# Curriculum of Diploma Programme

# in

# Computer Science

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

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

# Semester – V
# Teaching & Learning Scheme

| Course Codes | Category of course | CourseTitles | Teaching & Learning Scheme (Hours/Week) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Classroom Instruction (CI) | | Lab Instruction (LI) | Notional Hours (TW+ SL) | Total Hours (CI+LI+TW+SL) | Total Credits (C) |
| | | | L | T | | | | |
| **2418501** | **PCC** | **Data Communication and Computer Network** | 03 | - | 04 | 02 | 09 | 06 |
| **2418502** | **PCC** | **Software Engineering** | 02 | 01 | - | 02 | 05 | 04 |
| **2418503** | **PEC** | **Programme Electives* -** Any One | 03 | - | 04 | 02 | 09 | 06 |
| **2400504** | **OEC** | **Open Electives**/ COE** (Basic - Any One) | 03 | - | 04 | 02 | 09 | 06 |
| **2400505** | **NRC** | **Entrepreneurship Development & Start-ups** (Common for All Programmes) | - | - | 04 | 02 | 06 | 03 |
| **2418506** | **PSI** | **Summer Internship- II** (After 4th Sem) / Industrial Training (Common for all programmes) | - | - | 02 | 04 | 06 | 03 |
| **2418507** | **PSI** | **Minor Project** (Common for all programmes) | - | - | 02 | 02 | 04 | 02 |
| **Total** | | | **11** | **1** | **20** | **16** | **48** | **30** |

**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)

*: Data Science: Data Warehousing and Data Mining / Advanced JAVA Programming

**: 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 - V
## 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) | |
| **2418501** | **PCC** | **Data Communication and Computer Network** | 30 | 70 | 20 | 30 | 20 | 30 | 200 |
| **2418502** | **PCC** | **Software Engineering** | 30 | 70 | 20 | 30 | - | - | 150 |
| **2418503** | **PEC** | **Programme Electives*** - Any One | 30 | 70 | 20 | 30 | 20 | 30 | 200 |
| **2400504** | **OEC** | **Open Electives**/ COE** (Basic - Any One) | 30 | 70 | 20 | 30 | 20 | 30 | 200 |
| **2400505** | **NRC** | **Entrepreneurship Development & Start-ups** (Common for All Programmes) | - | - | 20 | 30 | 20 | 30 | 100 |
| **2418506** | **PSI** | **Summer Internship- II** (After 4th Sem) / Industrial Training (Common for all programmes) | **-** | **-** | 20 | 30 | 20 | 30 | 100 |
| **2418507** | **PSI** | **Minor Project** (Common for all programmes) | **-** | **-** | 10 | 15 | 10 | 15 | 50 |
| **Total** | | | **120** | **280** | **130** | **195** | **110** | **165** | **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.

*: Data Science: Data Warehousing and Data Mining / Advanced JAVA Programming

**: 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 : 2418501(T2418501/P2418501/S2418501)**

**B) Course Title :** Data Communication and Computer Network

**C) Pre- requisite Course(s) :**

**D) Rationale :**

**Data** communication and computer networks focuses on efficient and effective communication and sharing of information, hardware resource, and other the infrastructure for global communication and collaboration among various devices. It offers the ability for the diploma engineers to select relevant transmission media and observe the function of protocols available at Data link layer, Network layer, Transport layer, and Application layer. It also offers to create FTP and HTTP server.

**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** Choose the appropriate transmission media type based on the needs.
- **CO-2** Explain the function of Data link layer protocols.
- **CO-3** Create subnet for given IP
- **CO-4** Explain the function of Transport layer protocols
- **CO-5** Create FTP and HTTP server

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

| Course Outcomes (COs) | Programme Outcomes (POs) | | | | | | | Programme Specific Outcomes* (PSOs) | |
|---|---|---|---|---|---|---|---|---|---|
| | **PO-1** Basic and Discipline Specific Knowledge | **PO-2** Problem Analysis | **PO-3** Design/ Development of Solutions | **PO-4** Engineering Tools | **PO-5** Engineering Practices for Society, Sustainability and Environment | **PO-6** Project Management | **PO-7** Life Long Learning | **PSO-1** | **PSO-2** |
| **CO-1** | 1 | - | - | - | - | - | 1 | | |
| **CO-2** | 2 | 2 | 1 | 1 | - | - | 1 | | |
| **CO-3** | 2 | 2 | 1 | 1 | - | - | - | | |
| **CO-4** | 2 | 3 | 1 | 1 | - | - | - | | |
| **CO-5** | 2 | 3 | 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 | | | | |
| **2418501** | Data communication and Computer Network | 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) | |
| **2418501** | Data communication and Computer Network | 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: T2418501

