Bluetooth-enabled smartphone and a special Android application<br>iii. Develop a PLC program to control the robot in such a way that the robot can automatically pick and place components and works in sync with the conveyor belt system.<br>iv. Develop a Automation system to Open and close the door in the shop<br>v. Develop a line following robot with RFID sensor for supplying materials and automating workflow.<br>vi. Develop smart street light controlling mechanism which will Switch on/off the lights automatically depending on the intensity of the sunlight at that particular time of the day.<br>vii. Develop smart automated railway crossing system to detect train arrival and departure and send appropriate signals to the microcontroller. | CO5                    | 60          | 30        | 10            |

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

**Note:** This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

**P) Suggested Instructional/Implementation Strategies:** Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

**Q) List of Major Laboratory Equipment, Tools and Software:**

| S. No. | Name of Equipment, Tools and Software                                                                                               | Broad Specifications                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Relevant Experiment/Practical Number |
|--------|-------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|
| 1.     | SCADA software<br>(reputed make like Allen Bradley, Siemens etc.,)                                                                  | Ready-to-use symbol library, React and respond in real-time, Real time monitoring, Friendly, manageable, secure, extensible, Easy-to-use, easy to implement, Easy configuration, simplified maintenance, Communication with PLC, easy and flexible alarm definition, data collection and analysis for new and existing systems, easy-to-use for report generation, open access to historical data, different packages available with input/output structure. Open source software SCADA software: like Ellipse/FTVSE/Wonderware/ open SCADA can also be used                                                                                                                                                                                                                                                                              | 14                                   |
| 2.     | Universal PLC Training System with HMI<br>(Of reputed make such as Allen bradely, Siemens, etc.,)<br>Compatible with SCADA software | Human Machine Interface (HMI) display, PLC with 16 digital inputs, 16 digital outputs with RS232 communication facility. Open platform to explore wide PLC and HMI applications. Industrial look & feel. Toggle Switches, push to ON Switch, proximity sensor, visual indicator, audio indicator, and DC motor. Experiments configurable through patch board. Powerful instruction sets. Several sample ladder and HMI programs. PC based ladder and HMI programming. Extremely easy and student friendly software to develop different programs. Easy downloading of programs. Practice troubleshooting skills. Compact tabletop ergonomic design. Robust construction. PLC gateway for cloud connectivity. Open source software like Ladder logic simulator, Pico soft Simulator, Logixpro simulator, Simple EDA tools can also be used | 1 to 12                              |
| 3.     | Safety gears                                                                                                                        | Gloves, Safety goggles, Ear protection, Dust masks and respirators.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 13                                   |
| 4.     | Power tools                                                                                                                         | Power drills, Orbital sanders, Circular saws, Impact wrenches.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 13                                   |
| 5.     | Hand tools                                                                                                                          | Screwdrivers, Hammers, Hand saws, Hex Key Allen Wrench Set Inch and Metric, relay puller, Multi-Tool Wire Stripper/Crimper/Cutter                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 13                                   |
| 6.     | Electrical tools                                                                                                                    | Wire and cable strippers, Multimeters- Volts, Ohms, and Amps, Crimpers- Side Cutter Crimping, Wire Crimp Connector Kit, Digital Multimeter Clamp Meter with Amp, Volt, and Ohm, Non-Contact Voltage Tester                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 13                                   |
| 7.     | Spare parts                                                                                                                         | PLC Programming Cables, SD Card Reader Compact flash, Wire Nut Set, Fuses- Class J 30, 35, 60, and 100-amp fuses, Class CC 2, 3, 5, 10, 15, 20, and 30 -amp fuses, 5mm x 20mm 0.032 (for 4-20mA circuits), 0.5, 1, 2, 5, 10, and 15 amps, Cube Relays, Resistor Kit, batteries, LED Indicators PLC Processor (CPU), Input/ output module                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 13                                   |
| 8.     | Thermo-hygrometer                                                                                                                   | Measuring range Temp.: -30 ... 60°C / -22 ... 140°F<br>Measuring range rel. Humidity: 0 ... 100% rh, Measurement protocol as PDF, Data export possible as CSV, Readable without software, data sets of measured values can be stored.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 13                                   |
| 9.     | Digital Hygrometer                                                                                                                  | maximum humidity measurement- 100%RH, temperature measurement resolution -0.1egree centigrade, humidity measurement resolution -0.1%RH, minimum operating temperature - -10 to -20-degree centigrade, Maximum operating temperature +45 to +50 degree centigrade                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 13                                   |

**R) Suggested Learning Resources:****(a) Books:**

| S. No. | Titles                                                                      | Author(s)                                   | Publisher and Edition with ISBN                                   |
|--------|-----------------------------------------------------------------------------|---------------------------------------------|-------------------------------------------------------------------|
| 1.     | Introduction to Programmable Logic Controllers                              | Dunning, G.                                 | Thomson /Delmar learning, New Delhi, 2005, ISBN 13: 9781401884260 |
| 2.     | Programmable Logic Controllers                                              | Petrusella, F.D.                            | McGraw Hill India, New Delhi, 2010, ISBN: 9780071067386           |
| 3.     | Programmable Logic Controllers                                              | Hackworth, John;<br>Hackworth, Federic      | PHI Learning, New Delhi, 2003, ISBN: 9780130607188                |
| 4.     | Industrial automation and Process control                                   | Stenerson Jon                               | PHI Learning, New Delhi, 2003, ISBN: 9780130618900                |
| 5.     | Programmable Logic Controller                                               | Jadhav, V. R.                               | Khanna publishers, New Delhi, 2017, ISBN: 9788174092281           |
| 6.     | Programmable Logic Controllers and Industrial Automation - An introduction, | Mitra, Madhuchandra;<br>Sengupta, Samarjit, | Penram International Publication, 2015, ISBN: 9788187972174       |
| 7.     | Control System                                                              | Nagrath & Gopal                             | New Age International Pvt Ltd, ISBN: 9789386070111, 9789386070111 |
| 8.     | Linear Control Systems with MATLAB Applications, Publisher:                 | Manke, B. S.                                | Khanna Publishers, ISBN: 9788174093103, 9788174093103             |
| 9.     | Supervisory Control and Data Acquisition                                    | Boyar, S. A.                                | ISA Publication, USA, ISBN: 978-1936007097                        |
| 10.    | Practical SCADA for industry,                                               | Bailey David; Wright Edwin                  | Newnes (an imprint of Elsevier), UK 2003, ISBN:0750658053         |

**(b) Online Educational Resources:**

1. Software: - [www.fossee.com](http://www.fossee.com)
2. Software: - [www.logixpro.com](http://www.logixpro.com)
3. Software: - [www.plctutor.com](http://www.plctutor.com)
4. Software; - [www.ellipse.com](http://www.ellipse.com)
5. PLC lecture: - <https://www.youtube.com/watch?v=pPiXefBO2qo>
6. PLC tutorial: [http://users.isr.ist.utl.pt/~jag/aulas/apil3/docs/API\\_I\\_C3\\_3\\_ST.pdf](http://users.isr.ist.utl.pt/~jag/aulas/apil3/docs/API_I_C3_3_ST.pdf)
7. <https://www.youtube.com/watch?v=277wwYWolpw>-PLC system troubleshooting and repair. Industrial control panel. PLC system repair.
8. <https://www.youtube.com/watch?v=5Jmtvrch5Jg>
9. <https://www.youtube.com/watch?v=peyV9bwEaLY>
10. <https://www.youtube.com/watch?v=QdJhRmtKpxk&list=RDCMUCke36Liq-w5fboMHkq1APZw&index=3>
11. <https://www.youtube.com/watch?v=ygrrRwaJz3M>

**Note:** Teachers are requested to check the creative commons license status/ financial implications of the suggested OER, before use by the students.

**(c) Others:**

1. Learning Packages
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

\*\*\*\*\*

- A) **Course Code** : 2400604G(T2400604G/P2400604G/S2400604G)
- B) **Course Title** : Electric Vehicle (Advanced)
- C) **Prerequisite Course(s)** : Electric Vehicle (Basics)
- D) **Rationale** :

The automobile manufacturing sector in India is rapidly switching over to electric vehicles used for the public as well as private transport. The Govt. of India has launched the FAME-II Scheme (Faster Adoption and Manufacturing of Hybrid & Plug-in Electric Vehicles) to encourage the progressive induction of reliable, affordable and efficient electric and hybrid vehicles and to create demand for Electric Vehicles in the country. The technology is being evolved to enhance the vehicle's efficiency and running mileage by controlling the manufacturing, maintenance and recurring costs of such vehicles. Due to the rapid increase in EV demand, industries will also require skilled manpower in this area. This advanced course on electric vehicles is included as an open elective for all the diploma programmes to provide a sound knowledge of EVs to engineering diploma students and develop skills related to testing and maintenance of various electrical, electronic and mechanical systems in EVs.

- E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the learners' accomplishment of the following course outcomes. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

**After completion of the course, the student will be able to-**

- CO-1** Compute various parameters affecting Vehicle movement.
- CO-2** Test the operation of the different elements of the Automobile System.
- CO-3** Test the battery and motor used for Power Transmission in EVs.
- CO-4** Test electronic control unit system of EVs.
- CO-5** Interpret the impact of Grid to Vehicle (G2V) and Vehicle to Grid (V2G) during the charging cycle.

- F) **Suggested Course Articulation Matrix (CAM):**

| Course Outcomes (COs) | Programme Outcomes (POs)                        |                          |                                          |                           |                                                                           |                            |                            | Programme Specific Outcomes* (PSOs) |       |
|-----------------------|-------------------------------------------------|--------------------------|------------------------------------------|---------------------------|---------------------------------------------------------------------------|----------------------------|----------------------------|-------------------------------------|-------|
|                       | PO-1<br>Basic and Discipline Specific Knowledge | PO-2<br>Problem Analysis | PO-3<br>Design/ Development of Solutions | PO-4<br>Engineering Tools | PO-5<br>Engineering Practices for Society, Sustainability and Environment | PO-6<br>Project Management | PO-7<br>Life Long Learning | PSO-1                               | PSO-2 |
| CO-1                  | 3                                               | -                        | 1                                        | 2                         | -                                                                         | -                          | 1                          |                                     |       |
| CO-2                  | 3                                               | 2                        | 2                                        | 3                         | 1                                                                         | -                          | -                          |                                     |       |
| CO-3                  | 2                                               | 2                        | 2                                        | 3                         | 3                                                                         | 1                          | 3                          |                                     |       |
| CO-4                  | 2                                               | 3                        | -                                        | 2                         | 2                                                                         | -                          | 2                          |                                     |       |
| CO-5                  | 3                                               | 2                        | -                                        | 2                         | 3                                                                         | 1                          | 2                          |                                     |       |

**Legend:** High (3), Medium (2), Low (1) and No mapping (-)

\* PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

**G) Teaching & Learning Scheme:**

| Course Code | Course Title                | Scheme of Study (Hours/Week) |   |                      |                         |                           |                   |
|-------------|-----------------------------|------------------------------|---|----------------------|-------------------------|---------------------------|-------------------|
|             |                             | Classroom Instruction (CI)   |   | Lab Instruction (LI) | Notional Hours (TW+ SL) | Total Hours (CI+LI+TW+SL) | Total Credits (C) |
|             |                             | L                            | T |                      |                         |                           |                   |
| 2400604G    | Electric Vehicle (Advanced) | 03                           | - | 04                   | 02                      | 09                        | 06                |

**Legend:**

- CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)
- LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)
- Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.
- TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)
- SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.
- C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)
- Note:** TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

**H) Assessment Scheme:**

| Course Code | Course Title                | Assessment Scheme (Marks)           |                             |                                            |          |                                  |                                 | Total Marks (TA+TWA+LA) |
|-------------|-----------------------------|-------------------------------------|-----------------------------|--------------------------------------------|----------|----------------------------------|---------------------------------|-------------------------|
|             |                             | Theory Assessment (TA)              |                             | Term Work & Self-Learning Assessment (TWA) |          | Lab Assessment (LA)              |                                 |                         |
|             |                             | Progressive Theory Assessment (PTA) | End Theory Assessment (ETA) | Internal                                   | External | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |                         |
| 2400604G    | Electric Vehicle (Advanced) | 30                                  | 70                          | 20                                         | 30       | 20                               | 30                              | 200                     |

**Legend:**

- PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)
- PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)
- TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.)

**Note:**

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

- I) Course Curriculum Detailing:** This course curriculum detailing depicts learning outcomes at the course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (SW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to the attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020-related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

## J) Theory Session Outcomes (TSOs) and Units: T2400604G

| Major Theory Session Outcomes (TSOs)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Units                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Relevant COs Number(s) |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| TSO 1a. Explain the vehicle movement process<br>TSO 1b. Derive various equations for the movement of Vehicles<br>TSO 1c. Compute different resistances affecting Vehicle movement.<br>TSO 1d. Explain the dynamics of the given type of EV system.                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Unit-1.0 Vehicle Dynamics</b><br><br>1.1 Vehicle Movement<br>1.2 Rolling Resistance: Equation, Coefficient, factor affecting rolling resistance, typical values of rolling resistance<br>1.3 Grading resistance<br>1.4 Road resistance<br>1.5 Acceleration resistance<br>1.6 Total driving resistance<br>1.7 Aerodynamic drag: Equation, typical values of the drag coefficient.<br>1.8 Vehicle dynamics <ul style="list-style-type: none"> <li>Hybrid and Electric Vehicles</li> <li>DC Motor Dynamics and Control</li> <li>AC Motor Dynamics and Control</li> </ul>                                                                                                    | CO1                    |
| TSO 2 a. Identify the given elements of Automobile Systems.<br>TSO 2 b. Describe the functions of the given elements of Automobile Systems.<br>TSO 2 c. Explain the dynamic characteristics of the Disc Braking System for the given braking steps.<br>TSO 2 d. Describe the Procedure for testing the given AC/DC motors.<br>TSO 2 e. Describe the Procedure of Installation and Testing of the given EV Charging Stations.<br>TSO 2 f. Describe the Procedure for Commissioning EV Charging Stations.<br>TSO 2 g. Explain the functions of the EV Control Unit.                                                                                     | <b>Unit-2.0 Elements of Automobile</b><br><br>2.1 Suspension and Damping systems<br>2.2 Brake system: Half-step braking, Full step Braking<br>2.3 Transaxle<br>2.4 Elements of Noise Vibration and Harshness Control<br>2.5 Body balancing<br>2.6 Tyre Technology<br>2.7 AC/DC motor<br>2.8 Air-conditioning and Heating System<br>2.9 Lighting System<br>2.10 Automotive wiring system<br>2.11 Earthing and Insulation<br>2.12 Charging stations – Installation and Commissioning<br>2.13 Vehicle control unit                                                                                                                                                             | CO2                    |
| TSO 3a. Compare different power transmission systems in EVs.<br>TSO 3b. List the main Components of the EV Power Train.<br>TSO 3c. Explain the functions of the given EV Power Train component.<br>TSO 3d. Describe the testing procedure of the given EV Power Train component.<br>TSO 3e. Explain the regenerative braking operation in the given EV motor.<br>TSO 3f. Describe the speed control mechanism of the given motor.<br>TSO 3g. Explain various parameters of the given battery.<br>TSO 3h. Select the suitable battery for the given EV application.<br>TSO 3i. Describe the assembling and dismantling procedure of the given battery. | <b>Unit-3.0 EV Power Transmission System</b><br><br><b>3.1 Transmission System:</b> Single and Multi-transmission system<br><b>3.2 EV Power Train</b><br><b>3.3 EV Power Train Components:</b> Battery Pack, DC-AC Converter, Electric Motor, On-Board Charger.<br><b>3.4 Battery Parameters:</b> Voltage, Current, Charging rate, efficiency, energy density, power density, State of Charge (SoC), Depth of Discharge (DoD), State of Health (SoH), Operating Temperature, specific energy, specific power, life cycle and cost.<br><b>3.5 Battery Assembly and Dismantling.</b><br><b>3.6 Gear and Differential Assembly</b><br><b>3.7 Safe disposal of used battery</b> | CO3                    |