| Major Theory Session Outcomes (TSOs) | Units | Relevant Cos Number(s) |
|---|---|---|
| *TSO 1a.* Explain the process of data communication and its components.<br>*TSO 1b.* Explain the following terms in data communication<br>*TSO 1c.* Bandwidth, data transmission rate and baud rate.<br>*TSO 1d.* Differentiate between various models of communication and their applications.<br>*TSO 1e.* Differentiate between analog and digital signal transmission and the conversion processes between them.<br>*TSO 1f.* Select relevant type of transmission media depending on requirements.<br>*TSO 1g.* Classify the given networks into LAN and WAN<br>*TSO 1h.* List the different guided Transmission Media and Unguided Transmission Media<br>*TSO 1i.* Identify various Multiplexing and Switching techniques used in digital communication | **Unit-1.0 Data Communications and Transmission Media**<br>1.1 Process of data communication and its components: Transmitter, Receiver, Medium, Message, Protocol.<br>1.2 Protocol, Standard, Standard organization. Bandwidth, Data Transmission Rate, Baud Rate and Bits per second<br>1.3 Models of Communication (Simplex, Half Duplex, full Duplex)<br>1.4 Analog Signal and Digital Signal Transmission: Analog to Digital, Digital to Analog Conversion<br>1.5 Fundamentals of Computer Network: Definition and Need of Computer Network, Application, Network Benefits.<br>1.6 Classification of Network LAN and WAN<br>1.7 Network Architecture: Peer to peer, Client Server Network<br>1.8 Communication Media: guided Transmission Media, Twisted-Pair Cable, Coaxial Cable Fiber-optic Cable<br>1.9 Unguided Transmission Media, Radio Waves, Microwaves, Infrared, Satellite<br>1.10 Multiplexing: Frequency-Division Multiplexing, Time-Division Multiplexing. | **CO-1** |
| TSO.2.a Distinguish between error detection and error correction.<br>TSO.2.b Explain the coding techniques for data integrity.<br>TSO.2.c Calculate cyclic codes and checksum for error detection.<br>TSO.2.d Recognize the importance of framing in data transmission.<br>TSO.2.e Explain the techniques for error control in data communication. | **Unit 2.0 Data Link Layer**<br>2.1 **Introduction**: Types of Errors, Redundancy, Detection Versus Correction, Coding<br>2.2 **Block coding**: Error Detection, Error Correction Hamming Distance, Minimum Hamming Distance<br>2.3 **Cyclic codes**: Cyclic Redundancy Check, Polynomials, Cyclic Code Analysis, CHECKSUM<br>2.4 **Framing:** Fixed-Size Framing, Variable-Size Framing | **CO-2** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant Cos Number(s) |
|---|---|---|
| TSO.2.f Explain the function of Noisy and Noiseless channel protocols<br>TSO.2.g Explain the function of medium access control protocols.<br>TSO.2.h Explain the function of different channel partitioning protocols.<br>TSO.2.i Describe different types of Ethernets.<br>TSO.2.j Differentiate between various network connecting devices working at different TCP/IP layers. | 2.5 **Flow and error control:** Flow Control, Error Control<br>2.6 **Noiseless channels:** Simplest Protocol, Stop-and-Wait Protocol<br>2.7 **Noisy channels**: Stop-and-Wait Automatic Repeat Request, Go-Back-N Automatic Repeat Request, Selective Repeat Automatic Repeat Request, Piggybacking.<br>**2.8 Point-to-point protocol**<br>2.9 **Random access**: ALOHA, Carrier Sense Multiple Access (CSMA), Carrier Sense Multiple Access with Collision Detection (CSMACD), Carrier Sense Multiple Access with Collision Avoidance (CSMACA)<br>2.10 **Channelization**: Frequency-Division Multiple Access (FDMA), Time-Division Multiple Access (TDMA), Code-Division Multiple Access (CDMA)<br>2.11 **Ethernet**: Bridged Ethernet, Switched Ethernet Fast Ethernet, Gigabit Ethernet<br>2.12 **Connecting devices**: HUBs, Two-Layer Switches Routers, Three-Layer Switches, Gateway | |
| *TSO 3a.* Write different notations for IPv4 addresses.<br>*TSO 3b.* Differentiate between classful and classless addressing.<br>*TSO 3c.* Explain the function of Network Address Translation (NAT).<br>*TSO 3d.* Explain process of fragmentation in network layer protocols.<br>*TSO 3e.* Explain the functioning of ARP and RARP protocols.<br>*TSO 3f.* Explain the mechanism of packet receiving and forwarding in routing process.<br>*TSO 3g.* Differentiate between unicast and multicast routing protocols. | **Unit 3.0 Network Layer**<br>3.1 **IPv4 addresses**: Address Space, Notations, Classful Addressing, special case IP addresses, subnet, supernet, Classless Addressing, Network Address Translation (NAT), Datagram<br>3.2 Fragmentation, Checksum, Options<br>3.3 **Introduction to IPV6**: Advantages, Tunneling<br>3.4 **Address mapping:** Logical to Physical Address: ARP, Mapping Physical to Logical Address: RARP.<br>3.5 **Router Forwarding table, and Routing**: Function of unicast and multicast routing protocols | **CO-3** |
| *TSO 4a.* Explain client/server paradigm in process-to-process delivery.<br>*TSO 4b.* Explain the concepts of multiplexing and demultiplexing at transport layer.<br>*TSO 4c.* Differentiate between connectionless and connection-oriented services.<br>*TSO 4d.* Differentiate between reliable and unreliable communication.<br>*TSO 4e.* Differentiate the functioning of TCP and UDP protocol. | **Unit 4.0 Transport Layer**<br>4.1 **Process to Process Delivery: -**Client/Server Paradigm, Multiplexing and Demultiplexing, Connectionless Versus Connection-Oriented Service, Reliable Versus Unreliable<br>4.2 User datagram protocol (UDP): -Well-Known Ports for UDP, User Datagram, Checksum, UDP Operation, Use of UDP | **CO-4** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant Cos Number(s) |
|---|---|---|
| *TSO 4f.* Explain flow control mechanisms in TCP.<br>*TSO 4g.* Differentiate between open-loop and closed-loop congestion control. | 4.3 TCP: -TCP Services Features, Segment, A TCP Connection, Flow Control, Error Control<br>4.4 Congestion Control: - Open-Loop Congestion Control, Closed-Loop Congestion Control | |
| *TSO 5a.* Explain the functioning of DNS protocol.<br>*TSO 5b.* Differentiate between recursive and iterative domain name resolution.<br>*TSO 5c.* Explain the concept of remote logging using TELNET.<br>*TSO 5d.* Explain the roles of User Agent, Message Transfer Agent (SMTP), and Message Access Agent (POP and IMAP).<br>*TSO 5e.* Explain function of File Transfer Protocol (FTP) for file transfer.<br>*TSO 5f.* Differentiate between HTTP persistent and non-persistent connections.<br>*TSO 5g.* Explain the role of proxy servers in HTTP.<br>*TSO 5h.* Explain the functioning of DHCP | **Unit 5.0 Application Layer**<br>5.1 **Distribution of name space**: Hierarchy of Name Servers, Root Server, Primary and Secondary Servers<br>5.2 **DNS in the internet:** - Generic Domains, Country Domains, Inverse Domain<br>5.3 **Resolution**: -Resolver, Mapping Names to Addresses, Mapping Address to Names, Recursive Resolution, Iterative Resolution, Caching<br>5.4 **WWW: -** Architecture, Client (Browser), Server, Uniform Resource Locator, Cookies<br>5.5 **HTTP: -**HTTP Transaction, Persistent Versus Nonpersistent Connection, Proxy Server<br>**5.6 Dynamic Host Configuration Protocol (DHCP)**<br>5.7 **Remote logging: -** TELNET<br>5.8 **Electronic mail: -** ELECTRONIC MAIL, Architecture, User Agent, Message Transfer Agent: SMTP, Message Access Agent: POP and IMAP, Web-Based Mail<br>5.9 **File transfer: -**File Transfer Protocol (FTP) | **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: P2418501

| Practical/Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment/Practical Titles | Relevant COs Number (s) |
|---|---|---|---|
| LSO1.1 Recognize different Networking devices such LAN adapter, Hub, Switches, Routers.<br>LSO1.2 Prepare the UTP cable for cross and direct connection. | 1. | 1.1 Identify different Networking devices<br>1.2 Prepare different types of UTP cable | CO-1 |
| LSO.2.1 Create Star topology using network devices, cables, and Computers.<br>LSO.2.2 Configure wireless NIC and transfer files between systems in Wireless | 2. | 2.1 Create a network using Star topology.<br>2.2 Configure wireless NIC and transfer files between systems in Wireless network. | CO-2 |
| LSO.3.1 Configure Host IP, Subnet Mask and Default Gateway in a System.<br>LSO.3.2 Establish Peer to Peer network connection without Switch. | 3. | 3.1 Configure IP address using Network and Internet Setting in windows.<br>3.2 Establish Peer to Peer network connection using cross cable. | CO-3 |

| Practical/Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment/Practical Titles | Relevant COs Number (s) |
|---|---|---|---|
| LSO.4.1 Capture packet and analysis header using network simulator.<br>LSO.4.2 Configure Telnet Settings. | 4 | 4.1 Capture packet and analysis header using network simulator.<br>4.2 Perform remote login using Telnet. | CO-4 |
| LSO.5.1 Create HTTP server<br>LSO.5.2 Create FTP server | 5. | 5.1 Create HTTP sever<br>5.2 Create FTP server | 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: S2418501

**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 basic chat application that allows users to communicate over a local network.
2. Create a tool that monitors network bandwidth usage in real-time.
3. Create a simple remote desktop application that allows users to control a computer remotely over the network.

**c. Other Activities**:

1. Use network simulation tools like Cisco Packet Tracer, GNS3, or NS-3 to create and simulate network scenarios
2. Use packet capturing tools like Wireshark to capture and analyze network traffic in real-time.
3. Join online CTF challenges related to network security.
4. Study the function of all layers in TCP/IP suit.
5. Study all protocols of all layers of TCP/IP Suit.

**d. Self-Learning Topics**:

1. Learn about the virtualization of network functions, transforming traditionally hardware-based network functions into software.
2. Explore advanced concepts in QoS and QoE, including techniques for ensuring a high-quality user experience in networked applications.
3. Learn socket programming for process to process communication.
4. Learn different routing protocols.

**M) Suggested Course Evaluation Matrix:** 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) 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% | 15% | 15% |
| **CO-2** | 20% | 20% | 20% | 20% | 20% | 20% | 20% |
| **CO-3** | 25% | 25% | 25% | 20% | 20% | 20% | 20% |
| **CO-4** | 20% | 20% | 20% | 20% | 20% | 20% | 20% |
| **CO-5** | 20% | 20% | 20% | 20% | 20% | 25% | 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 cognitive domain of full course.

| Unit Title and Number | Total Classroom Instruction (Cl) Hours | Relevant COs Number(s) | Total Marks | ETA (Marks) | | |
|---|---|---|---|---|---|---|
| | | | | Remember (R) | Understanding (U) | Application & above (A) |
| **Unit-1.0** Data Communications and Transmission Media | 07 | CO-1 | 10 | 4 | 3 | 3 |
| **Unit 2.0** Data Link Layer | 10 | CO-2 | 14 | 4 | 4 | 6 |
| **Unit3.0** Network Layer | 15 | CO-3, CO-4 | 18 | 6 | 4 | 8 |
| **Unit 4.0** Transport Layer | 8 | CO-5 | 14 | 3 | 5 | 6 |
| **Unit 5.0** Application Layer | 8 | CO-5 | 14 | 3 | 5 | 6 |
| **Total** | **48** | - | **70** | **20** | **21** | **29** |

**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. | Identify different Networking devices. | CO-1 | 40 | 50 | 10 |
| 2. | Prepare different types of UTP cable. | CO-1 | 40 | 50 | 10 |
| 3. | Connect computers in Star topologies. | CO-1 | 40 | 50 | 10 |
| 4. | Configure wireless NIC and transfer files between systems in Wireless. | CO-2 | 30 | 60 | 10 |
| 5. | Configure Network and Internet Setting. | CO-2 | 40 | 50 | 10 |
| 6. | Establish Peer to Peer network connection using cross cable. | CO-2 | 50 | 40 | 10 |
| 7. | Capture packet and analysis header using network simulator. | CO-3 | 50 | 40 | 10 |
| 8. | Perform remote login using Telnet. | CO-5 | 50 | 40 | 10 |
| 9. | Create HTTP sever | CO-5 | 70 | 20 | 10 |
| 10. | Create FTP server | 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** (No Generic) Give basic configuration or Latest | Relevant Experiment/Practical Number |
|---|---|---|---|
| 1 | Computer System | Any General-purpose Computer | All |
| 2 | Simulator | Wind ump, cisco packet tracer, wire-shark, optional | All |
| 3 | Networking Device and Media | Switch and Router | All |

## R) Suggested Learning Resources:

### (a) Books:

| S. No. | Titles | Author(s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 1 | Computer Networking A top down Approach | F.Kurose | Pearson, ISBN-10: 9780133594140 ISBN-13:978-0133594140 |
| **2** | Computer Networks and Internet | D.E. Comer | Pearson, ISBN-10:0133587932 ISBN-13:978-0133587937 |
| **3** | Wireless Communications: Principles and Practice, 2nd edition | T. Rappaport | Prentice Hall, ISBN-10: 9788131731864 ISBN-13:978-8131731864 |
| **4** | Wireless Communication and Networking | John W. Mark, Weihua Zhuang | Prentice Hall, ISBN-10: 0130409057 ISBN-13:978-0130409058 |
| **5** | Data Communications and Networking | Behrouz A Forouzan | McGraw Hill, ISBN-10: 9780070634145 ISBN-13:978-0070634145 |

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

1. https://www.youtube.com/user/NetworKingInc
2. https://www.wiresharktraining.com/
3. https://www.netacad.com/
4. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/
5. https://www.edx.org/
6. https://www.coursera.org/

### (c) Others: (If any)

1. Learning Header files
2. Lab Manuals

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**A) Course Code : 2418502(T2418502/S2418502)**

**B) Course Title :** Software Engineering

**C) Pre- requisite Course(s) :**

**D) Rationale :**

Software Engineering is a systematic approach for software design, development, testing and maintenance by incorporating principles, techniques, and practices. Furthermore, software engineering helps to manage the costs, risks and schedule of the software development process. The goal of software engineering is to produce software that is efficient, easy to use, and maintain so as to fulfil the current and futuristic requirement of the user.

Through this course, student can develop abilities to build a framework to construct good quality software products and ensuring their reliability. Also, students can combine their domain-specific expertise with programming abilities to create superior software products.

**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** Choose suitable Software process model for software development.

**CO-2** Prepare software requirement specifications (SRS) for a given problem.

**CO-3** Construct data designs using different software models.

**CO-4** Evaluate size and cost of software product.

**CO-5** Plan software testing for quality assurance

**CO-6** Prepare plan to schedule and track the progress of a given project using project management techniques

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

| Course Outcomes (COs) | Programme Outcomes (POs) | | | | | | | Programme Specific Outcomes* (PSOs) | |
|---|---|---|---|---|---|---|---|---|---|
| | **PO-1** Basic and Discipline Specific Knowledge | **PO-2** Problem Analysis | **PO-3** Design/ Development of Solutions | **PO-4** Engineering Tools | **PO-5** Engineering Practices for Society, Sustainability and Environment | **PO-6** Project Management | **PO-7** Life Long Learning | **PSO-1** | **PSO-2** |
| **CO-1** | 1 | - | - | - | - | - | 1 | | |
| **CO-2** | 1 | 2 | 1 | 1 | - | - | 1 | | |
| **CO-3** | 2 | 2 | 1 | 1 | - | - | - | | |
| **CO-4** | 1 | 2 | 1 | 1 | - | - | - | | |
| **CO-5** | 2 | 1 | 2 | 1 | - | - | 1 | | |
| **CO-6** | 1 | 1 | 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 & 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 | | | | |
| **2418502** | Software Engineering | 02 | 01 | - | 02 | 05 | 04 |

**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) | |
| **2418502** | Software Engineering | 30 | 70 | 20 | 30 | - | - | 150 |

**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:** 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: T2418502**

| Major Theory Session Outcomes (TSOs) | Units | Relevant Cos Number(s) |
|---|---|---|
| *TSO 1a.* Identify the attributes that matches with standards for the given software application.<br>*TSO 1b.* Suggest the relevant software solution for the given problem with justification.<br>*TSO 1c.* Select the relevant software process model for the given problem statement.<br>*TSO 1d.* Select the relevant activities in agile development process in the given situation. | **Unit-1.0 Software Development Process**<br>1.1 Type of software, need for software engineering, software engineering as layered approach, its characteristics.<br>1.2 Software development frame work.<br>1.3 Software process framework, process models: perspective process models, specialized process models.<br>1.4 Agile software development: agile process and its importance, extreme programming, adaptive software development, scrum, dynamics system development method (DSDM), crystal<br>1.5 Selection criteria for software process model. | **CO-1** |
| TSO.2.a Apply the principles of software engineering for the given problem<br>TSO.2.b Analyze software requirement by following requirement engineering steps for the given problem.<br>TSO.2.c Represent the requirement engineering model for the given problem<br>TSO.2.d Prepare SRS for the given problem. | **Unit 2.0 Software Requirement Engineering**<br>2.1 Software engineering practices and its importance, core Principles.<br>2.2 Communication practices, planning practices, modeling Practices. Construction practices, software deployment (Statement and meaning of each Principles for each practice).<br>2.3 Requirement Engineering: Requirement gathering and Analysis, type of requirement (functional, product, organizational, external requirements) Electing requirements models, developing use cases building requirements models, requirement negotiation, validation.<br>2.4 Software Requirements Specification (SRS): need of SRS, Format, and its characteristic | **CO-2** |
| TSO.3.a Identify the elements of analysis model for the given software requirements.<br>TSO.3.b Apply the specified design feature for software requirements modeling.<br>TSO.3.c Represent the specified problem in the given design notation. | **Unit 3.0 Software Modeling and Design**<br>3.1 Translating requirement model into design model: data Modelling.<br>3.2 Analysis Modelling: Elements of Analysis model.<br>3.3 Design modelling: Fundamental design concept (Abstraction, Information hiding, | **CO-3** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant Cos Number(s) |
|---|---|---|
| | structure, modularity, concurrency, verification, Aesthetics)<br>3.4 Design notations: Data Flow Diagram (DFD), Structure Flowcharts, Decision Tables. | |
| TSO.4.a Estimate the size of the software product using the given method.<br>TSO.4.b Estimate the cost of the software product using the given empirical method.<br>TSO.4.c Evaluate the size of the given software using COCOMO model.<br>TSO.4.d Apply the RMMM strategy in identified risks for the given software development problem. | **Unit-4.0 Software Project Estimation**<br>4.1 The management spectrum-4P's<br>4.2 Metrics for size Estimation: Line of Code (LoC), Function Points (FP).<br>4.3 Project cost Estimation Approaches: Overview of Heuristic, Analytical, and Empirical Estimation.<br>4.4 COCOMO (Constructive Cost Model), COCOMO II.<br>4.5 Risk Management: Risk Identification, Risk Assessment, Risk Containment, RMMM Strategy. | **CO-4** |
| TSO.5.a Explain the given characteristic of software testing.<br>TSO.5.b Prepare test cases for the given problem.<br>TSO.5.c Analyze the test cases for a given problem.<br>TSO.5.d Describe the given Software Quality Assurance (SQA) activity.<br>TSO.5.e Describe the features of the given software quality evaluation standard. | **Unit 5.0 Software Testing and Quality Assurance:**<br>5.1 Testing-Meaning and purpose, testing methods- Black- box and White box, level of testing-Unit testing.<br>5.2 Test Documentation- Test case Template, test plan, Introduction to defect Report, test summary report.<br>5.3 Test planning and management: Test Strategy, Test Plan, Test Estimation, Test Case Design, Test Data Preparation, Test Progress Monitoring and Reporting.<br>5.4 Software Quality Management vs. Software Quality Assurance. Phases of Software Quality Assurance: Planning, Activities Audit, and review.<br>5.5 Quality Evaluation standards: Six sigma, ISO for software, CMMI: Levels, process areas. | **CO-5** |
| TSO.6.a Use the given scheduling technique for the identified project.<br>TSO.6.b Draw the activity network for the given task.<br>TSO.6.c Prepare the timeline chart/Gantt chart to track progress of the given project. | **Unit 6.0 Software Project Management**<br>6.1 Overview of project management activities, tasks, resources, Project Scheduling: Basic principle work breakdown structure, activity network and critical path method, scheduling Techniques (CPM, PERT).<br>6.2 Project Tracking; Timeline Charts. Earned value analysis, Gantt charts. | **CO-6** |