| Major Theory Session Outcomes (TSOs)                |                                                                                                                                                                                                                                                                                                                                                             | Units                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Relevant COs Number(s) |
|-----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| TSO 3j.                                             | Describe the Mechanism of Gear and Differential Assembly.                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                        |
| TSO 4a.<br>TSO 4b.<br>TSO 4c.<br>TSO 4d.<br>TSO 4e. | Describe the Vehicle Control Unit (VCU).<br>Describe the functions of the given component of the Electronic Control Unit.<br>Describe the connections of the given control unit with the EV sub-system.<br>Explain the Interaction of Controller Area Network Communication with VCU.<br>Describe the Troubleshooting and Assessment procedure of VCU.      | <b>Unit- 4.0 Vehicle Control Unit (VCU)</b><br><br>4.1 <b>Electronic Control Unit:</b> Battery Management System, DC-DC Converter, Thermal Management System and Body Control Module.<br>4.2 Predefined functions<br>4.3 Connections with EV subsystem<br>4.4 Controller Area Network (CAN) communication<br>4.5 Interaction of CAN Communication with VCU.<br>4.6 Troubleshooting and Assessment<br>4.7 Dynamometers: Introduction<br>4.8 Environmental Chambers | <b>CO4</b>             |
| TSO 5a.<br>TSO 5b.<br>TSO 5c.<br>TSO 5d.<br>TSO 5e. | Explain the Classification of Charging Technologies.<br>Explain the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid.<br>Describe the testing procedure of the given Bi-directional charging systems.<br>Explain the Energy Management Strategies in the EV.<br>Explain the Wireless Power Transfer (WPT) technique for EV Charging. | <b>Unit- 5.0 EV Charging Technologies</b><br><br>5.1 Charging Technology: Classification<br>5.2 Grid-to-Vehicle (G2V)<br>5.3 Vehicle to Grid (V2G) or Vehicle to Buildings (V2B) or Vehicle to Home(V2H).<br>5.4 Bi-directional EV Charging Systems.<br>5.5 Energy Management Strategies.<br>5.6 Wireless Power Transfer (WPT) technique for EV Charging.                                                                                                         | <b>CO5</b>             |

**Note:** One major TSO may require more than one theory session/Period.

#### K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical:P2400604G

| Practical/Lab Session Outcomes (LSOs) |                                                                                                                                                                                                                                                                                     | S. No. | Laboratory Experiment/Practical Titles                                            | Relevant COs Number(s) |
|---------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------------------------------------------------------------------------|------------------------|
| LSO 2.1<br>LSO 2.2                    | Test the operation of the Control Disc Braking system and control the regenerative braking system using a test rig.<br>Test the performance (Speed v/s Braking Torque) of the Disc Braking System in Half step and Full step braking modes.                                         | 1.     | • Testing of Control Disc Braking system and Control Regenerative Braking system. | CO2                    |
| LSO 2.3                               | Test the performance of different types of propulsion motors.                                                                                                                                                                                                                       | 2.     | • Testing of Motors                                                               |                        |
| LSO 2.4                               | Test the continuity of the automotive wiring system in the EV                                                                                                                                                                                                                       | 3.     | • Testing of the automotive wiring system.                                        |                        |
| LSO 3.1<br>LSO 3.2<br>LSO 3.3         | Test the performance of a new set of batteries and aged batteries.<br>Compare the performance of the battery and find the Fuel Gauge after discharging the battery.<br>a. 0% - 100%<br>b. 30% - 100%<br>c. 50% - 100%<br>Evaluate the following parameters of the given EV battery. | 4.     | • Testing of Batteries used in EVs                                                | CO2, CO3               |

| Practical/Lab Session Outcomes (LSOs)                                                                                                                                                                                                                                                                                                                                                                                                                                                             | S. No. | Laboratory Experiment/Practical Titles                                                                                                                 | Relevant COs Number(s) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| a. Specific power<br>b. Specific energy<br>c. Life span and<br>d. Cost parameters<br><br>LSO 3.4 Evaluate the State of Health (SoH) of the given EV Battery after several charge/discharge cycles.                                                                                                                                                                                                                                                                                                |        |                                                                                                                                                        |                        |
| LSO 3.5 Test the dynamic performance of the given motor;<br>a) Speed and torque spectrum.<br>b) Speed and torque oscillation<br>c) Friction torque friction spectrum.<br><br>LSO 3.6 Test the following speed-controlled performance characteristics of the given motor;<br>a. Motor voltage over time<br>b. Motor current over time.<br>c. Speed and torque over time.<br>d. Torque over speed.<br>e. Current over speed.<br>f. Electrical input power and the mechanical input power over speed | 5.     | <ul style="list-style-type: none"> <li>Speed control of Electrical Motors</li> </ul>                                                                   |                        |
| LSO 4.1 Connect the components of the EC Units with EV subsystems.<br>LSO 4.2 Troubleshoot basic faults in the electronic control unit of EV.                                                                                                                                                                                                                                                                                                                                                     | 6.     | <ul style="list-style-type: none"> <li>Connection of Electronic Control Unit components</li> <li>Troubleshooting of electronic control unit</li> </ul> | CO4                    |
| LSO 5.1 Evaluate the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid.                                                                                                                                                                                                                                                                                                                                                                                                     | 7.     | <ul style="list-style-type: none"> <li>Impacts of G2V and V2G</li> </ul>                                                                               | CO 5                   |
| LSO 5.2 Prepare a layout of a charging station                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 8.     | <ul style="list-style-type: none"> <li>Demonstration of Charging stations</li> </ul>                                                                   |                        |

**L) Suggested Term Work and Self-Learning: S2400604G** Some sample suggested assignments, micro projects and other activities are mentioned here for reference.

**a. Assignments:** Questions/ Problems/ Numerical/ Exercises to be provided by the course teacher in line with the targeted COs.

**b. Micro Projects:**

- Design and build a physical model of an EV motor and powertrain components from scratch.
- Build and simulate communication systems of EVs using some software tools.
- Prepare a report on “the way carbon credit works and companies utilize it to reduce their emission values”.
- Develop an EV prototype power train using locally procured hardware components.

**c. Other Activities:**

**1. Seminar Topics:**

- Safe disposal process of Used Batteries.
- Charging Technologies used for charging the EV.
- EV power transmission systems.

2. **Surveys** – Visit an electric vehicle manufacturing plant and prepare report on HVAC system used in EV.

**3. Self-Learning Topics:**

- Impact of fleet charging of EVs on Power Systems.
- Energy Management in EV.
- Fuel Cell powered bus.
- EV Battery disposal and recycling.
- Mobility and connectors.

**M) Suggested Course Evaluation Matrix:** The course teacher has to decide and use the appropriate assessment strategy and its weightage, in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of the student in each of these designed activities is to be used to calculate **CO attainment**.

| COs         | Course Evaluation Matrix                                  |                             |                                      |                |                   |                                  |                                 |
|-------------|-----------------------------------------------------------|-----------------------------|--------------------------------------|----------------|-------------------|----------------------------------|---------------------------------|
|             | Theory Assessment (TA)**                                  |                             | Term Work Assessment (TWA)           |                |                   | Lab Assessment (LA)#             |                                 |
|             | Progressive Theory Assessment (PTA)<br>Class/Mid Sem Test | End Theory Assessment (ETA) | Term Work & Self-Learning Assessment |                |                   | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |
|             |                                                           |                             | Assignments                          | Micro Projects | Other Activities* |                                  |                                 |
| CO-1        | 20%                                                       | 15%                         | 20%                                  | --             | --                | --                               | --                              |
| CO-2        | 20%                                                       | 20%                         | 20%                                  | --             | --                | 35%                              | 25%                             |
| CO-3        | 20%                                                       | 30%                         | 20%                                  | 70%            | 40%               | 40%                              | 25%                             |
| CO-4        | 20%                                                       | 25%                         | 20%                                  | 30%            | 20%               | 10%                              | 25%                             |
| CO-5        | 20%                                                       | 10%                         | 20%                                  | --             | 40%               | 15%                              | 25%                             |
| Total Marks | 30                                                        | 70                          | 20                                   | 20             | 10                | 20                               | 30                              |
|             |                                                           |                             | 50                                   |                |                   |                                  |                                 |

**Legend:**

\*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

\*\*: Mentioned under point- (N)

#: Mentioned under point- (O)

**Note:** The percentage given are approximate

- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

**N) Suggested Specification Table for End Semester Theory Assessment:** Specification table represents the reflection of sample representation of assessment of the cognitive domain of the full course.

| Unit Title and Number                  | Total Classroom Instruction (CI) Hours | Relevant COs Number (s) | Total Marks | ETA (Marks)  |                   |                         |
|----------------------------------------|----------------------------------------|-------------------------|-------------|--------------|-------------------|-------------------------|
|                                        |                                        |                         |             | Remember (R) | Understanding (U) | Application & above (A) |
| Unit-1.0 Vehicle Dynamics              | 8                                      | CO1                     | 12          | 4            | 5                 | 3                       |
| Unit-2.0 Elements of Automobile.       | 10                                     | CO2                     | 15          | 5            | 6                 | 4                       |
| Unit-3.0 EV Power Transmission System. | 14                                     | CO3                     | 20          | 4            | 10                | 6                       |
| Unit-4.0 Vehicle Control Unit (VCU)    | 10                                     | CO4                     | 15          | 4            | 6                 | 5                       |
| Unit-5.0 Charging Technologies         | 6                                      | CO5                     | 8           | 3            | 3                 | 2                       |
| Total Marks                            | 48                                     |                         | 70          | 20           | 30                | 20                      |

**Note:** Similar table can also be used to design class/mid-term/ internal question papers for progressive assessment.

**O) Suggested Assessment Table for Laboratory (Practical):**

| S. N. | Laboratory Practical Titles                                                     | Relevant COs Number(s) | PLA /ELA    |           |               |
|-------|---------------------------------------------------------------------------------|------------------------|-------------|-----------|---------------|
|       |                                                                                 |                        | Performance |           | Viva-Voce (%) |
|       |                                                                                 |                        | PRA* (%)    | PDA** (%) |               |
| 1     | Testing of Control Disc Braking system and Control Regenerative Braking system. | CO2                    | 60          | 30        | 10            |
| 2     | Testing of Motors.                                                              |                        |             |           |               |
| 3.    | Testing of automotive wiring system.                                            |                        |             |           |               |
| 4.    | Testing of Batteries used in EVs                                                | CO2, CO3               | 60          | 30        | 10            |
| 5.    | Speed control of Electrical Motors                                              |                        | 60          | 30        | 10            |
| 6.    | Connection of Electronic Control Unit components                                | CO4                    | 60          | 30        | 10            |
| 7.    | Troubleshooting of electronic control unit                                      |                        |             |           |               |
| 8.    | Impacts of G2V and V2G                                                          | CO 5                   | 30          | 60        | 10            |
| 9.    | Demonstration of Charging stations                                              |                        | 70          | 20        | 10            |

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

**Note:** This table can be used for both the end semester as well as progressive assessment of practicals. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student's performance.

**P) Suggested Instructional/Implementation Strategies:** Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

**Q) List of Major Laboratory Equipment, Tools and Software:**

| S. No. | Name of Equipment, Tools and Software                 | Broad Specifications                                                                                                | Relevant Experiment/Practical Number |
|--------|-------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|--------------------------------------|
| 1.     | Disc Braking and Regenerative braking system test rig | Test rig equipment for Demonstration of Disc Braking and Regenerative Braking system operation.                     | 1                                    |
| 2.     | Disc Braking System                                   | Test rig / Software for testing the performance of the disc braking system in Half step and Full step braking mode. | 1                                    |
| 3.     | Induction motor                                       | Induction motor For EV applications with testing kit                                                                | 2,5                                  |
| 4.     | Switched reluctance motor                             | Switched reluctance motor for EV applications with testing kit                                                      | 2,5                                  |

| S. No. | Name of Equipment, Tools and Software                                                                |  | Broad Spec                                                                                     |
|--------|------------------------------------------------------------------------------------------------------|--|------------------------------------------------------------------------------------------------|
| 5.     | Permanent magnet (PM) DC motors                                                                      |  | Permanent magnet (PM) DC motor with testing kit                                                |
| 6.     | Automotive wiring system                                                                             |  | Testing facility of automotive wiring /actual EV systems                                       |
| 7.     | Lithium Ion and Lead-acid Batteries                                                                  |  | 12V, 7Ah with testing setup.                                                                   |
| 8.     | Nickel-based batteries (metal hydride and cadmium battery).                                          |  | 12V, 7Ah with testing setup.                                                                   |
| 9.     | Battery tester                                                                                       |  | For testing battery parameters                                                                 |
| 10.    | Battery charger                                                                                      |  | Battery charger for EV                                                                         |
| 11.    | Battery Management System                                                                            |  | Training kit or simulation for BMS                                                             |
| 12.    | DC-DC Converter                                                                                      |  | 48V to 12V bidirectional DC-DC                                                                 |
| 13.    | Power Analyser                                                                                       |  | To observe the impacts of G2V                                                                  |
| 14.    | BMS setup                                                                                            |  | For Demonstration & training                                                                   |
| 15.    | DC power supply                                                                                      |  | 0-32V                                                                                          |
| 16.    | Charging Station Simulator                                                                           |  | For Demonstration & training                                                                   |
| 17.    | EC Unit with EV subsystems                                                                           |  | Electronic Control Unit Hardware demonstrating the Connection of components with EV subsystems |
| 18.    | Facility to demonstrate the impact of the Grid on Vehicle Charging and Vehicle Charging on the Grid. |  | -                                                                                              |