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

## K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: (Not Applicable)

## L) Suggested Term Work and Self Learning: S2418502

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

**b. Micro Projects:**

a. Study and analyze given software and write characteristics and function of the same.
b. Choose any problem statement and use data models to represent the situation
    I. Search and utilize different UML tools to represent models.
c. Choose a problem create activity network and use different project scheduling and tracking tools for the same.
d. Apply any testing tools (Selenium, JUnit, etc.) to ensure test cover, defect detection, test management, and Test Execution and Reporting for given problem.
e. Apply any project management tool (Microproject Project, Jira work management, etc.) to performs Project planning, Task management, Collaboration and Communication, Time tracking, Resources management, and Gantt Charts and Timelines for given problem.

**c. Other Activities:**

1. Seminar Topics:
    - Software development life cycle Models
    - Software Development Ethics: (Address ethical considerations in software engineering, such as data privacy, responsible AI, and the impact of technology on society)
    - Principles, methodologies, and best practices of Agile software development
    - Software Testing Strategies: (various software testing techniques, including manual testing, automated testing, and exploratory testing, and their significance in delivering quality software)
    - Challenges in Software Engineering

2. Self-Learning Topics:

- Different stages of the SDLC
- Techniques for improving code quality, such as code reviews, refactoring, and code analysis tools.
- Software testing techniques, such as unit testing, integration testing, and acceptance testing.

**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) 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% | - | 17% | -- | - |
| **CO-2** | 20% | 20% | 20% | 20% | 17% | - | - |
| **CO-3** | 20% | 20% | 20% | 20% | 17% | - | - |
| **CO-4** | 20% | 20% | 15% | 20% | 17% | - | - |
| **CO-5** | 15% | 15% | 15% | 20% | 16% | - | - |
| **CO-6** | 10% | 10% | 15% | 20% | 16% | - | - |
| **Total Marks** | **30** | **70** | **20** | **20** | **10** | **-** | **-** |
| | | | **50** | | | | |

**Legend:**

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

**: Mentioned under point- (N)

**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 (Cl) Hours | Relevant COs Number(s) | Total Marks | ETA (Marks) | | |
|---|---|---|---|---|---|---|
| | | | | Remember (R) | Understanding (U) | Application & above (A) |
| **Unit-1.0** Software Development Process | 6 | CO-1 | 09 | 3 | 3 | 3 |
| **Unit 2.0** Software Requirement Engineering | 9 | CO-2 | 14 | 4 | 4 | 6 |
| **Unit 3.0** Software Modeling and Design | 10 | CO-3 | 14 | 4 | 4 | 6 |
| **Unit 4.0** Software Project Estimation | 9 | CO-4 | 14 | 4 | 4 | 6 |
| **Unit 5.0** Software Testing and Quality Assurance | 7 | CO-5 | 10 | 3 | 3 | 4 |
| **Unit 6.0** Software Project Management | 7 | CO-6 | 09 | 2 | 3 | 4 |
| **Total** | **48** | **-** | **70** | **20** | **21** | **29** |

**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): (Not Applicable)

**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: (Not Applicable)

## R) Suggested Learning Resources:

### (a) Books:

| S. No. | Titles | Author(s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 1 | Software Engineering concepts | Fairly, Richard | McGraw Hill higher education, new Delhi -2001, ISBN-13: 9780074631218 |
| 2 | Software Engineering: A practitioner's approach | Pressman, Roger S. | McGraw Hill higher education, new Delhi, (Seventh Edition) ISBN : 978-0-07-337597-7 |
| **3** | Software Engineering principles and practices | Jain, Deepak | Oxford university press, New Delhi, ISBN :9780195694840 |
| 4 | Fundamentals of Software Engineering | Rajib Mall | Prentice Hall India Learning Private Limited, ISBN-13: 978-8120348981 |

### (b) Online Educational Resources:

1. https://www.tutorialspoint.com/software_engineering/index.htm
2. https://www.goskills.com/Project-Management/Resources/How-to-create-a-project-management-plan
3. https://www.javatpoint.com/software-testing-tutorial
4. https://www.codingninjas.com/studio/library/software-engineering

**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** : **2418503A(T2418503A/P2418503A/S2418503A)**

**B) Course Title** : Data Science: Data Warehousing and Data Mining

**C) Pre- requisite Course(s)** : Probability and Statistics, Python/JAVA

**D) Rationale** :

Data warehousing provides a structured and integrated repository for historical and real-time data, facilitating informed decision-making. It ensures data quality, consistency, and accessibility, leading to more reliable business intelligence and reporting. Data mining complements data warehousing by uncovering hidden patterns and insights within large datasets. It has significant applications in healthcare, genomics, and scientific research for discovering patterns and trends. Overall, data warehousing and data mining together provide a competitive advantage and drive data-driven decision-making, ultimately improving business performance.

**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 statistical methods and forecasting techniques for data analysis.
- **CO-2** Explain the architecture and benefits of data warehousing.
- **CO-3** Prepare / Pre-process data for data mining.
- **CO-4** Use classification techniques for predicting class label attributes.
- **CO-5** Use clustering techniques to identify groups of similar objects in datasets.

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

| Course Outcomes (COs) | Programme Outcomes (POs) | | | | | | | Programme Specific Outcomes* (PSOs) | |
|---|---|---|---|---|---|---|---|---|---|
| | **PO-1** Basic and Discipline Specific Knowledge | **PO-2** Problem Analysis | **PO-3** Design/ Development of Solutions | **PO-4** Engineering Tools | **PO-5** Engineering Practices for Society, Sustainability and Environment | **PO-6** Project Management | **PO-7** Life Long Learning | **PSO-1** | **PSO-2** |
| **CO-1** | 2 | - | - | - | - | - | 1 | | |
| **CO-2** | 2 | 1 | 1 | - | - | - | 1 | | |
| **CO-3** | 2 | 2 | 1 | 1 | - | - | - | | |
| **CO-4** | 2 | 3 | 3 | 2 | - | - | - | | |
| **CO-5** | 2 | 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 | | | | |
| **2418503A** | Data Science: Data Warehousing and Data Mining | 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) | |
| **2418503A** | Data Science: Data Warehousing and Data Mining | 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%)** aswell 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: T2418503A

| Major Theory Session Outcomes (TSOs) | Units | Relevant Cos Number(s) |
|---|---|---|
| TSO1.a Identify various data collection methods and sources in data science.<br>TSO1.b Explain the various data types and data structures used in data science.<br>TSO1.c Differentiate between data types and data structures in data science.<br>TSO1.d List different statistical methods used in data science for data analysis.<br>TSO1.e Explain the principle of Hypothesis Testing<br>TSO1.f Compare the methodologies of various Forecasting techniques. | **Unit-1.0 Data Science: Concepts and Techniques**<br>1.1 Concepts and Importance<br>1.2 Data Types and Data Structures in Data Science<br>1.3 Data Collection and Data Sources in Data Science<br>1.4 Exploratory Data Analysis (EDA)<br>1.5 Statistical Methods for Data Analysis in Data Science<br>• Descriptive Analysis<br>• Exploratory Analysis<br>• Inferential Analysis<br>• Predictive Analysis<br>• Linear Regression<br>• Logistic Regression<br>1.6 Probability and Probability Distributions in Data Science<br>1.7 Hypothesis Testing<br>1.8 Forecasting Techniques<br>• Delphi<br>• Input Output Analysis<br>• Extrapolation<br>• Time Series analysis<br>1.9 Data Ethics and Privacy in Data Science | **CO-1** |
| TSO2.a Explain the need for a separate data warehouse in the context of data storage and retrieval.<br>TSO2.b Differentiate between the various Data Warehouse Models.<br>TSO2.c Explain the benefits of data warehousing in terms of data management and decision-making.<br>TSO2.d List the benefits of OLAP in analytical tasks.<br>TSO2.e Differentiate between OLAP and data mining. | **Unit-2.0 Data Warehousing and On-Line Analytical Processing**<br>2.1 Definition of Data Warehouse<br>2.2 Need for separate data warehouse<br>2.3 Data Warehouse Models:<br>• Enterprise Warehouse<br>• Data Mart<br>• Virtual Warehouse<br>2.4 Difference between Operational Database System and Data Warehouse<br>2.5 Conceptual Modeling of Data Warehouse<br>2.6 Data warehouse architecture<br>2.7 Benefits of data warehousing<br>2.8 Introduction to Online Analytical Processing | **CO-2** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant Cos Number(s) |
|---|---|---|
| | 2.8.1 OLAP applications<br>2.8.2 Features of OLAP<br>2.8.3 Benefits of OLAP<br>2.8.4 Strengths of OLAP<br>2.8.5 Comparison between OLTP and OLAP<br>2.8.6 Differences between OLAP and data mining<br>2.9 OLAP Operations (Roll-up, Drill down, Slice and dice)<br>2.10 Data Cube Computation<br>2.11 Data warehouses versus OLTP: similarities and distinction | |
| TSO 3a. Explain the fundamental concepts of data mining.<br>TSO 3b. Explain the significance of data mining and its applications in solving real- world problems.<br>TSO 3c. List various data mining techniques.<br>TSO 3d. Explain the importance of data preprocessing and major tasks involved in data preprocessing.<br>TSO 3e. List steps to integrate a data mining system with a database.<br>TSO 3f. Explain major issues in data mining. Differentiate between operational database systems and data warehouses. | **Unit 3.0 Introduction to Data Mining**<br>3.1 Introduction<br>3.2 Data Mining as Evolution of Information Technology<br>3.3 Types of data for mining<br>• Database Data<br>• Data Warehouses<br>• Transactional Data<br>• Other types of data<br>3.4 Need of Data Mining<br>3.5 Data Mining Application<br>3.6 Data Preprocessing<br>3.6.1 Need for Data Preprocessing<br>3.6.2 Major Tasks in Data Preprocessing<br>3.6.3 Data Preprocessing Methods<br>• Data cleaning<br>• Data integration<br>• Data transformation<br>• Data reduction<br>• Data Discretization<br>3.7 Data Mining Techniques<br>• - Predictive modeling Database segmentation<br>• Link analysis<br>• Deviation detection<br>3.8 Integration of a Data Mining System with Database<br>3.9 Major Issues in Data Mining | **CO-3** |
| *TSO 4a.* Explain the approaches used to solve classification problems including the steps involved in the process.<br>*TSO 4b.* Explain the evaluation of classifiers using appropriate techniques to assess their performance.<br>*TSO 4c.* Explain different classification metrics such as accuracy, precision, recall.<br>*TSO 4d.* Explain the concept of pattern- based | **Unit 4.0 Classification Methods**<br>4.1 Introduction to Classification<br>4.2 Approach to solve classification problems<br>4.3 Evaluation of Classifiers<br>4.4 Classification Metrics<br>4.5 Types of Classification<br>4.5.1 Posteriori Classification<br>4.5.2 Priori Classification<br>4.5.3 Binary Classification | **CO-4** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant Cos Number(s) |
|---|---|---|
| classification.<br>*TSO 4e.* Explain the characteristics of lazy learners in classification.<br>*TSO 4f.* Give examples of real-world applications of classification. | 4.5.4 Multi-class Classification<br>4.6 Classification Techniques<br>4.6.1 Bayesian Classification<br>4.6.2 Support Vector Machine<br>4.6.3 Decision Tree<br>4.6.4 Dimensionality Reduction<br>4.7 Pattern Based Classification<br>4.8 Over-fitting and Under-fitting<br>4.9 Lazy Learners<br>4.10 Applications of Classification | |
| TSO 5a. Identify the requirements for conducting cluster analysis.<br>TSO 5b. Explain the various applications of cluster analysis in real-world scenarios.<br>TSO 5c. Explain different basic clustering methods, including partitioning, hierarchical, and density-based methods.<br>TSO 5d. Differentiate between agglomerative and divisive hierarchical clustering techniques.<br>TSO 5e. Explain the techniques for identifying and handling outliers in cluster analysis.<br>TSO 5f. Explain the role of web mining in extracting valuable information from different web-based sources. | **Unit 5.0: Cluster Analysis and Web Mining**<br>5.1 Introduction to Cluster Analysis<br>5.2 Requirements for cluster analysis<br>5.3 Applications of Cluster Analysis<br>5.4 Overview of basic clustering methods<br>5.5 Major Clustering Methods<br>5.5.1 Partitioning Based<br>• k-Means Clustering- A Centroid-Based Technique<br>5.5.2 Hierarchical Based<br>• Agglomerative<br>• Divisive<br>5.5.3 Density Based<br>• DBSCAN: Density-Based Clustering Based on Connected<br>5.6 Agglomerative versus Divisive Hierarchical Clustering<br>5.7 Distance Measures in Algorithmic Methods<br>5.8 Applications of Cluster Analysis<br>5.9 Identifying and handling of outliers<br>5.10 Outlier Detection Techniques<br>5.11 WEB MINING: Basic concepts<br>5.12 PAGE RANK Algorithm<br>5.13 HITS Algorithm | **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: P2418503A