## R) Suggested Learning Resources:

### (a) Books:

| S. No. | Titles                                                                                                        | Author(s)                        | Publisher and Edition with ISBN                                                               |
|--------|---------------------------------------------------------------------------------------------------------------|----------------------------------|-----------------------------------------------------------------------------------------------|
| 1.     | Electric Vehicles: And the End of the ICE age                                                                 | Anupam Singh                     | Kindle Edition<br>ASIN: B07R3WFR28                                                            |
| 2.     | Wireless Power Transfer Technologies for Electric Vehicles (Key Technologies on New Energy Vehicles)          | Xi Zhang, Chong Zhu, Haitao Song | Springer Verlag, Singapore; 1st ed. 2022 edition (23 January 2022)<br>ISBN-13: 978-9811683473 |
| 3.     | Modern Electric, Hybrid Electric, and Fuel Cell Vehicles                                                      | EHSANI                           | CRC Press; Third edition (1 January 2019) ISBN-13: 978-0367137465                             |
| 4.     | Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles | John G. Hayes, G. Abas Goodarzi  | Wiley; 1st edition (26 January 2018)<br>ISBN-13: 978-1119063643                               |
| 5.     | New Perspectives on Electric Vehicles                                                                         | Marian Găiceanu (Editor)         | IntechOpen (30 March 2022)<br>ISBN-13: 978-1839696145                                         |

| S. No. | Titles                                                 | Author(s)                          | Publisher and Edition with ISBN                                                              |
|--------|--------------------------------------------------------|------------------------------------|----------------------------------------------------------------------------------------------|
| 6.     | Electric and Hybrid Vehicles,                          | Tom Denton, Taylor & Francis       | 2nd Edition (2020)<br>ISBN- 9780429296109                                                    |
| 7.     | Hybrid Electric Vehicles: Energy Management Strategies | S. Onori, L. Serrao and G. Rizzoni | Springer (2016)<br>ISBN: 978-1-4471-6781-5                                                   |
| 8.     | Electric & Hybrid Vehicles                             | A.K. Babu                          | Khanna Publishing House, New Delhi,<br>1st Edition (2018)<br>ISBN: 9789386173713, 9386173719 |
| 9.     | Power Electronics: Circuits, Devices and Applications, | Rashid, M. H.                      | Pearson, 3rd edition, (2013)<br>ASIN: B07HB3BM1W                                             |

**(b) Online Educational Resources:**

1. <https://www.energy.gov/eere/fuelcells/fuel-cell-systems>
2. <https://powermin.gov.in/en/content/electric-vehicle>
3. <https://www.iea.org/reports/electric-vehicles>
4. <https://www.oercommons.org/search?f.search=Electric+Vehicles>
5. <https://fame2.heavyindustries.gov.in/Index.aspx>

**Note:** Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

**(c) Others:**

1. Learning Packages on EV
2. EV Users' Guide
3. EV Manufacturers' Manual
4. EV Lab Manuals

\*\*\*\*\*

- A) **Course Code** : 2400604H(T2400604H/P2400604H/S2400604H)
- B) **Course Title** : Robotics (Advanced)
- C) **Pre- requisite Course(s)** : Robotics (Basic)
- D) **Rationale** :

Efficiency and quality are the demands of industry 4.0. Robotics is a constituent of Industry 4.0 which not only provides the former two but also is beneficial for hazardous and similar challenging situations. The use of robotic technology is developing at a very fast rate in all types of industries whether manufacturing, service or tertiary. Engineers should be competent to use the robotic technology for industry and society advantage. This course aims for the diploma engineers to have advanced skills in robotic applications and use in digital manufacturing.

- E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

**After completion of the course, the students will be able to-**

- CO-1** Plan the use of robots in engineering applications.
- CO-2** Elucidate the conceptual place of the robotic components for engineering processes.
- CO-3** Use robots for small automatic robotic applications.
- CO-4** Compute the economics associated with use of robots in industries.
- CO-5** Select appropriate robot for industrial requirements and other applications.

- F) **Suggested Course Articulation Matrix (CAM):**

| Course Outcomes (COs) | Programme Outcomes (POs)                        |                          |                                         |                           |                                                                           |                            |                            | Programme Specific Outcomes* (PSOs) |       |
|-----------------------|-------------------------------------------------|--------------------------|-----------------------------------------|---------------------------|---------------------------------------------------------------------------|----------------------------|----------------------------|-------------------------------------|-------|
|                       | PO-1<br>Basic and Discipline Specific Knowledge | PO-2<br>Problem Analysis | PO-3<br>Design/Development of Solutions | PO-4<br>Engineering Tools | PO-5<br>Engineering Practices for Society, Sustainability and Environment | PO-6<br>Project Management | PO-7<br>Life Long Learning | PSO-1                               | PSO-2 |
| CO-1                  | -                                               | -                        | 3                                       | -                         | 2                                                                         | -                          | 2                          |                                     |       |
| CO-2                  | -                                               | 2                        | 3                                       | 2                         | -                                                                         | -                          | -                          |                                     |       |
| CO-3                  | 3                                               | 2                        | 3                                       | -                         | -                                                                         | -                          | 2                          |                                     |       |
| CO-4                  | 3                                               | -                        | -                                       | 2                         | -                                                                         | -                          | -                          |                                     |       |
| CO-5                  | 3                                               | 2                        | -                                       | -                         | 2                                                                         | -                          | -                          |                                     |       |

**Legend:** High (3), Medium (2), Low (1) and No mapping (-)

\* PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

- G) **Teaching & Learning Scheme:**

| Course Code | Course Title        | Scheme of Study (Hours/Week) |   |                      |                         |                           |                   |
|-------------|---------------------|------------------------------|---|----------------------|-------------------------|---------------------------|-------------------|
|             |                     | Classroom Instruction (CI)   |   | Lab Instruction (LI) | Notional Hours (TW+ SL) | Total Hours (CI+LI+TW+SL) | Total Credits (C) |
|             |                     | L                            | T |                      |                         |                           |                   |
| 2400604H    | Robotics (Advanced) | 03                           | - | 04                   | 02                      | 09                        | 06                |

**Legend:**

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances/ problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

**Note:** TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

**H) Assessment Scheme:**

| Course Code | Course Title        | Assessment Scheme (Marks)           |                             |                                            |          |                                  |                                 | Total Marks (TA+TWA+LA) |
|-------------|---------------------|-------------------------------------|-----------------------------|--------------------------------------------|----------|----------------------------------|---------------------------------|-------------------------|
|             |                     | Theory Assessment (TA)              |                             | Term Work & Self-Learning Assessment (TWA) |          | Lab Assessment (LA)              |                                 |                         |
|             |                     | Progressive Theory Assessment (PTA) | End Theory Assessment (ETA) | Internal                                   | External | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |                         |
| 2400604H    | Robotics (Advanced) | 30                                  | 70                          | 20                                         | 30       | 20                               | 30                              | 200                     |

**Legend:**

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

**Note:**

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done internally (40%) as well as externally (60%). Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

**I) Course Curriculum Detailing:** This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

**J) Theory Session Outcomes (TSOs) and Units: T2400604H**

| Major Theory Session Outcomes (TSOs)                                                                                                                                                                                                                                                                                                                       | Units                                                                                                                                                                                                                                                                                             | Relevant COs Number(s) |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| TSO 1a. Define the need and scope of industrial robots.<br>TSO 1b. Describe the concept of robot dynamics with regards to methods for orientation and location of objects.<br>TSO 1c. Analyse robot direct kinematics for the given 2 DOF planar manipulator.<br>TSO 1d. List types of robots<br>TSO 1e. List safety steps while handling the given robot. | <b>Unit-1.0 Robot Kinematics, Dynamics and Industrial Applications</b><br><br>1.1 Definition need and scope of Industrial robots<br>1.2 Robot dynamics – Methods for orientation and location of objects<br>1.3 Planar Robot Kinematics – Direct and inverse kinematics for 2 Degrees of Freedom. | CO2, CO3               |

| Major Theory Session Outcomes (TSOs)                                                                                        | Units                                                                                                                                                                                                                      | Relevant COs Number(s) |
|-----------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| TSO 1f. Interface robots with the given welding machine.                                                                    | 1.4 Safety while operating and handling robot                                                                                                                                                                              |                        |
| TSO 1g. Interface robots with the given painting machine.                                                                   | 1.5 Robot Industrial applications:                                                                                                                                                                                         |                        |
| TSO 1h. Interface robots with the given assembly machine.                                                                   | <ul style="list-style-type: none"> <li>Welding Robots-Welding Guns, Welding Electrodes, Welding Power Sources, shielding gases, Robot interfacing</li> <li>Spray painting Robots, assembly operation, cleaning.</li> </ul> |                        |
| TSO 2a. Explain the techniques to control robot motion.                                                                     | <b>Unit– 2.0 Robot Drives, Control and Material Handling</b>                                                                                                                                                               | <b>CO2, CO3</b>        |
| TSO 2b. Describe the given robot drive system.                                                                              | 2.1 Controlling the Robot motion.                                                                                                                                                                                          |                        |
| TSO 2c. Describe the types of grippers.                                                                                     | 2.2 Position and velocity sensing devices.                                                                                                                                                                                 |                        |
| TSO 2d. Design grippers for specific application.                                                                           | 2.3 Drive systems – Hydraulic and Pneumatic drives                                                                                                                                                                         |                        |
| TSO 2e. Test the designed gripper for the application.                                                                      | 2.4 Linear and rotary actuators and control valves                                                                                                                                                                         |                        |
| TSO 2f. Use Bar code technology for robotic applications.                                                                   | 2.5 Electro hydraulic servo valves, electric drives, motors                                                                                                                                                                |                        |
| TSO 2g. Integrate radio frequency identification technology in robotic applications.                                        | 2.6 End effectors – Vacuum, magnetic and air operated grippers                                                                                                                                                             |                        |
| TSO 2h. Assemble an automated guided vehicle for the given situation using standard components.                             | 2.7 Material Handling; automated guided vehicle systems, automated storage and retrieval systems (ASRS)                                                                                                                    |                        |
| TSO 2i. Assemble a simple automated storage and retrieval systems (ASRS) for the given situation using standard components. | 2.8 Bar code technology                                                                                                                                                                                                    |                        |
|                                                                                                                             | 2.9 Radio frequency identification technology.                                                                                                                                                                             |                        |
| TSO 3a. Differentiate between various work cell layouts.                                                                    | <b>Unit– 3.0 Robot Cell Design and Application</b>                                                                                                                                                                         | <b>CO3</b>             |
| TSO 3b. Select work cell for specific robot with justification.                                                             | 3.1 Robot work cell design, control and safety                                                                                                                                                                             |                        |
| TSO 3c. Analyse robot cycle time.                                                                                           | 3.2 Robot cell layouts                                                                                                                                                                                                     |                        |
| TSO 3d. Explain industrial applications of robotic cell.                                                                    | 3.3 Multiple Robots and machine interference                                                                                                                                                                               |                        |
| TSO 3e. Follow safety procedures in robotic cell.                                                                           | 3.4 Robot cycle time analysis                                                                                                                                                                                              |                        |
|                                                                                                                             | 3.5 Industrial application of robotic cells                                                                                                                                                                                |                        |
| TSO 4a. List different programming languages for the robots                                                                 | <b>Unit– 4.0 Robot Programming and Economics of Robotization</b>                                                                                                                                                           | <b>CO1, CO4, CO5</b>   |
| TSO 4b. Describe artificial intelligence                                                                                    | 4.1 Characteristics of task level languages through programming methods                                                                                                                                                    |                        |
| TSO 4c. Write a programme in the required language to operate a robot for the given task.                                   | 4.2 Motion interpolation                                                                                                                                                                                                   |                        |
| TSO 4d. Optimise robot programming parameters.                                                                              | 4.3 Artificial intelligence: Goals of artificial intelligence, AI techniques, problem representation in AI                                                                                                                 |                        |
| TSO 4e. Select a robot on the basis of cycle time analysis.                                                                 | 4.4 Problem reduction and solution techniques.                                                                                                                                                                             |                        |
| TSO 4f. Conduct an economic analysis for use of robots.                                                                     | 4.5 Application of AI and KBES in Robots                                                                                                                                                                                   |                        |
| TSO 4g. Follow testing methods and acceptance rules for industrial robots.                                                  | 4.6 Selection of Robots; Factors influencing the choice of a robot, selection of robot components, robot performance testing, work cycle time analysis                                                                     |                        |
|                                                                                                                             | 4.7 Economics analysis for robotics, cost data required for the analysis                                                                                                                                                   |                        |
|                                                                                                                             | 4.8 Methods of economic analysis; Pay back method, equivalent uniform annual cost method, return on investment method.                                                                                                     |                        |
|                                                                                                                             | 4.9 Testing methods and acceptance rules for industrial robots                                                                                                                                                             |                        |

| Major Theory Session Outcomes (TSOs)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Units                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Relevant COs Number(s) |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| TSO 5a. Describe applications of robots in healthcare and medicine.<br>TSO 5b. Describe applications of robots in Construction industry.<br>TSO 5c. Describe applications of robots in Underground coal mining.<br>TSO 5d. Describe applications of robots in utilities, military & firefighting operations.<br>TSO 5e. Describe applications of robots in undersea and space<br>TSO 5f. Describe applications of robots in brief in logistics, retail and hospitality, and smart cities.<br>TSO 5g. Describe applications of robots in farming and agriculture in brief<br>explain in brief the use of microrobots, nano robots, soft robots, humanoid robots | <b>Unit-5.0 Applications in Non-manufacturing Environments</b><br><br>5.1 Applications of Robots in <ul style="list-style-type: none"> <li>Healthcare and medicine</li> <li>Construction industry</li> <li>Underground coal mines</li> <li>Utilities, military &amp; firefighting operations</li> <li>Undersea</li> <li>Space</li> <li>Logistics,</li> <li>Retail and Hospitality</li> <li>Smart Cities</li> <li>Farming and Agriculture</li> </ul> 5.2 Overview of Microrobots, nano robots, soft robots, humanoid robots | <b>CO5</b>             |

**Note:** One major TSO may require more than one Theory session/Period.

### K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400604H

| Practical/Lab Session Outcomes (LSOs)                                                                                                                                                                               | S. No. | Laboratory Experiment/Practical Titles                                                  | Relevant COs Number(s) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------------------------------------------------------------------------------|------------------------|
| LSO 1.1 Identify Wireless Sensor Network.<br>LSO 1.2 Use wireless sensor Network for different robotic applications                                                                                                 | 1.     | Identify different wireless sensor network in robotics viz. ZigBee, LoRa.               | CO1, CO3               |
| LSO 2.1 Identify different Radio Frequency (RF) Controlled Wireless<br>LSO 2.2 Use Radio Frequency (RF) Controlled Wireless for different robotic applications.                                                     | 2.     | Use different Radio Frequency (RF) Controlled Wireless Robots.                          | CO1, CO2               |
| LSO 3.1 Identify the different Voice operated robot with speaker identification technology<br>LSO 3.2 Use different Voice operated robot with speaker identification technology for different robotic applications. | 3.     | Examine different voice operated robot with speaker identification technology.          | CO1, CO3               |
| LSO 4.1 Identify the components required for a computer-controlled pick and place robot (wireless).<br>LSO 4.2 Integrate the components for the required application.                                               | 4.     | Design a computer-controlled pick and place robot (wireless)                            | CO1                    |
| LSO 5.1 Identify the components required for a Zigbee controlled Boat with wireless video and voice transmission.<br>LSO 5.2 Integrate the components for the required application.                                 | 5.     | Design a Zigbee controlled Boat with wireless video and voice transmission.             | CO2, CO3               |
| LSO 6.1 Identify the components required for a PC controlled wireless Multipurpose robot for engineering applications.<br>LSO 6.2 Integrate the components for the required application.                            | 6.     | Design a PC controlled wireless Multipurpose robot for simple engineering applications. | CO2, CO4, CO5          |
| LSO 7.1 Identify the components required for an unmanned arial photography                                                                                                                                          | 7.     | Design an unmanned arial photography system.                                            | CO3, CO5               |

| Practical/Lab Session Outcomes (LSOs)                                                                                                                                          | S. No. | Laboratory Experiment/Practical Titles                                                              | Relevant COs Number(s) |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------------------------------------------------------------------------------------------|------------------------|
| LSO 7.2 Integrate the components for the required application.                                                                                                                 |        |                                                                                                     |                        |
| LSO 8.1 Develop a program<br>LSO 8.2 Simulate palletizing and depalletizing operations through robots.                                                                         | 8.     | Develop program for real time (online TPP) Palletizing and Depalletizing operations through robots. | CO5                    |
| LSO 9.1 Develop a program<br>LSO 9.2 Simulate direction control and step control logic for robotization                                                                        | 9.     | Develop TPP / Offline program for vision-based inspection for robots.                               | CO4, CO5               |
| LSO 10.1 Develop a program<br>LSO 10.2 Simulate robotising an inspection and part assembly.                                                                                    | 10.    | Program and simulate coordinated identification, inspection and part assembly for robots.           | CO1, CO5               |
| LSO 11.1 Develop a program.<br>LSO 11.2 Simulate obstacle avoidance of robots.                                                                                                 | 11.    | Develop obstacle avoidance robot Programming                                                        | CO1, CO5               |
| LSO 12.1 PLC programming.<br>LSO 12.2 Simulate robotising of welding operation.                                                                                                | 12.    | Program and simulate welding operation using robot simulation software.                             | CO1, CO5               |
| LSO 13.1 Simulate robotising of drilling operation.                                                                                                                            | 13.    | TPP / Offline program for drilling operation.                                                       | CO1, CO5               |
| LSO 14.1 Develop a program for an industrial application.<br>LSO 14.2 Execute the robot programme.                                                                             | 14.    | Program to execute an industrial robot application using a given configuration.                     | CO1, CO5               |
| LSO 15.1 Use robot simulation software for Direct Kinematic analysis upto 4-axis robots<br>LSO 15.2 Correlate the simulated results with respective mathematical calculations. | 15.    | Analyse Direct Kinematics of 4-axis robot using available software.                                 | CO2                    |

**L) Suggested Term Work and Self Learning: S2400604H** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

- a. Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.
- b. Micro Projects:** A suggestive list of micro-projects is given here. Similar micro-projects that match the COs could be added by the concerned course teacher. The student should strive to identify eco-friendly or recycled material prior to selection for robotic applications.
  1. Develop coin separating robot.
  2. Develop robot using radio frequency sensors for material handling.
  3. Develop robot for land mine detection.
  4. Develop a robot for car washing.
- c. Other Activities:**
  1. Seminar Topics: Recent developments in the industrial applications of robotics
  2. Visits: Visit a robotic exhibition.
  3. Case Study: Identify a robotic application in automobiles and present a case study
  4. Download videos related to simple robotic applications in domestic and industrial purposes.
  5. Self-Learning Topics:
    - Robotic component manufacturers

**M) Suggested Course Evaluation Matrix:** The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate CO attainment.

| COs         | Course Evaluation Matrix                                  |                             |                                       |                |                   |                                  |                                 |
|-------------|-----------------------------------------------------------|-----------------------------|---------------------------------------|----------------|-------------------|----------------------------------|---------------------------------|
|             | Theory Assessment (TA)**                                  |                             | Term Work Assessment (TWA)            |                |                   | Lab Assessment (LA)#             |                                 |
|             | Progressive Theory Assessment (PTA)<br>Class/Mid Sem Test | End Theory Assessment (ETA) | Term Work & Self- Learning Assessment |                |                   | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |
|             |                                                           |                             | Assignments                           | Micro Projects | Other Activities* |                                  |                                 |
| CO-1        | 25%                                                       | 23%                         | 20%                                   | 10%            | 25%               | 10%                              | 20%                             |
| CO-2        | 20 %                                                      | 23%                         | 20%                                   | 10%            | 25%               | 20%                              | 20%                             |
| CO-3        | 15%                                                       | 17%                         | 20%                                   | 25%            | 25%               | 20%                              | 20%                             |
| CO-4        | 20%                                                       | 20%                         | 20%                                   | 15%            | 25%               | 20%                              | 20%                             |
| CO-5        | 20%                                                       | 17%                         | 20%                                   | 40%            | --                | 30%                              | 20%                             |
| Total Marks | 30                                                        | 70                          | 20                                    | 20             | 10                | 20                               | 30                              |
|             |                                                           |                             | 50                                    |                |                   |                                  |                                 |

**Legend:**

\*: Other Activities include self-learning, seminar, visits, surveys, product development, software development etc.

\*\*: Mentioned under point- (N)

#: Mentioned under point-(O)

**Note:**

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

**N) Suggested Specification Table for End Semester Theory Assessment:** Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

| Unit Number and Title                                           | Total Classroom Instruction (CI) Hours | Relevant COs Number (s) | Total Marks | ETA (Marks)  |                   |                         |
|-----------------------------------------------------------------|----------------------------------------|-------------------------|-------------|--------------|-------------------|-------------------------|
|                                                                 |                                        |                         |             | Remember (R) | Understanding (U) | Application & above (A) |
| Unit-1.0 Robot Kinematics, Dynamics and Industrial Applications | 12                                     | CO2, CO3                | 16          | 6            | 5                 | 5                       |
| Unit- 2.0 Robot Drives, Control and Material Handling           | 10                                     | CO2, CO3                | 16          | 4            | 8                 | 4                       |
| Unit- 3.0 Robot Cell Design and Application                     | 8                                      | CO3                     | 12          | 2            | 4                 | 6                       |
| Unit- 4.0 Robot Programming and Economics of Robotization       | 10                                     | CO1, CO4, CO5           | 14          | 4            | 4                 | 6                       |
| Unit- 5.0 Applications in Non-manufacturing Environments        | 8                                      | CO5                     | 12          | 4            | 4                 | 4                       |
| Total Marks                                                     | 48                                     |                         | 70          | 20           | 25                | 25                      |

**Note:** Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

**O) Suggested Assessment Table for Laboratory (Practical):**

| S. No. | Laboratory Practical Titles                                                                         | Relevant COs Number(s) | PLA/ELA     |           |               |
|--------|-----------------------------------------------------------------------------------------------------|------------------------|-------------|-----------|---------------|
|        |                                                                                                     |                        | Performance |           | Viva-Voce (%) |
|        |                                                                                                     |                        | PRA* (%)    | PDA** (%) |               |
| 1.     | Identify different wireless sensor network in robotics viz. ZigBee, LoRa.                           | CO1, CO3               | 40          | 50        | 10            |
| 2.     | Use different Radio Frequency (RF) Controlled Wireless Robots.                                      | CO1, CO2               | 40          | 50        | 10            |
| 3.     | Examine different voice operated robot with speaker identification technology.                      | CO1, CO3               | 40          | 50        | 10            |
| 4.     | Design a computer-controlled pick and place robot (wireless)                                        | CO1, CO4               | 40          | 50        | 10            |
| 5.     | Design a Zigbee controlled Boat with wireless video and voice transmission.                         | CO2, CO3               | 40          | 50        | 10            |
| 6.     | Design a PC controlled wireless Multipurpose robot for simple engineering applications.             | CO3, CO4               | 40          | 50        | 10            |
| 7.     | Design an unmanned arial photography system.                                                        | CO3, CO5               | 40          | 50        | 10            |
| 8.     | Develop program for real time (online TPP) Palletizing and Depalletizing operations through robots. | CO5                    | 40          | 50        | 10            |
| 9.     | Develop TPP / Offline program for vision-based inspection for robots.                               | CO4, CO5               | 40          | 50        | 10            |
| 10.    | Program and simulate coordinated identification, inspection and part assembly for robots.           | CO1, CO5               | 40          | 50        | 10            |
| 11.    | Develop Obstacle avoidance robot Programming                                                        | CO1, CO5               | 40          | 50        | 10            |
| 12.    | Program and simulate welding operation using robot simulation software.                             | CO1, CO5               | 40          | 50        | 10            |
| 13.    | TPP / Offline program for drilling operation.                                                       | CO1, CO5               | 40          | 50        | 10            |
| 14.    | Program to execute an industrial robot application using a given configuration.                     | CO1, CO5               | 40          | 50        | 10            |
| 15.    | Analyse Direct Kinematics of 4-axis robot using available software.                                 | CO2, CO3               | 40          | 50        | 10            |

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

**Note:** This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

**P) Suggested Instructional/Implementation Strategies:** Different Instructional/Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Portfolio Based Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field, Information and Communications Technology (ICT) Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Sessions, Video Clippings, Use of Open Educational Resources(OER), MOOCs etc.

## Q) List of Major Laboratory Equipment, Tools and Software:

| S. No. | Name of Equipment, Tools and Software                                              | Broad Specifications                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Relevant Experiment/<br>Practical Number |
|--------|------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|
| 1.     | 6 Axis Articulated Robot (Material Handling)- 1 No                                 | <ul style="list-style-type: none"> <li>Articulated Type</li> <li>Controlled axis: 6-axes (J1, J2, J3, J4, J5, J6)</li> <li>Reach: 717 mm</li> <li>Installation Floor, Upside-down (Angle mount)</li> <li>Motion range (Maximum Speed) <ul style="list-style-type: none"> <li>J1 Axis Rotation 7.85 rad/s</li> <li>J2 Axis Rotation 6.63 rad/s</li> <li>J3 Axis Rotation 9.08 rad/s</li> <li>J4 Axis Rotation 9.60 rad/s</li> <li>J5 Axis Rotation 9.51 rad/s</li> <li>J6 Axis Rotation 17.45 rad/s</li> </ul> </li> <li>Max. load capacity Wrist: 4Kg</li> <li>Allowable Load moment 16.6 N-m at wrist J4 Axis, J5 Axis, J6 Axis</li> <li>Allowable Load inertia).47 kg-m<sup>2</sup> at wrist J4 Axis J5 Axis, J6 Axis</li> <li>Repeatability: +/- 0.05mm</li> <li>Mass: 21 Kg Minimum</li> <li>Installation environment: Ambient temperature: 0 – 45°C</li> <li>Ambient humidity: Normally 75%RH or less. No dew, nor frost allowed.</li> <li>Vibration Acceleration: 4.9 m/s<sup>2</sup> (0.5G or less)</li> </ul> | 1, 2, 3, 12                              |
| 2.     | 6 Axis Articulated Robot (General Purpose-Welding, Assembly, Drilling) - 1 No      | Link 1: 300 mm Link 2: 300 mm Joint actuator: DC Stepper Motor Transmission: Timing Belt Drive Position feedback: Proximity Switch Gripper actuator: Pneumatic Weight of robot: 50 Kg. Accuracy: ±0.3 Repeatability: ±0.2 Tip Velocity range: 500 mm / min Pay load capacity: 2 kg (including gripper) J1 - Waist: ± 140° J2 - Shoulder: - 100 - 60° J3 - Elbow: - 70 + 10° J4 - Wrist rotate: ± 70° J5 - Wrist pitch: ± 35° J6 - Wrist roll: ± 180° External I/O 8 Programmable digital inputs 8 Programmable digital outputs                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 8, 9, 14                                 |
| 3.     | A mounted vision system with software (Free open source Robot simulation software) | Integrity Serial Bus System, CAN to Build Intelligent Device Network, Open Hardware Platform, Arduino, to control Robot sub-Systems of motor-sensor, movable Omni Wheel of Omni-Directional, Actuator operation control by DC Encoder Motor, DC-Motor control and operation by Accelerometer, Gyro, Ultrasonic and PSD sensor, Androx Studio; brushless ILM 70×10 Robo Drive DC motor; sensor-actuator units of ARMAR-4; SD-25-160-2A-GR-BB Harmonic Drive reduction gear unit high gear ratio of 160: 1; structural parts (white) are made out of high-strength aluminum, Hollow shaft with strain gauges for torque sensing, motor's magnetic incremental encoder (AMS5306), digital buses (SPI or 12C); Motor interface PCB includes a 13-Bit temperature-to-digital converter with a temperature range from -40°C to 125°C (Analog Devices ADT7302)                                                                                                                                                               | 3, 4, 5, 11                              |
| 4.     | 6-axis Robotics Trainer                                                            | Programmable robotic arm with an interactive front panel. Software to demonstrates functioning of the trainer as well as allows a user to develop their own                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 3, 4, 5, 13                              |

| S. No. | Name of Equipment, Tools and Software |   | Broad Specification                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|--------|---------------------------------------|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|        |                                       |   | programs. NV330; 8 bit microprocessors; Record and Playback; interfacing with PLC; Touch operation; Auto set to home position; developed; Data acquisition using                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 5.     | E-Yantra Firebird kit                 | • | <ul style="list-style-type: none"> <li>• Fire Bird V 2560 Robot</li> <li>• Spark V Robot</li> <li>• Fire Bird V P89V51RD2 adapter</li> <li>• Fire Bird V LPC2148 adapter</li> <li>• LSM303 3 axis digital accelerometer magnetometers</li> <li>• L3G4200 3 axis digital gyroscope</li> <li>• Gyroscope, accelerometer module for the robot</li> <li>• GPS receiver</li> <li>• Zigbee Modules 100m range</li> <li>• Zigbee Modules Adapter</li> <li>• Metal-gear Servo Motors</li> <li>• Servo Motor Based Gripper robot</li> <li>• Sharp infrared range sensor</li> <li>• Arduino Uno/Nano</li> <li>• Hexapod</li> <li>• 16 Programming Software Boot loader, Flash Magic)</li> </ul> |
| 6.     | Robot simulator for Robotics          |   | Educational networking licensed simulation software                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| 7.     | Assorted sensors                      |   | Optical encoders, Acoustic sensors, RTD, Thermistor, strain gauge, p                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 8.     | Vision equipment                      |   | Camera, Imaging Components: F Volume Sensors                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 9.     | Raspberry Pi kit                      |   | 1.2GHz quad-core Broadcom BCM2835 DDR2 RAM with in-built Wi-Fi & Bluetooth 3D graphics core 40 pin extended pins Micro SD slot Multiple ports sized HDMI, four pole stereo video port, CSI camera port and BaseT Ethernet Micro-USB, power                                                                                                                                                                                                                                                                                                                                                                                                                                            |