| Practical/Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment/Practical Titles | Relevant COs Number (s) |
|---|---|---|---|
| LSO 1.1 List the necessary data preprocessing methods<br>LSO 1.2 Identify the suitable datasets for using as input in linear regression and logistic regression.<br>LSO 1.3 Calculate the efficiency of the various algorithms used for statistical analysis. | 1. | 1.1 Practice the necessary basic functions to handle the dataset.<br>1.2 Perform the statistical analysis by using linear regression and logistic regression on suitable dataset. Conduct the time using different sizes of datasets.<br>1.3 Perform the statistical analysis by using logic regression on suitable datasets. Conduct the time using different sizes of datasets. | CO-1 |
| LSO 2.1 Explain the OLAP operations with suitable examples.<br>LSO 2.2 Explain the OLAP cube construction process with necessary steps.<br>LSO 2.3 List the OLAP queries for any data.<br>LSO 2.4 Differentiate the OLTP and OLAP queries and operations. | 2. | 2.1 Perform the necessary OLAP Operations<br>2.2 Demonstrate the OLAP Cube construction<br>2.3 Apply the OLAP Queries on suitable input.<br>2.4 Demonstrate the OLTP using a dataset | CO-2 |
| LSO 3.1 Explain the data pre-processing tasks<br>LSO 3.2 Explain the attribute reduction in a dataset<br>LSO 3.3 Handle the missing values in a dataset.<br>LSO 3.4 Explain the data segmentation | 3. | 3.1 Perform the following data pre-processing tasks using a dataset.<br>• Data cleaning<br>• Data integration<br>3.2 Perform the following data pre-processing tasks using a dataset.<br>• Data reduction<br>• Data transformation<br>3.3 Pre-process a given dataset based on Attribute selection<br>3.4 Pre-process a given dataset based on Handling Missing Values<br>3.5 Perform data segmentation on a dataset | CO-3 |
| LSO 4.1 Identify the suitable datasets for demonstrating the various algorithms<br>LSO 4.2 Explain the Apriori algorithm.<br>LSO 4.3 Explain the FP-Growth<br>LSO 4.4 Calculate the Information Gain Ratio<br>LSO 4.5 Explain the Bayesian Classifier<br>LSO 4.6 Explain the Decision Tree<br>LSO 4.7 Explain the SVM | 4 | 4.1 Implement the Apriori algorithm.<br>4.2 Implementation of FP-Growth<br>4.3 Calculate the Information Gain Ration for the input dataset<br>4.4 Implementation of Bayesian Classifier<br>4.5 Implementation of Decision Tree<br>4.6 Implementation of SVM<br>4.7 Demonstrate the pattern based classification | CO-4 |
| LSO 5.1 Identify the suitable datasets for demonstrating the various algorithms<br>LSO 5.2 Explain the k-means clustering algorithm<br>LSO 5.3 Explain the DBSCAN algorithm | 5. | 5.1 Implement the K-Means clustering algorithm on a dataset<br>5.2 Implement the DBSCAN algorithm on a dataset | CO-5 |

| Practical/Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment/Practical Titles | Relevant COs Number (s) |
|---|---|---|---|
| LSO 5.4 Differentiate the k-Means and DBSCAN<br>LSO 5.5 Explain the Hierarchical clustering algorithm<br>LSO 5.6 Explain the page ranking algorithm<br>LSO 5.7 Explain the HITS algorithm | | 5.3 Implement the Hierarchical algorithm on a dataset<br>5.4 Implement the Page Ranking algorithm<br>5.5 Implement the HITS algorithm | |

## L) Suggested Term Work and Self Learning: S2418503A

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

1. Differentiate the Linear Regression and Logistic Regression with examples.
2. Explain the role of time series analysis in the process of forecasting.
3. Explain in detail about the hypothesis testing with suitable example.
4. Explain the OLAP operations by using a database.
5. Demonstrate the data cube operation by using a real time dataset.
6. Write the importance of the data pre-processing methods over the decision-making process on any dataset. Justify it.
7. Differentiate the posterior classification and priori classification with suitable examples.
8. Construct a decision tree for forecasting the Weather of the city in future.
9. Differentiate the agglomerative clustering and divisive clustering with suitable examples.
10. Write the advantages and disadvantages of the k-Means clustering and DBSCAN algorithm.

**b. Micro Projects: Troubleshooting and Maintenance of a Classroom Computer Lab**

1. Social Network Analysis: Analyze a social network dataset to understand network structure, identify influential nodes, or detect communities within the network.
2. Clustering:
   a. k-Means Clustering: Apply the K-Means clustering algorithm to group data points into clusters. Experiment with different values of K to understand its impact.
   b. Hierarchical Clustering: Implement hierarchical clustering on a dataset, visualize dendrograms, and analyze the results.
3. Classification:
   a. Decision Trees: Build a decision tree model for classification using a popular dataset like the Iris dataset. Evaluate the model's accuracy, and visualize the decision tree.
   b. Support Vector Machines (SVM): Use SVM to classify data points into different classes. Experiment with different kernels (linear, radial basis function) and tune hyper-parameters.
4. Web Scraping and Data Extraction: Write a Python script to scrape data from a website. Extract relevant information and store it in a structured format (e.g., CSV, Excel). Apply basic data cleaning techniques to the extracted data.
5. Use a classification dataset and implement machine learning algorithms like decision trees, Random forests, or support vector machines to classify data points. Evaluate the models using metrics like accuracy, precision, recall, and F1-score

**c. Other Activities**:

1. Lab Activities:
    - Install Python IDE and important Python Libraries
    - Install Anaconda and find the features of Jupyter Notebook.
    - Import various module using 'import '
    - Use Pip Python package manager.
    - Import Libraries and Functions in Python

2. Explore different tools related to data mining and data warehousing like **Weka**, **Python** with **Scikit-learn**, **R**.

3. Explore data visualization tools of Python like Matplotlib, Plotly. (https://matplotlib.org/, https://plotly.com/python/)

4. Explore statistical tools for data analysis like Numpy, Pandas, Scipy. (https://numpy.org/, https://pandas.pydata.org/, https://www.scipy.org/)

5. Self-Learning Topics:

    - Statistics and Probability: Understand foundational concepts like probability, statistical distributions, and hypothesis testing.
    - Machine Learning: Study algorithms for supervised learning (regression, classification) and unsupervised learning (clustering, dimensionality reduction).
    - Deep Learning: Dive into neural networks, frameworks like Tensor-Flow and PyTorch, and applications like image and natural language processing.
    - Natural Language Processing (NLP): Explore NLP techniques for text analysis, sentiment analysis, and language generation.
    - Data Integration: Understand techniques for integrating data from various sources into a data warehouse.
    - Data Warehouse Cloud Services: Get familiar with cloud-based data warehousing solutions like Amazon Redshift, Google BigQuery, and Snowflake.
    - Data Ethics and Privacy: Understand the ethical considerations and legal aspects of working with data.

**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) 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% | 10% | 20% | 15% | 20% | 20% |
| **CO-2** | 20% | 20% | 10% | 20% | 25% | 20% | 20% |
| **CO-3** | 20% | 20% | 20% | 20% | 20% | 20% | 20% |
| **CO-4** | 25% | 25% | 30% | 20% | 20% | 20% | 20% |
| **CO-5** | 20% | 20% | 30% | 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 is 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** Data Science: Concepts and Techniques | 8 | CO-1 | 10 | 2 | 4 | 4 |
| **Unit 2.0** Data Warehousing and On- Line Analytical Processing | 10 | CO-2 | 14 | 4 | 4 | 6 |
| **Unit3.0** Introduction to Data Mining | 12 | CO-3 | 14 | 5 | 5 | 4 |
| **Unit 4.0** Classification Methods | 10 | CO-4 | 18 | 5 | 6 | 7 |
| **Unit 5.0** Cluster Analysis and Web Mining | 8 | CO-5 | 14 | 4 | 4 | 6 |
| **Total** | **48** | **-** | **70** | **20** | **23** | **27** |