## R) Suggested Learning Resources:

## (a) Books:

| S. No. | Titles                                         | Author(s)                 | Publisher and Edition with ISBN                                   |
|--------|------------------------------------------------|---------------------------|-------------------------------------------------------------------|
| 1.     | Introduction to Robotics Mechanics and Control | John Craig                | Pearson Education<br>978-9356062191                               |
| 2.     | Robotics and controls                          | Mittal R.K., Nagrath I.J. | Tata McGraw Hill Education Pvt. Ltd.;<br>2017; 978-0070482937     |
| 3.     | Robotics and Image Processing: An Introduction | Janaki Raman. P. A        | Tata McGraw Hill Publishing company<br>Ltd., 1998; 978-0074621677 |

| S. No. | Titles                                                        | Author(s)                                                                | Publisher and Edition with ISBN                        |
|--------|---------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------|
| 4.     | Industrial Robotics -Technology, Programming and Applications | Nicholas Odrey, Mitchell Weiss, Mikell Groover Roger Nagel, Ashish Dutta | McGraw Hill Education; 2nd Edition; 978 -1259006210    |
| 5.     | Robotic Engineering: an integrated approach                   | Richard D. Klafter, Thomas A. Thomas A. Chmielewski, Michael Negin       | Prentice Hall of India, N. Delhi, 2009; 978-8120308428 |
| 6.     | Industrial Robotics Technology, Programming and Applications  | Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey     | McGraw-Hill Education, Second Edition 978-1259006210   |
| 7.     | Robotics                                                      | Appuu Kuttan K. K.                                                       | Dreamtech Press, First Edition, 2020, 978-9389583281   |
| 8.     | Introduction to Robotics: Analysis, Control, Applications     | Saeed B. Niku                                                            | Wiley; Second Edition, 978-8126533121                  |
| 9.     | Essentials of Robotics Process Automation                     | S. Mukherjee                                                             | Khanna Publication, First Edition, 978-9386173751      |
| 10.    | Robotics                                                      | R R Ghorpade, M M Bhoomkar                                               | Nirali Prakashan 978-9388897020                        |

**(b) Online Educational Resources:**

1. <https://web.iitd.ac.in/~saha/ethiopia/appln.pdf>
2. <https://nptel.ac.in/courses/112105249>
3. <https://www.robotsscience.com/industrial/industrial-robots-types-applications-benefits-and-future/>
4. [https://www.marian.ac.in/public/images/uploads/pdf/online-class/MODULE-6%20ROBOTICS%20INDL\\_APPLNS-converted.pdf](https://www.marian.ac.in/public/images/uploads/pdf/online-class/MODULE-6%20ROBOTICS%20INDL_APPLNS-converted.pdf)
5. <https://forcedesign.biz/blog/5-common-industrial-robot-applications>
6. <https://www.hitechnectar.com/blogs/top-industrial-robotics-applications-role-of-robots-in-manufacturing/> <http://www.robotics.org/>
7. [https://en.wikipedia.org/wiki/Industrial\\_robot](https://en.wikipedia.org/wiki/Industrial_robot)
8. <https://www.youtube.com/watch?v=fH4VwTgfyRQ>
9. [https://www.youtube.com/watch?v=aW\\_BM\\_S0z4k](https://www.youtube.com/watch?v=aW_BM_S0z4k)
10. <https://www.automate.org/industry-insights/smarter-robot-grasping-with-sensors-software-the-cloud>
11. <https://robots.ieee.org/robots/?t=all>
12. [https://www.youtube.com/watch?v=fc\\_Cynqr6jM](https://www.youtube.com/watch?v=fc_Cynqr6jM)

**Note:** Teachers are requested to check the creative commons license status/ financial implications of the suggested OER, before use by the students.

**(c) Others:****1. Learning Packages:**

- <https://www.edx.org/learn/robotics>
- <https://www.coursera.org/courses?query=robotics>
- <https://www.udemy.com/topic/robotics/>
- <https://library.e.abb.com/public/9a0dacfddec8aa03dc12578ca003bfd2a/Learn%20with%20ABB.%20Robotics%20package%20for%20education.pdf>

**2. Users' Guide:**

- <https://roboindia.com/store/DIY-do-it-your-self-educational-kits-robotics-embedded-system-electronics>
- <https://www.robomart.com/diy-robotic-kits>
- <https://www.scientechworld.com/robotics>

**3. Lab Manuals:**

- [http://www-cvr.ai.uiuc.edu/Teaching/ece470/docs/ROS\\_LabManual.pdf](http://www-cvr.ai.uiuc.edu/Teaching/ece470/docs/ROS_LabManual.pdf)
- <https://www.jnec.org/labmanuals/mech/be/sem1/Final%20Year%20B.Tech-ROBOTICS%20LAB%20%20MANUAL.pdf>

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- A) **Course Code** : 2400604I(T2400604I/P2400604I/S2400604I)
- B) **Course Title** : Transformer Manufacturing and Repairing (Advanced)
- C) **Pre- requisite Course(s)** : Transformer Manufacturing and Repairing (Basic)
- D) **Rationale** :

Transformers are an essential component in Power systems. They help transmit electrical energy at various voltage and current levels to minimize losses and achieve other technical objectives. They are rated from a few kVA to large MVA. Power systems are growing to meet the increased demand. Hence, the manufacturing of new transformers and repair of existing transformers are vital. This advanced course will help the students understand the concepts of manufacturing and repair of transformers at par with the industries. The knowledge gained through this course will help the students choose their career in transformer manufacturing and repair.

- E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

**After completion of the course, the students will be able to-**

- CO-1** Analyze the materials used in transformer manufacturing.
- CO-2** Assemble the transformer based on specific requirements.
- CO-3** Design using software based on specific requirements.
- CO-4** Analyze the working conditions of transformers.
- CO-5** Apply the concepts for practical use.

- F) **Suggested Course Articulation Matrix (CAM):**

| Course Outcomes (COs) | Programme Outcomes(POs)                         |                          |                                          |                           |                                                                           |                            |                            | Programme Specific Outcomes* (PSOs) |       |
|-----------------------|-------------------------------------------------|--------------------------|------------------------------------------|---------------------------|---------------------------------------------------------------------------|----------------------------|----------------------------|-------------------------------------|-------|
|                       | PO-1<br>Basic and Discipline Specific Knowledge | PO-2<br>Problem Analysis | PO-3<br>Design/ Development of Solutions | PO-4<br>Engineering Tools | PO-5<br>Engineering Practices for Society, Sustainability and Environment | PO-6<br>Project Management | PO-7<br>Life Long Learning | PSO-1                               | PSO-2 |
| CO-1                  | 3                                               | -                        | -                                        | -                         | 2                                                                         | -                          | 3                          |                                     |       |
| CO-2                  | 3                                               | 3                        | 2                                        | 2                         | 2                                                                         | -                          | 3                          |                                     |       |
| CO-3                  | 3                                               | 2                        | 2                                        | 2                         | -                                                                         | -                          | 3                          |                                     |       |
| CO-4                  | 3                                               | 1                        | 1                                        | 1                         | 1                                                                         | -                          | 3                          |                                     |       |
| CO-5                  | 3                                               | 2                        | 3                                        | 3                         | 3                                                                         | 1                          | 3                          |                                     |       |

Legend: High (3), Medium (2), Low (1) and No mapping (-)

\* PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

- G) **Teaching & Learning Scheme:**

| Course Code | Course Title                                       | Scheme of Study (Hours/Week) |   |                      |                         |                           |                   |
|-------------|----------------------------------------------------|------------------------------|---|----------------------|-------------------------|---------------------------|-------------------|
|             |                                                    | Classroom Instruction (CI)   |   | Lab Instruction (LI) | Notional Hours (TW+ SL) | Total Hours (CI+LI+TW+SL) | Total Credits (C) |
|             |                                                    | L                            | T |                      |                         |                           |                   |
| 2400604     | Transformer Manufacturing and Repairing (Advanced) | 03                           | - | 04                   | 02                      | 09                        | 06                |

**Legend:**

- CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)
- LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)
- Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.
- TW: **Term Work** (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)
- SL: Self Learning, MOOCs, spoken tutorials, **online educational resources** etc.
- C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)
- Note:** **TW** and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

**H) Assessment Scheme:**

| Course Code | Course Title                                       | Assessment Scheme (Marks)           |                             |                                            |          |                                  |                                 | Total Marks (TA+TWA+LA) |
|-------------|----------------------------------------------------|-------------------------------------|-----------------------------|--------------------------------------------|----------|----------------------------------|---------------------------------|-------------------------|
|             |                                                    | Theory Assessment (TA)              |                             | Term Work & Self-Learning Assessment (TWA) |          | Lab Assessment (LA)              |                                 |                         |
|             |                                                    | Progressive Theory Assessment (PTA) | End Theory Assessment (ETA) | Internal                                   | External | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |                         |
| 2400604     | Transformer Manufacturing and Repairing (Advanced) | 30                                  | 70                          | 20                                         | 30       | 20                               | 30                              | 200                     |

**Legend:**

- PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)
- PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)
- TWA:** Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.)

**Note:**

- Separate passing is must for progressive and end semester assessment for both theory and practical.
- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

- I) Course Curriculum Detailing:** This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, **Society connect**, Indian Knowledge System (IKS) and others must be integrated appropriately.

## J) Theory Session Outcomes (TSOs) and Units: T2400604I

| Major Theory Session Outcomes (TSOs)                                                                                                                                                                                                                                                                                                                    | Units                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Relevant COs Number(s) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| <p><i>TSO 1a.</i> Explain the use of different materials in transformers.</p> <p><i>TSO 1b.</i> List the various types of materials used in transformers.</p> <p><i>TSO 1c.</i> Explain the insulating materials.</p> <p><i>TSO 1d.</i> Explain the winding material.</p> <p><i>TSO 1e.</i> Explain the magnetic materials.</p>                         | <p><b>Unit-1.0 Transformer Materials</b></p> <p>1.1 Review of basic materials and their processing</p> <p>1.2 Insulating oil, insulating paper, pressboard, wood</p> <p>1.3 Insulated copper conductor for windings, crepe paper, sealing materials</p> <p>1.4 cold-rolled grain oriented electrical steel sheet, structural steel, future trends</p> <p>1.5 Magnetic Circuit Materials</p>                                                                   | CO1                    |
| <p><i>TSO 2a.</i> Explain the basic concept of transformer design.</p> <p><i>TSO 2b.</i> List the various parameters to be considered during design.</p> <p><i>TSO 2c.</i> Choose the number of turns, the core diameter.</p> <p><i>TSO 2d.</i> Select the winding wires and strips.</p> <p><i>TSO 2e.</i> Choose the size of HV and LV conductors.</p> | <p><b>Unit-2.0 Transformer Design</b></p> <p>2.1 Basic Concept of Design.</p> <p>2.2 Selection of number of turns.</p> <p>2.3 Selection of core diameter.</p> <p>2.4 Selection of winding wires and strips.</p> <p>2.5 Size HV and LV conductors.</p> <p>2.6 Transposition</p>                                                                                                                                                                                | CO1, CO2               |
| <p><i>TSO 3a.</i> Explain the concept of computer aided design.</p> <p><i>TSO 3b.</i> Learn the programming skills,</p> <p><i>TSO 3c.</i> Modify the programming considering other aspects.</p> <p><i>TSO 3d.</i> Validate and print the design.</p> <p><i>TSO 3e.</i> Use software to design.</p>                                                      | <p><b>Unit-3.0 Transformer Design – Using CAD</b></p> <p>3.1 Computer aided design: Basic concept, specification needs.</p> <p>3.2 Computer programming, variable inputs, program convergence.</p> <p>3.3 Design output, design modification, other aspects of design.</p> <p>3.4 Design validation, design package, computer design printout.</p> <p>3.5 Software application for design.</p>                                                                | CO3, CO4               |
| <p><i>TSO 4a.</i> Explain the testing of Transformer oil.</p> <p><i>TSO 4b.</i> Use of Transformer oil.</p> <p><i>TSO 4c.</i> List the causes of oil ageing.</p> <p><i>TSO 4d.</i> List the various tests to monitor the working conditions of a transformer.</p>                                                                                       | <p><b>Unit-4.0 Transformer Condition Monitoring</b></p> <p>4.1 Transformer oil testing and Interpretation</p> <p>4.2 Introduction, mineral insulating oil.</p> <p>4.3 Four functions of transformer oil.</p> <p>4.4 Causes of oil ageing.</p> <p>4.5 Various tests on transformer oil such as power factor, moisture, neutralization number, interfacial tension, relative density, color, visual examination, breakdown voltage, dissolved gas analysis.</p> | CO3, CO4               |
| <p><i>TSO 5a.</i> Apply the concepts for practical use.</p> <p><i>TSO 5b.</i> Design a practical power transformer.</p>                                                                                                                                                                                                                                 | <p><b>Unit-5.0 Transformer Design - Practical Applications</b></p> <p>5.1 Design of a 100 KVA transformer.</p> <p>5.2 Design of 630 KVA transformer.</p> <p>5.3 Design of 5 MVA, 33/11 KV transformer</p>                                                                                                                                                                                                                                                     | CO4, CO5               |

**Note:** One major TSO may require more than one Theory session/Period.

**K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400604I**

| Practical/Lab Session Outcomes (LSOs)                                                                                                                                | S. No. | Laboratory Experiment/Practical Titles                                | Relevant COs Number(s) |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------------------------------------------------------------|------------------------|
| <i>LSO 1.1.</i> Knowledge of knowing the various components of a power transformer.<br><i>LSO 1.2.</i> Explain the use of those components in the power transformer. | 1.     | Dismantling a power transformer and understanding various components. | CO1                    |
| <i>LSO 2.1.</i> Design a transformer using computer programming considering various aspects.                                                                         | 2.     | Designing a transformer using computer programming.                   | CO1                    |
| <i>LSO 3.1.</i> Use of a commercial software to design a transformer.                                                                                                | 3.     | Application of software for transformer design.                       | CO1                    |
| <i>LSO 4.1.</i> Understand the breakdown voltage (BDV) of transformer oil.                                                                                           | 4.     | Breakdown voltage test of transformer oil.                            | CO2                    |
| <i>LSO 5.1.</i> Explain the practical applications of power transformers.<br><i>LSO 5.2.</i> Knowledge of various transformers used in substations.                  | 5.     | Substation visit to see the application of power transformers.        | CO3, CO4, CO5          |

**L) Suggested Term Work and Self Learning: S2400604I** Some sample suggested assignments, micro project and other activities are mentioned here for reference.**a. Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

- Explore recent advancements in core material technology.
- Discuss the lifecycle, recycling, and disposal of transformer materials and their environmental footprint.
- Discuss the key parameters and design equations used in transformer design.
- Explore the steps involved in modeling the transformer core using CAD software.
- Use CAD software to simulate different winding configurations and their impact on performance.
- Discuss the advantages of real-time data collection and analysis for proactive maintenance.
- Investigate the different requirements for distribution transformers in urban versus rural settings.

**b. Micro Projects:**

- Compare the performance of different insulating materials used in transformers (e.g., paper, pressboard, Nomex).
- Study the magnetic properties of different core materials (e.g., silicon steel, amorphous steel).
- Evaluate the environmental impact of transformer materials and their disposal methods.
- Build a small-scale transformer to understand the basics of transformer construction and operation.
- Investigate the impact of different winding techniques on transformer efficiency and performance.
- Compare different core materials to determine their effect on transformer performance.
- Design various core shapes (e.g., E-core, toroidal, C-core) using CAD and analyze their magnetic properties.
- Design and optimize different winding layouts to improve efficiency and reduce losses.
- Design a system to monitor and log the temperature of transformer components.
- Monitor transformer vibrations to detect mechanical issues.
- Design a system to monitor the quality of transformer oil.
- Develop a lightweight, portable transformer for powering equipment at outdoor events.

**c. Other Activities:**

## 1. Seminar Topics:

- Silicon Steel in Transformer Manufacturing.
- Impact of Environmental Factors on Transformer Design.
- Introduction to CAD in Transformer Design.
- Cost Estimation and Analysis in Transformer Design Using CAD.
- Impact of Environmental Conditions on Transformer Monitoring.
- Oil Quality Analysis in Transformer Maintenance.
- Designing Transformers for Industrial Applications.

## 2. Visits:

- Visit to nearby transformer manufacturing station. Prepare report of visit with special comments on transformer winding technique, winding material and insulating material used.
- Visit to nearby transformer manufacturing station. Prepare report of visit with manufacturing process, different stages of production, and the quality control measures and technologies involved in transformer manufacturing.

## 3. Self-learning topics:

- Types of insulation materials used in transformers (e.g., paper, pressboard, synthetic materials, and mineral oil)
- Nanomaterials in Transformer Construction.
- Thermal management in transformer design.
- Vibration of transformer.
- Smart transformer used in smart grid.

**M) Suggested Course Evaluation Matrix:** The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

| COs         | Course Evaluation Matrix                                  |                             |                                      |                |                   |                                  |                                 |
|-------------|-----------------------------------------------------------|-----------------------------|--------------------------------------|----------------|-------------------|----------------------------------|---------------------------------|
|             | Theory Assessment (TA)**                                  |                             | Term Work Assessment (TWA)           |                |                   | Lab Assessment (LA)#             |                                 |
|             | Progressive Theory Assessment (PTA)<br>Class/Mid Sem Test | End Theory Assessment (ETA) | Term Work & Self Learning Assessment |                |                   | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |
|             |                                                           |                             | Assignments                          | Micro Projects | Other Activities* |                                  |                                 |
| CO-1        | 15%                                                       | 15%                         | 15%                                  | -              | -                 | 20%                              | 20%                             |
| CO-2        | 10%                                                       | 10%                         | 10%                                  | 25%            | -                 | 10%                              | 20%                             |
| CO-3        | 15%                                                       | 15%                         | 15%                                  | 25%            | 33%               | 15%                              | 20%                             |
| CO-4        | 30%                                                       | 30%                         | 30%                                  | 25%            | 33%               | 15%                              | 20%                             |
| CO-5        | 30%                                                       | 30%                         | 30%                                  | 25%            | 34%               | 40%                              | 20%                             |
| Total Marks | 30                                                        | 70                          | 20                                   | 20             | 10                | 20                               | 30                              |
|             |                                                           |                             | 50                                   |                |                   |                                  |                                 |

**Legend:**

\*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

\*\* : Mentioned under point- (N)

# : Mentioned under point-(O)

**Note:**

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

**N) Suggested Specification Table for End Semester Theory Assessment:** Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

| Unit Title and Number                                | Total Classroom Instruction (CI) Hours | Relevant COs Number(s) | Total Marks | ETA (Marks)  |                   |                         |
|------------------------------------------------------|----------------------------------------|------------------------|-------------|--------------|-------------------|-------------------------|
|                                                      |                                        |                        |             | Remember (R) | Understanding (U) | Application & above (A) |
| Unit-1.0 Transformer Materials                       | 8                                      | CO1                    | 10          | 3            | 3                 | 4                       |
| Unit-2.0 Transformer Design                          | 12                                     | CO1, CO2               | 10          | 3            | 2                 | 5                       |
| Unit-3.0 Transformer Design- Using CAD               | 12                                     | CO3, CO4               | 10          | 5            | 2                 | 3                       |
| Unit-4.0 Transformer Condition Monitoring            | 8                                      | CO3, CO4               | 20          | 5            | 6                 | 9                       |
| Unit-5.0 Transformer Design - Practical Applications | 8                                      | CO4, CO5               | 20          | 4            | 6                 | 10                      |
| <b>Total</b>                                         | <b>48</b>                              | -                      | <b>70</b>   | <b>20</b>    | <b>19</b>         | <b>31</b>               |

**Note:** Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

**O) Suggested Assessment Table for Laboratory (Practical):**

| SN | Laboratory Practical Titles                                           | Relevant COs Number(s) | PLA/ELA     |              |                      |
|----|-----------------------------------------------------------------------|------------------------|-------------|--------------|----------------------|
|    |                                                                       |                        | Performance |              | Viva-<br>Voce<br>(%) |
|    |                                                                       |                        | PRA*<br>(%) | PDA**<br>(%) |                      |
| 1. | Dismantling a power transformer and understanding various components. | CO1                    | 30          | 60           | 10                   |
| 2. | Designing a transformer using computer programming.                   | CO1                    | 40          | 50           | 10                   |
| 3. | Application of software for transformer design.                       | CO1                    | 30          | 60           | 10                   |
| 4. | Breakdown voltage test of transformer oil.                            | CO2                    | 30          | 60           | 10                   |
| 5. | Substation visit to see the application of power transformers.        | CO3, CO4, CO5          | 30          | 60           | 10                   |

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

**Note:** This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

**P) Suggested Instructional/Implementation Strategies:** Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Field Trips, Portfolio Based, Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field Information and Communications Technology (ICT)Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Session, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

**Q) List of Major Laboratory Equipment, Tools and Software:**

| S. No. | Name of Equipment, Tools and Software | Broad Specifications                                                                                                                       | Relevant Experiment/Practical Number                                  |
|--------|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|
| 1.     | Transformer, Multi-meter, LCR Meter   | 3 Phase Transformer, Multi-meter, LCR Meter, Tools to dismantle transformer.                                                               | Dismantling a power transformer and understanding various components. |
| 2.     | MATLAB, PC                            | MATLAB Software and Desktop PC (As per requirement).                                                                                       | Designing a transformer using computer programming                    |
| 3.     |                                       | Machine Design Software and Desktop PC (As per requirement).                                                                               | Application of software for transformer design.                       |
| 4.     | Transformer Oil Testing Kit           | Transformer oil testing kit, transformer oil,                                                                                              | Breakdown voltage test of transformer oil.                            |
| 5.     | Equipment for a prototype substation  | Power transformer, circuit breaker, relay, Insulator, Isolator, Bus-bar, capacitor bank, Fuse, current transformer, potential transformer. | Substation visit to see the application of power transformers         |

**R) Suggested Learning Resources:****(a) Books:**

| S. No. | Titles                                                         | Author(s)                  | Publisher and Edition with ISBN                                                     |
|--------|----------------------------------------------------------------|----------------------------|-------------------------------------------------------------------------------------|
| 1.     | Transformer Engineering Design and Practice                    | S.V.Kulkarni, S.A.Khaparde | CBS Publishers, 2004<br>ISBN: 9780824757281, 0824757289                             |
| 2.     | Design of Transformers                                         | Indrajit Dasgupta          | Tata McGraw Hill India, 2002<br>ISBN: 0071331352, 9780071331357                     |
| 3      | Principles of Electrical Machine Design With Computer Programs | S. K. Sen                  | Oxford & IBH Publishing Company Pvt. Limited, 2006. ISBN: 9788120415218, 8120415213 |

**(b) Online Educational Resources:**

**Note:** Teachers are requested to check the creative commons **license** status/ financial implications of the suggested, online educational resources before use by the students.

**(c) Others:**

\*\*\*\*\*

- A) **Course Code** : 2400604J(T2400604J/P2400604J/S2400604J)
- B) **Course Title** : Optical Fiber and 5G Communication (Advance)
- C) **Pre- requisite Course(s)** : Optical Fiber and 5G Communication (Basics)
- D) **Rationale** :

A course on Optical Fiber and 5G Communication (Advance) is essential to understand the modern high-speed data transmission, which is crucial for supporting the growing demand for fast and reliable internet services. It equips students with the knowledge to design and implement 5G networks, which is going to be an integral part of the wireless communication infrastructures fields, students gain comprehensive insights into how advanced communication systems operate and interact, preparing them for careers in telecommunications and networking.

- E) **Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor and Affective) in classroom/ laboratory/ workshop/ field/ industry.

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

- CO-6 Analyze various 5G radio-access technologies.
- CO-7 Identify different components of GSM architecture.
- CO-8 Describe the channel and channel behavior of the wireless channel.
- CO-9 Analyze different mitigation techniques.
- CO-10 Summarize different emerging technologies for next generation communication networks.

- F) **Suggested Course Articulation Matrix (CAM):**

| Course Outcomes (COs) | Programme Outcomes (POs)                        |                          |                                          |                           |                                                                           |                            |                            | Programme Specific Outcomes* (PSOs) |       |
|-----------------------|-------------------------------------------------|--------------------------|------------------------------------------|---------------------------|---------------------------------------------------------------------------|----------------------------|----------------------------|-------------------------------------|-------|
|                       | PO-1<br>Basic and Discipline Specific Knowledge | PO-2<br>Problem Analysis | PO-3<br>Design/ Development of Solutions | PO-4<br>Engineering Tools | PO-5<br>Engineering Practices for Society, Sustainability and Environment | PO-6<br>Project Management | PO-7<br>Life Long Learning | PSO-1                               | PSO-2 |
| CO-1                  | 3                                               | -                        | 2                                        | 3                         | -                                                                         | -                          | 2                          |                                     |       |
| CO-2                  | 3                                               | 2                        | 2                                        | 2                         | 2                                                                         | 2                          | -                          |                                     |       |
| CO-3                  | 3                                               | 2                        | 2                                        | 2                         | 3                                                                         | 2                          | -                          |                                     |       |
| CO-4                  | 3                                               | 3                        | -                                        | 2                         | -                                                                         | -                          | -                          |                                     |       |
| CO-5                  | 3                                               | -                        | 3                                        | 3                         | 3                                                                         | 3                          | 2                          |                                     |       |

Legend: High (3), Medium (2), Low (1) and No mapping (-)

\* PSOs will be developed by respective programme coordinator at institute level. As per latest NBA guidelines, formulating PSOs is optional

- G) **Teaching & Learning Scheme:**

| Course Code | Course Title                                 | Scheme of Study (Hours/Week) |   |                      |                         |                           |                   |
|-------------|----------------------------------------------|------------------------------|---|----------------------|-------------------------|---------------------------|-------------------|
|             |                                              | Classroom Instruction (CI)   |   | Lab Instruction (LI) | Notional Hours (TW+ SL) | Total Hours (CI+LI+TW+SL) | Total Credits (C) |
|             |                                              | L                            | T |                      |                         |                           |                   |
| 2400604J    | Optical Fiber and 5G Communication (Advance) | 03                           | - | 04                   | 02                      | 09                        | 06                |

**Legend:**

- CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)
- LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)
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- TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)
- SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.
- C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)
- Note:** TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

**H) Assessment Scheme:**

| Course Code | Course Title                                 | Assessment Scheme (Marks)           |                             |                                            |          |                                  |                                 | Total Marks (TA+TWA+LA) |
|-------------|----------------------------------------------|-------------------------------------|-----------------------------|--------------------------------------------|----------|----------------------------------|---------------------------------|-------------------------|
|             |                                              | Theory Assessment (TA)              |                             | Term Work & Self-Learning Assessment (TWA) |          | Lab Assessment (LA)              |                                 |                         |
|             |                                              | Progressive Theory Assessment (PTA) | End Theory Assessment (ETA) | Internal                                   | External | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |                         |
| 2400604J    | Optical Fiber and 5G Communication (Advance) | 30                                  | 70                          | 20                                         | 30       | 20                               | 30                              | 200                     |

**Legend:**

- PTA: Progressive Theory Assessment in classroom (includes class test, mid-term test and quiz using online/offline modes)
- PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)
- TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.)

**Note:**

- Separate passing is must for progressive and end semester assessment for both theory and practical.
- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

- II) Course Curriculum Detailing:** This course curriculum detailing depicts learning outcomes at course level and session level and their attainment by the students through Classroom Instruction (CI), Laboratory Instruction (LI), Term Work (TW) and Self Learning (SL). Students are expected to demonstrate the attainment of Theory Session Outcomes (TSOs) and Lab Session Outcomes (LSOs) leading to attainment of Course Outcomes (COs) upon the completion of the course. While curriculum detailing, NEP 2020 related reforms like Green skills, Sustainability, Multidisciplinary aspects, Society connect, Indian Knowledge System (IKS) and others must be integrated appropriately.