**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. | Practice the necessary basic functions to handle the dataset. | CO-1 | 40 | 50 | 10 |
| 2. | Perform the statistical analysis by using linear regression and logistic regression on suitable dataset. Conduct the time using different sizes of datasets. | CO-1 | 40 | 50 | 10 |
| 3. | Perform the statistical analysis by using logic regression on suitable datasets. Conduct the time using different sizes of datasets. | CO-1 | 40 | 50 | 10 |
| 4. | Perform the necessary OLAP Operations | CO-2 | 30 | 60 | 10 |
| 5. | Demonstrate the OLAP Cube construction | CO-2 | 40 | 50 | 10 |
| 6. | Apply the OLAP Queries on suitable input. | CO-2 | 50 | 40 | 10 |
| 7. | Demonstrate the OLTP using a dataset | CO-2 | 50 | 40 | 10 |
| 8. | Perform the following data pre-processing tasks using a dataset.<br>a. Data cleaning<br>b. Data integration | CO-3 | 50 | 40 | 10 |
| 9. | Perform the following data pre-processing tasks using a dataset.<br>a. Data reduction<br>b. Data transformation | CO-3 | 50 | 40 | 10 |
| 10. | Pre-process a given dataset based on Attribute selection | CO-3 | 50 | 40 | 10 |
| 11. | Pre-process a given dataset based on Handling Missing Values | CO-3 | 70 | 20 | 10 |
| 12. | Perform data segmentation on a dataset | CO-3 | 70 | 20 | 10 |
| 13. | Implement the Apriori algorithm on a dataset. | CO-4 | 50 | 40 | 10 |
| 14. | Implement the FP-Growth algorithm on a dataset | CO-4 | 50 | 40 | 10 |
| 15. | Calculate the Information Gain Ration for the input dataset | CO-4 | 50 | 40 | 10 |
| 16. | Classify the input data records by using Bayesian Classifier | CO-4 | 50 | 40 | 10 |
| 17. | Construct a decision tree for the given input dataset using J48 classifier | CO-4 | 50 | 40 | 10 |
| 18. | Perform the binary classification on a dataset using SVM classifier | CO-4 | 50 | 40 | 10 |
| 19. | Demonstrate the pattern based classification | CO-4 | 50 | 40 | 10 |
| 20. | Implement the K-Means clustering algorithm on a dataset | CO-5 | 50 | 40 | 10 |

| S. No. | Laboratory Practical Titles | Relevant COs Number(s) | PLA/ELA | | |
|---|---|---|---|---|---|
| | | | Performance | | Viva-Voce (%) |
| | | | PRA* (%) | PDA** (%) | |
| 21. | Implement the DBSCAN algorithm on a dataset | CO-5 | 50 | 40 | 10 |
| 22. | Implement the Hierarchical algorithm on a dataset | CO-5 | 50 | 40 | 10 |
| 23. | Implement the Page Ranking algorithm | CO-5 | 50 | 40 | 10 |
| 24. | Implement the HITS algorithm | 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 i5, 4 GB RAM, 15 GB free disk space | All |
| 2. | Data Analysis Tools | SPSS software, Excel Software | All |
| 3 | Data warehousing open source tools | WEKA 3<br>Orange Data Mining<br>Rapid Miner<br>Scikit-learn<br>KNIME | All |

## R) Suggested Learning Resources:

### (a) Books:

| S. NO. | Title of Book | Author | Publication |
|---|---|---|---|
| 1 | Data Mining Tools and Techniques | J. Han and M. Kamber | Morgan Kaufmann Publishers, 3rd Edition, ISBN 978-0-12-381479-1 |
| **2** | Data Mining Introductory and Advanced Topics | M.H. Dunham, Sridhar | Pearson Education, 1ST Edition, ISBN 10-8177587854, ISBN-13-978-8177587852 |
| **3** | Introduction to Data Mining | Pang-Ning Tan, Michael Steinbach and Vipin Kumar | Pearson Education, 1ST Edition, ISBN10 – 9332571406 ISBN 13-978-9332571402 |
| **4** | Data warehousing - concepts, Techniques, Products and Applications | Prabhu | Prentice Hall of India, 3rd Revised edition, ISBN 10-978-8120336278 |

### (b) Online Educational Resources:

1. https://www.geeksforgeeks.org/data-science-tutorial/
2. https://www.javatpoint.com/data-science
3. https://www.tutorialspoint.com/data_science/index.htm
4. https://www.w3schools.com/datascience/

*****

**A) Course Code** : **2418503B(T2418503B/P2418503B/S2418503B)**

**B) Course Title** : Advanced JAVA Programming

**C) Pre- requisite Course(s)** : Java Programming

**D) Rationale** :

The curriculum integrates JDBC (Java Database Connectivity), Java Servlets, and JSP (Java Server Page) to provide a comprehensive understanding of Java web development. JDBC equips students with database connectivity skills, allowing them to interact with databases, execute SQL queries, and manage data effectively. Java Servlets enable students to create dynamic web applications, handle HTTP requests, providing a strong foundation for server-side programming. JSP extends this knowledge by teaching students how to develop web pages with embedded Java code, making web application development more efficient. The curriculum emphasizes practical application through hands-on exercises, enabling students to build database-driven web applications. By combining these technologies, students are well-prepared to pursue careers in web development, as they gain expertise in building dynamic and data-driven web solutions.

**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** Develop executable applet code that can be embedded into web pages.
- **CO-2** Develop applications using Abstract Window Toolkit
- **CO-3** Use SQL statements in java for creating tables and performing CRUD (Create, Read, Update, Delete) operations using JDBC.
- **CO-4** Develop server-side programs using servlets.
- **CO-5** Develop a JSP program that retrieves and displays database records.

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

| Course Outcomes (COs) | Programme Outcomes (POs) | | | | | | | Programme Specific Outcomes* (PSOs) | |
|---|---|---|---|---|---|---|---|---|---|
| | **PO-1** Basic and Discipline Specific Knowledge | **PO-2** Problem Analysis | **PO-3** Design/ Development of Solutions | **PO-4** Engineering Tools | **PO-5** Engineering Practices for Society, Sustainability and Environment | **PO-6** Project Management | **PO-7** Life Long Learning | **PSO-1** | **PSO-2** |
| **CO-1** | 1 | - | 1 | - | - | - | - | | |
| **CO-2** | 1 | 2 | 2 | 1 | - | 1 | - | | |
| **CO-3** | 1 | 2 | 2 | 1 | - | 1 | - | | |
| **CO-4** | 1 | 2 | 2 | 1 | - | 1 | 2 | | |
| **CO-5** | 1 | 2 | 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 | | | | |
| **2418503B** | Advanced JAVA Programming | 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) | |
| **2418503B** | Advanced JAVA Programming | 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: T2418503B