**J) Theory Session Outcomes (TSOs) and Units: T2400604J**

| Major Theory Session Outcomes (TSOs)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Units                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Relevant COs Number(s) |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| <p><i>TSO 1f.</i> Highlight the need for 5G communication system.</p> <p><i>TSO 1g.</i> Describe the radio spectrum and channel model with the help of suitable sketch and tables.</p> <p><i>TSO 1h.</i> Describe the working of the 5G physical layer with the help of a suitable sketch.</p> <p><del><i>TSO 1i.</i></del> Describe 5G network slicing with an example.</p> <p><i>TSO 1j.</i> Explain the mobility and hands-off management in 5G environment.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <p><b>Unit-1.0 5G Radio Access Technology</b></p> <p>1.6 5G Radio Spectrum</p> <p>1.7 5G Channel Model</p> <p>1.8 Radio Interface Architecture</p> <p>1.9 5G Physical Layer</p> <p>1.10 5G Radio-Access Technologies</p> <p>1.11 Introduction To 5G Network Slicing</p> <p>1.12 Mobility and Handoff Management In 5G</p>                                                                                                                                                     | <b>CO1</b>             |
| <p><i>TSO 2f.</i> Describe the architecture and key components of basic GSM (Global System for Mobile Communications) networks.</p> <p><i>TSO 2g.</i> List the components of the GSM(LTE) system.</p> <p><i>TSO 2h.</i> Describe the working of the various components and their functions of the given type of wireless communication network</p> <p><i>TSO 2i.</i> Analyze the functions of base station subsystems (BS)</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <p><b>Unit-2.0 Study of GSM Architecture</b></p> <p>2.7 GSM System Architecture (LTE)</p> <p>2.8 Explain the different components of Wireless Communication Network</p> <p>2.9 Operation of base station (BS) subsystems</p>                                                                                                                                                                                                                                                  | <b>CO2</b>             |
| <p><i>TSO 3f.</i> Explain different principles and various factors affecting radio wave propagation in different environments.</p> <p><i>TSO 3g.</i> Apply the free space propagation model to estimate signal strength and coverage.</p> <p><i>TSO 3h.</i> Explain how reflection, scattering, and diffraction impact radio wave behaviour and signal quality.</p> <p><i>TSO 3i.</i> Use the given type of path loss models to predict signal degradation over distance.</p> <p><i>TSO 3j.</i> Differentiate between large-scale and small-scale fading and their effects on wireless communication.</p> <p><i>TSO 3k.</i> Analyze the characteristics and behaviour of wireless channels, including their impact on signal transmission.</p> <p><i>TSO 3l.</i> List the noise sources present in the wireless channel.</p> <p><i>TSO 3m.</i> Describe the effects of noise on signal propagation through wireless channels and its impact on signal quality.</p> <p><i>TSO 3n.</i> Calculate the capacity of channels with Additive White Gaussian Noise (AWGN).</p> | <p><b>Unit-3.0 Channel and channel behavior</b></p> <p>3.6 Analysis of radio wave propagation</p> <p>3.7 Free Space Propagation Model</p> <p>3.8 Reflection, Scattering, Diffraction of Radio Waves</p> <p>3.9 Path Loss Models</p> <p>3.10 Study of Fading (Large, small-scale fading)</p> <p>3.11 Analysis of Wireless Channel</p> <p>3.12 Analysis of Noise, types of noise</p> <p>3.13 Capacity of AWGN and Fading Channel (only formula and its variable parameters)</p> | <b>CO3</b>             |
| <p><i>TSO 4e.</i> Describe various diversity techniques to improve signal reliability and performance in wireless communication.</p> <p><i>TSO 4f.</i> Describe receiver diversity methods and their impact on enhancing signal quality and reducing errors.</p> <p><i>TSO 4g.</i> Describe transmitter diversity techniques and their role in mitigating fading and improving communication robustness.</p> <p><i>TSO 4h.</i> Describe the principles and applications of Multiple Input Multiple Output (MIMO) technology.</p> <p><i>TSO 4i.</i> Suggest the techniques to correct distortions and mitigate inter-symbol interference in wireless communication systems.</p>                                                                                                                                                                                                                                                                                                                                                                                         | <p><b>Unit-4.0 Mitigation Techniques</b></p> <p>4.6 Diversity techniques</p> <p>4.7 Analysis of various receiver diversity techniques</p> <p>4.8 Analysis of various transmitter diversity techniques</p> <p>4.9 MIMO technology advantages in communication systems</p> <p>4.10 Equalization techniques and their importance in communication systems</p>                                                                                                                    | <b>CO4</b>             |
| <p><i>TSO 5c.</i> Discuss the various types of dispersion in optical fibre design</p> <p><i>TSO 5d.</i> Explain the optimization technique of single mode fibre.</p> <p><i>TSO 5e.</i> Describe the working and characteristics of different optical networks.</p> <p><i>TSO 5f.</i> Explain the nonlinear effect on network performance of</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <p><b>Unit-5.0 Advanced Optical Fiber Communication and Emerging Technologies</b></p> <p>5.4 Advanced Optical Fiber: Dispersion issues, Dispersion shifted, Dispersion flattened, Dispersion Compensating fibre</p> <p>5.5 Design and optimization of single-mode fibers</p> <p>5.6 Optical Networks- Basic Networks SONET, SDH-</p>                                                                                                                                          | <b>CO5</b>             |

| Major Theory Session Outcomes (TSOs)                                                                                                                                                                                                                                                                                                                                                          | Units                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Relevant COs Number(s) |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| <p>optical fibre systems.</p> <p><i>TSO 5g.</i> Explain multicarrier modulation techniques to enhance data transmission and system performance.</p> <p><i>TSO 5h.</i> Describe the principles and advantages of Orthogonal Frequency Division Multiplexing (OFDM) in improving bandwidth efficiency and reducing interference.</p> <p><i>TSO 5i.</i> Analyze given emerging technologies.</p> | <p>wavelength-routed networks</p> <p>5.7 Nonlinear effect on Network Performance, performance of various systems (WDM, DWDM + SOA)</p> <p>5.8 Multicarrier Modulation Technique</p> <p>5.9 Orthogonal Frequency Division Multiplexing (OFDM)</p> <p>5.10 Emerging Technology: Green Communication network, Vehicle 2 everything (V2X), Aerial Communication, Satellite Communication (LEO), Tactile Internet (TI), Free Space Optics (FSO), Near Field Communication, Quantum Communication, Molecular Communication</p> |                        |

**Note:** One major TSO may require more than one Theory session/Period.

### K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400604J

| Practical/Lab Session Outcomes (LSOs)                                                         | S. No. | Laboratory Experiment/Practical Titles                                                             | Relevant COs Number(s) |
|-----------------------------------------------------------------------------------------------|--------|----------------------------------------------------------------------------------------------------|------------------------|
| <i>LSO 1.3.</i> Noise Modelling and its effect on Wireless Data Transmission                  | 1.     | Characterization and Impact of Noise on Wireless Data Transmission: A Comprehensive                | CO1                    |
| <i>LSO 2.2.</i> Effect of fading on wireless data transmission in terms of outage probability | 2.     | Evaluating Fading Effects on Wireless Data Transmission: Outage Probability Analysis               | CO2                    |
| <i>LSO 3.2.</i> Capacity of Wireless Channel (AWGN v/s Fading)                                | 3.     | Comparative Study of Channel Capacity: AWGN versus Fading Channels                                 | CO3                    |
| <i>LSO 4.2.</i> Implementation of receiver diversity technique.                               | 4.     | Practical Implementation and Evaluation of Receiver Diversity Techniques in Wireless Communication | CO4                    |
| <i>LSO 5.3.</i> Implementation of transmitter diversity technique.                            | 5.     | Practical Implementation and Performance Analysis of Transmitter Diversity Techniques              | CO4                    |
| <i>LSO 6.1</i> Implement the (2X2) of MIMO system.                                            | 6.     | Design and Implementation of MIMO Technology                                                       | CO4                    |
| <i>LSO 7.1</i> Implement of OFDM system and test the performance.                             | 7.     | Performance Evaluation of Orthogonal Frequency Division Multiplexing (OFDM) in Wireless Systems    | CO5                    |

**L) Suggested Term Work and Self Learning: S2400604J** Some sample suggested assignments, micro project and other activities are mentioned here for reference.

**d. Assignments:** Questions/Problems/Numerical/Exercises to be provided by the course teacher in line with the targeted COs.

**e. Micro Projects:**

Here are five micro projects that can be included in an optical fiber and 5G communication course to give students hands-on experience with practical applications of the concepts learned:

#### 1. Design of solar cell enabled Base Station for Green Communication Network

**Task:** Conduct a feasibility study on integrating solar cells with base stations, design a prototype solar-powered base station, simulate its energy efficiency and environmental impact, evaluate its carbon footprint reduction, and document the design and performance outcomes.

#### 2. Path loss models for Aerial Communication Network

**Task:** Research and adapt existing path loss models for aerial networks, develop tailored models for scenarios like drones, validate with field or simulation data, compare model performance, and document findings with recommendations for network design.

#### 3. Resource allocation for 5G communication Network

**Task:** Identify challenges in 5G resource allocation, develop an optimization strategy, simulate the strategy's effectiveness, implement it in a test environment, and analyze results to enhance resource allocation and network performance.

**4. LEO Satellite based IoT communication**

**Task:** Research LEO satellite technologies for IoT, design a communication system using LEO satellites, simulate system performance, conduct a cost-benefit analysis compared to other methods and prepare a brief report of the same.

**5. QoS requirements for Tactile Internet**

**Task:** Define QoS requirements for tactile internet applications, develop a QoS framework, test the framework in various scenarios, evaluate its performance, and prepare a report with recommendations for meeting QoS standards in tactile internet networks.

**f. Other Activities:**

g. Seminar Topics: Some of the suggested seminar topics are

- "Advancements in 5G Technology and beyond"
- "The Future of Wireless Communication: 5G and Beyond"
- "Integrating Haptics with 5G Networks: Opportunities and Challenges"
- "Security Strategies for 5G Networks: Ensuring Robust Protection"
- "AR/VR-enabled Systems in 5G: Innovations and Implementation"

h. Visits: Visit nearby telephone exchanges or wireless communication-related companies

**M) Suggested Course Evaluation Matrix:** The course teacher has to decide and use appropriate assessment strategy and its weightage in theory, laboratory and Term Work for ensuring CO attainment. The response/performance of each student in each of these designed activities is to be used to calculate **CO attainment**.

| COs         | Course Evaluation Matrix                                  |                             |                                      |                |                   |                                  |                                 |
|-------------|-----------------------------------------------------------|-----------------------------|--------------------------------------|----------------|-------------------|----------------------------------|---------------------------------|
|             | Theory Assessment (TA)**                                  |                             | Term Work Assessment (TWA)           |                |                   | Lab Assessment (LA)#             |                                 |
|             | Progressive Theory Assessment (PTA)<br>Class/Mid Sem Test | End Theory Assessment (ETA) | Term Work & Self Learning Assessment |                |                   | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |
|             |                                                           |                             | Assignments                          | Micro Projects | Other Activities* |                                  |                                 |
| CO-1        | 15%                                                       | 15%                         | 15%                                  | -              | -                 | 20%                              | 20%                             |
| CO-2        | 10%                                                       | 10%                         | 10%                                  | 25%            | -                 | 10%                              | 20%                             |
| CO-3        | 15%                                                       | 15%                         | 15%                                  | 25%            | 33%               | 15%                              | 20%                             |
| CO-4        | 30%                                                       | 30%                         | 30%                                  | 25%            | 33%               | 15%                              | 20%                             |
| CO-5        | 30%                                                       | 30%                         | 30%                                  | 25%            | 34%               | 40%                              | 20%                             |
| Total Marks | 30                                                        | 70                          | 20                                   | 20             | 10                | 20                               | 30                              |
|             |                                                           |                             | 50                                   |                |                   |                                  |                                 |

**Legend:**

\*: Other Activities include self- learning, seminar, visits, surveys, product development, software development etc.

\*\*: Mentioned under point- (N)

#: Mentioned under point-(O)

**Note:**

- The percentage given are approximate
- In case of Micro Projects and End Laboratory Assessment (ELA), the achieved marks will be equally divided in all those COs mapped with total experiments.
- For CO attainment calculation indirect assessment tools like course exit survey need to be used which comprises of questions related to achievement of each COs.

**N) Suggested Specification Table for End Semester Theory Assessment:** Specification table represents the reflection of sample representation of assessment of cognitive domain of full course.

| Unit Title and Number                                                   | Total Classroom Instruction (CI)Hours | Relevant COs Number(s) | Total Marks | ETA (Marks)  |                   |                         |
|-------------------------------------------------------------------------|---------------------------------------|------------------------|-------------|--------------|-------------------|-------------------------|
|                                                                         |                                       |                        |             | Remember (R) | Understanding (U) | Application & above (A) |
| Unit-1.0 5G Radio Access Technology                                     | 8                                     | CO1                    | 12          | 4            | 4                 | 4                       |
| Unit-2.0 Study of GSM Architecture                                      | 8                                     | CO2                    | 12          | 4            | 4                 | 4                       |
| Unit-3.0 Channel and channel behavior                                   | 8                                     | CO3                    | 12          | 4            | 4                 | 4                       |
| Unit-4.0 Mitigation Techniques                                          | 12                                    | CO3                    | 14          | 4            | 4                 | 6                       |
| Unit-5.0 Advanced Optical Fiber Communication and Emerging Technologies | 12                                    | CO2                    | 20          | 6            | 6                 | 8                       |
| <b>Total</b>                                                            | <b>48</b>                             | <b>-</b>               | <b>70</b>   | <b>22</b>    | <b>22</b>         | <b>26</b>               |

**Note:** Similar table can also be used to design class/mid-term/ internal question paper for progressive assessment.

**O) Suggested Assessment Table for Laboratory (Practical):** Kindly change this table as per the list of experiment in the above list

| Sl. No | Laboratory Practical Titles                                                                                     | Relevant COs Number(s) | PLA/ELA     |           |               |
|--------|-----------------------------------------------------------------------------------------------------------------|------------------------|-------------|-----------|---------------|
|        |                                                                                                                 |                        | Performance |           | Viva-Voce (%) |
|        |                                                                                                                 |                        | PRA* (%)    | PDA** (%) |               |
| 6.     | Characterization and Impact of Noise on Wireless Data Transmission: A Comprehensive                             | CO1                    | 30          | 60        | 10            |
| 7.     | Evaluating Fading Effects on Wireless Data Transmission: Outage Probability Analysis                            | CO2                    | 40          | 50        | 10            |
| 8.     | Comparative Study of Channel Capacity: AWGN versus Fading Channels                                              | CO3                    | 30          | 60        | 10            |
| 9.     | Practical Implementation and Evaluation of Receiver Diversity Techniques in Wireless Communication              | CO4                    | 30          | 60        | 10            |
| 10.    | Practical Implementation and Performance Analysis of Transmitter Diversity Techniques                           | CO4                    | 30          | 60        | 10            |
| 11.    | Design and Implementation of MIMO Technology                                                                    | CO4                    | 30          | 60        | 10            |
| 12.    | Development and Performance Evaluation of Orthogonal Frequency Division Multiplexing (OFDM) in Wireless Systems | CO5                    | 30          | 60        | 10            |

**Legend:**

PRA\*: Process Assessment

PDA\*\*: Product Assessment

**Note:** This table can be used for both end semester as well as progressive assessment of practical. Rubrics need to be prepared by the course teacher for each experiment/practical to assess the student performance.

**P) Suggested Instructional/Implementation Strategies:** Different Instructional/ Implementation Strategies may be appropriately selected, as per the requirement of the content/outcome. Some of them are Improved Lecture, Tutorial, Case Method, Group Discussion, Industrial visits, Industrial Training, Field Trips, Portfolio Based, Learning, Role Play, Live Demonstrations in Classrooms, Lab, Field Information and Communications Technology (ICT)Based Teaching Learning, Blended or flipped mode, Brainstorming, Expert Session, Video Clippings, Use of Open Educational Resources (OER), MOOCs etc.

**Q) List of Major Laboratory Equipment, Tools and Software:**

Please insert laboratory equipment in this format

| Sl. No. | Name of Equipment, Tools, and Software                                                                                                           | Relevant Experiment/ Practical Number |
|---------|--------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|
| 1.      | Software-Defined Radio (SDR) kit : Allows for the implementation and testing of 5G communication protocols.                                      | All                                   |
| 2.      | 5G NR Testbed: Complete test setups for developing and testing 5G NR systems.                                                                    | All                                   |
| 3.      | Vector Signal Analyzer (VSA) and Vector Signal Generator (VSG): For generating and analyzing complex modulated signals used in 5G communication. | All                                   |
| 4.      | MIMO (Multiple Input Multiple Output) Test System (2X2, and more): For testing MIMO technology, which is essential for 5G networks.              | All                                   |
| 5.      | MATLAB/Mathematica                                                                                                                               | All                                   |

**R) Suggested Learning Resources:****(a) Books**

Here are some essential books for Optical Fiber and 5G Communication.

| Sl. No. | Titles                                                | Author(s)                                                                           | Publisher and Edition with ISBN                                    |
|---------|-------------------------------------------------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------|
| 1.      | Millimeter Wave Wireless Communications               | Theodore S. Rappaport, Robert W. Heath Jr., Robert C. Daniels, and James N. Murdock | Cambridge University Press, 2024. ISBN 9781009489836               |
| 2.      | 5G NR: The Next Generation Wireless Access Technology | Erik Dahlman, Stefan Parkvall, and Johan Skold                                      | Academic Press, 2020. ISBN-10. 0128143231; ISBN-13. 978-0128143230 |
| 3.      | Wireless Communications                               | Andreas F. Molisch,                                                                 | John Wiley & Sons, 2012. ISBN: 8126542322                          |
| 4.      | Wireless Communications                               | Andrea Goldsmith                                                                    | Cambridge University Press, 2005. ISBN: 9780511841224              |

**(b) Online Educational Resources:**

Here are some valuable online references for a course in Optical Fiber and 5G Communication:

1. Prof. Aditya K. Jagannatham— NPTEL **Principles of Modern CDMA/ MIMO/ OFDM Wireless Communications**
2. **Coursera** - Post Graduate Certificate in 5G Technology and IoT: This program covers the essentials of 4G and 5G systems, including key technical advancements and challenges. It also delves into topics such as massive MIMO, OFDM, and mm Wave communication, providing a solid foundation in modern wireless communication (Coursera).
3. **Coursera** - 5G and Beyond Wireless Technologies: This course provides an in-depth understanding of 5G New Radio standards, beam management, cell-free massive MIMO, and intelligent reflecting surfaces, making it an excellent resource for those looking to explore the cutting-edge aspects of 5G technology (Coursera).
4. **Coursera** - 5G for Everyone: Gain an in-depth understanding of how 5G is revolutionizing the way we do business in the 2020s with technologies that make 5G possible, including mm Wave, Massive MIMO, RAN, and more. Learn how companies can use 5G Private Networks and Industrial IoT to transform the way they operate daily. Gain the base-level knowledge of 5G you need to continue your wireless education and advance in the rapidly growing field of wireless technology.

**MIT OCW - Principles of Wireless Communications:** This course is an introduction to the design, analysis, and fundamental limits of wireless transmission systems. Topics to be covered include: wireless channel and system models; fading and diversity; resource management and power control; multiple-antenna and MIMO systems; space-time codes and decoding algorithms; multiple-access techniques and multiuser detection; broadcast codes and precoding; cellular and ad-hoc network topologies; OFDM and ultrawideband systems; and architectural issues.

**Note:** Teachers are requested to check the creative commons license status/ financial implications of the suggested, online educational recourses before use by the students.

**(c) Others: In this section provide the software name (if any) data sheet according to this course.**

- a. Operating / Manufacturers' Manuals
- b. Lab Manuals

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- A) **Course Code** : 2418605(P2418605/S2418605)  
B) **Course Title** : Major Project  
C) **Pre- requisite Course(s)** :  
D) **Rationale** :

Project work plays a very important role in engineering education in developing core technical skills, soft skills and higher level of cognitive, psychomotor and affective domain skills. Major Project work is normally done when students have acquired sufficient knowledge, skills and attitude and are able to integrate all these, entirely in new situation or task to solve the problems of the industries/field agencies/etc.

Through major project work, students get direct exposure to the world of work in their relevant field. They are intrinsically motivated to explore new things, new methods, new design, many more ideas and also develop out of the box thinking abilities, creative and innovative capabilities. It also develops many soft skills like confidence, communication skills, creative ability, inquisitiveness, learning to learn skills, lifelong learning skills, problem solving skills, management skills, positive attitude, ethics etc.

Normally in a curriculum document, there is a mention of project work indifferent context. In situation one, project work is reflected as micro project under each and every course curricular detailing, in the form of Term work mentioned under different semesters. These projects are normally related to the developing skills in respective course of the specific programme.

In the context of diploma programme in Bihar, minor project work will be carried out in Semester 5 with emphasis on project planning.

Major project work is reflected as a course in the total programme structure, normally at 6<sup>th</sup> semester depending on the requirement of the programme. Through major project, students try to bring the industrial/real world problems in institutional setting, may be in collaboration/ networking with industries/field agencies/enterprises as per the requirement of different diploma programmes.

- E) **Course Outcomes:** After the completion of the course, teachers are expected to ensure the accomplishment of following course outcomes by the learners. For this, the learners are expected to perform various activities related to three learning domains (Cognitive, Psychomotor, and Affective) in classroom/ laboratory/ workshop/ field/ industry.

**After completion of the major project work, students will be able to –**

- CO-1** Integrate the knowledge (K), skills (S), attitudes (A) developed, in a new task or problem identified in the form of project work.
- CO-2** Develop higher level of cognitive, psychomotor and affective domain skills relevant to the course/programme.
- CO-3** Solve the industrial/real world problems/tasks by Integrating the generic skills/soft skills/employable skills with relevant technical skills.
- CO-4** Develop the capabilities and skills of innovativeness, creativity, resourcefulness, time management, problem solving abilities, interpersonal skills, pro-activeness, cost effectiveness, environment consideration and sustainability.
- CO-5** Prepare the project report.

**F) Suggested Course Articulation Matrix (CAM):**

| Course Outcomes (COs) | Programme Outcomes (POs)                        |                          |                                          |                           |                                                                           |                            |                            | Programme Specific Outcomes* (PSOs) |       |
|-----------------------|-------------------------------------------------|--------------------------|------------------------------------------|---------------------------|---------------------------------------------------------------------------|----------------------------|----------------------------|-------------------------------------|-------|
|                       | PO-1<br>Basic and Discipline Specific Knowledge | PO-2<br>Problem Analysis | PO-3<br>Design/ Development of Solutions | PO-4<br>Engineering Tools | PO-5<br>Engineering Practices for Society, Sustainability and Environment | PO-6<br>Project Management | PO-7<br>Life Long Learning | PSO-1                               | PSO-2 |
| CO-1                  | 3                                               | 2                        | 3                                        | -                         | -                                                                         | -                          | 1                          |                                     |       |
| CO-2                  | 3                                               | -                        | 3                                        | -                         | -                                                                         | -                          | 1                          |                                     |       |
| CO-3                  | 3                                               | -                        | 3                                        | 3                         | -                                                                         | -                          | 1                          |                                     |       |
| CO-4                  | 3                                               | 2                        | 3                                        | -                         | 2                                                                         | 2                          | 1                          |                                     |       |
| CO-5                  | 3                                               | -                        | 3                                        | -                         | -                                                                         | 2                          | -                          |                                     |       |

**Legend:** High (3), Medium (2), Low (1) and No mapping (-)

\* PSOs will be developed by the respective program coordinator at the institute level. As per the latest NBA guidelines, formulating PSOs is optional

**G) Teaching & Learning Scheme:**

| Course Code | Course Title  | Scheme of Study (Hours/Week) |   |                      |                         |                           |                   |
|-------------|---------------|------------------------------|---|----------------------|-------------------------|---------------------------|-------------------|
|             |               | Classroom Instruction (CI)   |   | Lab Instruction (LI) | Notional Hours (TW+ SL) | Total Hours (CI+LI+TW+SL) | Total Credits (C) |
|             |               | L                            | T |                      |                         |                           |                   |
| 2418605     | Major Project | -                            | - | 08                   | 04                      | 12                        | 06                |

**Legend:**

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Case method, Demonstrations, Video demonstration, Problem based learning etc. to deliver theoretical concepts)

LI: Laboratory Instruction (Includes experiments/practical performances /problem-based experiences in laboratory, workshop, field or other locations using different instructional/Implementation strategies)

Notional Hours: Hours of engagement by learners, other than the contact hours for ensuring learning.

TW: Term Work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

C: Credits = (1 x CI hours) + (0.5 x LI hours) + (0.5 x Notional hours)

**Note:** TW and SL have to be planned by the teacher and performed by the learner under the continuous guidance and feedback of teacher to ensure outcome of learning.

**H) Assessment Scheme:**

| Course Code | Course Title  | Assessment Scheme (Marks)           |                             |                                            |          |                                  |                                 | Total Marks (TA+TWA+LA) |
|-------------|---------------|-------------------------------------|-----------------------------|--------------------------------------------|----------|----------------------------------|---------------------------------|-------------------------|
|             |               | Theory Assessment (TA)              |                             | Term Work & Self-Learning Assessment (TWA) |          | Lab Assessment (LA)              |                                 |                         |
|             |               | Progressive Theory Assessment (PTA) | End Theory Assessment (ETA) | Internal                                   | External | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) |                         |
| 2418605     | Major Project | -                                   | -                           | 20                                         | 30       | 50                               | 100                             | 200                     |

**Legend:**

PTA: Progressive Theory Assessment in class room (includes class test, mid-term test and quiz using online/offline modes)

PLA: Progressive Laboratory Assessment (includes process and product assessment using rating Scales and rubrics)

TWA: Term work & Self Learning Assessment (Includes assessment related to student performance in assignments, seminars, micro projects, industrial visits, self-learning, any other student activities etc.

**Note:**

- ETA & ELA are to be carried out at the end of the term/ semester.
- Term Work is to be done by the students under the guidance of internal faculty but its assessment will be done **internally (40%)** as well as **externally (60%)**. Assessment related to planning and execution of Term Work activities like assignment, micro project, seminar and self-learning is to be done by internal faculty (Internal Assessment) whereas assessment of output/product/ presentation related to these activities will be carried out by external faculty/expert (External Assessment). However, criteria of internal as well as external assessment may vary as per the requirement of respective course. For valid and reliable assessment, the internal faculty should prepare checklist & rubrics for these activities.

**I) Suggested Implementation of Major Project:**

Under the minor project in fifth semester, project planning is almost over. The projects are identified and allocated to students. Teacher's role is important as they act as guide, facilitator, catalyzer, motivator to promote brain storming, thinking, creativity, initiativeness and many other skills in the students. Teachers should help or guide continually to monitor whether the students are proceeding in the right direction as per outcomes to be attained.

It is also suggested that teachers are not supposed to guide and plan each and every step from the point of view of execution of the project, otherwise it will curb the creativity or thinking process of the students. Teachers have to see that he or she is able to create think tank for this fast-technological world of work for the growth of our country. Following points should be taken into consideration while implementing the major project work.

The following steps are undertaken under the major project-

1. Design, Development and Execution of the Major Project.
2. Quality of Project Report Writing and its Presentation.

**1.0 Design, Development and Execution of Major Project:**

Projects design, development, execution is done by the students under the guidance and feedback by respective teachers for attainment of courses specific outcomes, POs and PSOs.

Continual Monitoring, feedback and assessment mechanism on weekly progress/updates on action taken on different criteria and sub-criteria of the project work need to be planned for individual and team of students. Path breaking teachers who think out of the box are required to guide, monitor and evaluate the project work.

### 1.1 Unique Features of Major Project:

Following important characteristic features of project need to be given special emphasis during the implementation and evaluation of the major project work-

- Innovativeness
- Creativity
- Originality
- Pro-activeness
- Initiabiveness
- Cost Effectiveness
- Resourcefulness
- Development of Soft Skills/Generic Skills
- Ethical Issues
- Environmental Considerations
- Simulated/Automated Industry's/Improvised Process
- Application or Utility in the World of Work.
- Relevance to the Curriculum
- Mapping of Outcomes of Project with Pos and PSOs (if applicable)
- Feasibility of Implementation of the Project

### 2.0 Quality of Project Report Writing and its Presentation:

Following points need to be taken care of during report writing, its implementation and evaluation-

- Report writing as per prescribed format
- Clarity of outcomes
- Innovativeness
- Presentation of Data
- Data Analysis, Interpretation and Result
- Quality of Product/Prototype

### 2.1 Project Report Writing:

The suggested format of the project report is mentioned below for teacher's and students' reference:

- i. Problem Statement/ Project Title
- ii. Abstract
- iii. Literature Review
- iv. Outcomes of the Project
- v. Project Planning, Design and Development
- vi. Methodology
- vii. Implementation and Testing
- viii. Result and its Interpretation
- ix. Summary
- x. References / Bibliography

**2.2 Presentation & Discussion:**

Quality of presentation of data need to be ensured using the following criteria -

- Clarity in Communication and Presentation
- Voice Audibility
- Use of Media and Methods
- Satisfying the Queries of Audience
- Attainment of Outcomes

**2.3 Project's Potential:**

Futuristic scope and recommendation for further studies related to project may be assessed from the following criteria -

- Papers Published or Award Received
- Exhibition or Display or Showcase of Project in Competition or Exhibition or Tech Fest
- Evaluation of Working/Testing of Projects or Prototype
- Relevance and Applications in the World of Work
- Recognition in any Form
- Related Areas/Sub Areas for Further Studies

**J) Assessment of the Major Project:**

For objective, valid and reliable assessment, different tools of assessment such as a checklist, rating scale, assessment rubric, observation schedule, portfolio assessment, incidental records etc. need to be prepared. Even the students may been courage to adopt self-assessment techniques using the assessment rubrics.

The students need to be assessed continuously based on the suggested below mentioned assessment criteria at project planning stage. The project guide must prepare detailed rubric(s) for each criteria to have more valid and reliable assessment. Criteria of assessment of major project work are mentioned below.

**Assessment Scheme for Major Project**

| S. No. | Suggested Assessment Criteria                                                                                                                                                                                                                                                              | Suggested Weightage (%) |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|
| 1.     | <b>Project Planning during Minor Project Work</b><br><br>1.1 Identification of Area/Problem Statement<br>1.2 Literature Survey<br>1.3 Formulation of Project Title<br>1.4 Clarity in Formulation of Outcomes of The Project<br>1.5 Preparation of Synopsis<br>1.6 Presentation of Synopsis | 30                      |
| 2.     | <b>Design, Development and Execution of the Project.</b><br><br>2.1 Unique Features of Major Project                                                                                                                                                                                       | 45                      |
| 3.     | <b>Quality of Report Writing and Presentation.</b><br><br>3.1 Report Writing<br>3.2 Presentation & Discussion<br>3.3 Project's Potential                                                                                                                                                   | 25                      |
|        | <b>TOTAL</b>                                                                                                                                                                                                                                                                               | 100                     |

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