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| *TSO 1a.* Explain concept of applet life cycle.<br>*TSO 1b.* Differentiate between applet and application.<br>*TSO 1c.* Develop code for simple java applets.<br>*TSO 1d.* Use applet tag and its parameter.<br>*TSO 1e.* Use the methods of the applet and component classes. | **Unit-1.0 JAVA Applet**<br>1.1 Applet: Local and remote applets, Difference between applet and application, Applet life cycle, Developing executing applet code<br>1.2 Web page design: Applet tag, Adding applet to HTML file, Passing parameter to applet, Various methods and component classes to develop basic applet, Running applet.<br>1.3 Applet graphics: Drawing shapes and text, Handling graphics in applets, Animation with applets. | **CO-1** |
| *TSO 2a.* Explain the fundamental concepts of windows in AWT.<br>*TSO 2b.* Compare AWT and Swing for developing graphical user interfaces.<br>*TSO 2c.* Differentiate between various event classes in AWT.<br>*TSO 2d.* List the advantages and disadvantages of different layout managers.<br>*TSO 2e.* Explain the role and purpose of event listener interfaces.<br>*TSO 2f.* Create an event-handling mechanism using event listener interfaces. | **Unit-2.0 Abstract Window Toolkit (AWT)**<br>2.1 Abstract Window Toolkit: Class hierarchy, Window fundamentals<br>2.2 Frame Window: Creating a frame window in the applet, Canvas, Creating a window program<br>2.3 Graphics-AWT Controls: Labels, TextField, Pushbuttons<br>2.4 Layout Managers: Flow Layout, Border Layout, Grid Layout, Card Layout<br>2.5 Developing Graphical User Interface using Swing: JApplet, JLabel, JTextField, JButton, JCheckBox, JRadioButton, JComboBox, Menus<br>2.6 Event Classes: MouseEvent Class, ActionEvent Class, WindowEvent Class<br>2.7 Event Listen Interface: MouseListener, ActionListener, WindowListener and KeyListner | **CO-2** |
| *TSO 3a.* Describe the basics of JDBC and its connectivity. | **Unit-3.0 Java Data Base Connectivity (JDBC)**<br>3.1 JDBC Architecture: Two-Tier Database Design, Three-Tier Database Design | **CO-3** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| *TSO 3b.* Explain the key components of the JDBC API and their functions.<br>*TSO 3c.* Compare different types of JDBC drivers.<br>*TSO 3d.* Develop Java code to work with JDBC statements.<br>*TSO 3e.* Explain the process of managing connections and resources in JDBC.<br>*TSO 3f.* Implement transactions in JDBC, including both auto-commit and manual transaction management.<br>*TSO 3g.* List the advantages and disadvantages of JDBC. | 3.2 The JDBC API: The API components, Database operation: creating tables, CRUD (Create, Read, Update, and Delete) operations using SQL.<br>3.3 Establishing a JDBC Connection: JDBC Data Types, JDBC drivers, Connection management and resource cleanup, JDBC- Statements, Prepared Statement and Callable Statement, JDBC- Result Set, JDBC- Transactions, JDBC- Exception Handling.<br>3.4 JDBC- Advantages and Disadvantages | |
| *TSO 4a.* Describe life cycle of servlet.<br>*TSO 4b.* Explain the purpose and key features of the javax.servlet package.<br>*TSO 4c.* Differentiate between the javax.servlet and javax.servlet.http packages.<br>*TSO 4d.* Explain the components and purpose of the Java Servlet Development Kit (SDK).<br>*TSO 4e.* Create a servlet that serves specific web application functionality.<br>*TSO 4f.* Evaluate the benefits and drawbacks of using servlets for web development | **Unit-4.0 Servlets Programming**<br>4.1 Servlet API<br>4.2 javax.servlet Package<br>4.3 The javax.servlet. HTTP Package<br>4.4 The life cycle of a servlet<br>4.5 The Java Servlet Development Kit<br>4.6 The Simple Servlet: Create and compile servlet source code, Start a web browser and request the servlet, Example of echo servlet, Deployment in Tomcat server, Handling HTTP Requests and Responses | **CO-4** |
| *TSO 5a.* Explain the architecture of JSP and its Life-cycle.<br>*TSO 5b.* Differentiate between various JSP implicit objects.<br>*TSO 5c.* Develop simple programs using Java Server Pages tags<br>*TSO 5d.* Write JSP expressions to display dynamic content within a web page.<br>*TSO 5e.* Create JSP pages using action tags to implement various functionalities.<br>*TSO 5f.* Implement a JSP program that fetches and displays database records. | **Unit-5.0 Java Server Pages (JSP)**<br>5.1 Relation of Applets and Servlets with JSP<br>5.2 Lifecycle of JSP<br>5.3 JSP Scripting Elements<br>5.4 JSP Implicit Objects: Implicit objects- example of out and request, Response implicit object, Page Context, page and exception implicit object<br>5.5 JSP Expressions<br>5.6 JSP Action Tags<br>5.7 JSP Declarations<br>5.8 JSP- Standard Tag Library (JSTL)<br>5.9 Difference between JSP and Servlet<br>5.10 Simple JSP program to fetch database records | **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: P2418503B

| Practical/Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment/Practical Titles | Relevant COs Number(s) |
|---|---|---|---|
| *LSO 1.1.* Implementation of Applet for<br>a) displaying clock<br>b) Filling colors in the shape<br>c) Creating an event listener<br>d) Displaying image | 1. | a) Write a program to display clock using Applet.<br>b) Write a program to fill colors in shapes using Applet.<br>c) Write a program to create an event listener in Applet.<br>d) Write a program to display image using Applet. | CO-1 |
| *LSO 2.1.* Use AWT components to create Label, textfield, textarea, button,checkbox, radio button.<br>*LSO 2.2.* Create a form using Component list and choice.<br>*LSO 2.3.* Create a simple calculator by using grid layout. | 2. | a) Write a program for using the following awt components: Label, text field, text area, button, checkbox, radio button.<br>b) Write a program to design a form using the components list and choice.<br>c) Write a program to design a simple calculator by using grid layout. | CO-2 |
| *LSO 3.1.* Create a program to<br>a) Connect with JDBC database.<br>b) Insert values into Table.<br>c) Delete values from Table. | 3. | a) Write a java program that connects to a database using JDBC.<br>b) Write a java program to connect to database using JDBC &insert values into table.<br>c) Write a java program to connect to a database using JDBC and delete values from table. | CO-3 |
| *LSO 4.1.* Illustrate counter concept using deployment descriptor.<br>*LSO 4.2.* Create a web form which process servlet and apply concept of cookies and sessions. | 4. | a) Write a simple servlet program which maintains a counter for the number of times it has been accessed since its loading; initialize the counter Using deployment descriptor.<br>b) Create a web form which processes servlet and demonstrates use of Cookies and sessions. | CO-4 |
| *LSO 5.1.* Illustrate the concept of JSP for developing web pages. | 5. | a) Write a simple JSP program for user registration and then control will be transfer it into second page.<br>b) Write a simple JSP program for user login form with static and dynamic database<br>c) Write a JSP program to display the grade of a student by accepting the marks of five subjects. | 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: S2418503B

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. Create a web-based system for managing employee leave requests and approvals.
2. Develop a system that manages patient records, appointments, and billing for a hospital.
3. Build an e-commerce platform with product listings, user accounts, and a recommendation system.
4. Create a real-time chat application where users can register, join chat rooms, and exchange messages.

**c. Other Activities:**

1. Seminar on Java EE (Enterprise Edition) for Web Applications.
2. Seminar on Java Security Best Practices.
3. Seminar on Spring Framework in Java Development.
4. Seminar on Microservices Architecture in Java.

**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) 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% | 15% | 20% | 20% |
| **CO-2** | 25% | 25% | 25% | 20% | 25% | 20% | 20% |
| **CO-3** | 20% | 20% | 20% | 20% | 20% | 20% | 20% |
| **CO-4** | 20% | 20% | 20% | 20% | 20% | 20% | 20% |
| **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) |
| **Unit-1.0** JAVA Applet | 8 | CO-1 | 10 | 3 | 2 | 5 |
| **Unit-2.0** Abstract window Toolkit (AWT) | 10 | CO-2 | 18 | 6 | 4 | 8 |
| **Unit-3.0** Java Data Base Connectivity (JDBC) | 10 | CO-3 | 14 | 3 | 4 | 7 |
| **Unit-4.0** Servlets Programming | 10 | CO-4 | 14 | 4 | 4 | 6 |
| **Unit- 5.0** Java Server Pages (JSP) | 10 | CO-5 | 14 | 4 | 4 | 6 |
| **Total** | **48** | **-** | **70** | **20** | **18** | **32** |

**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 display clock using Applet | CO-1 | 30 | 60 | 10 |
| 2. | Write a program to fill colors in shapes using Applet. | CO-1 | 30 | 60 | 10 |
| 3. | Write a program to create an event listener in Applet | CO-1 | 30 | 60 | 10 |
| 4. | Write a program to display image using Applet | CO-1 | 30 | 60 | 10 |
| 5. | Write a program for using the following awt components: Label, text field, text area, button, checkbox, radio button. | CO-2 | 30 | 60 | 10 |
| 6. | Write a program to design a form using the components list and choice. | CO-2 | 30 | 60 | 10 |
| 7. | Write a program to design a simple calculator by using grid layout. | CO-2 | 30 | 60 | 10 |
| 8. | Write a java program that connects to a database using JDBC. | CO-3 | 30 | 60 | 10 |
| 9. | Write a java program to connect to database using JDBC & insert values into table. | CO-3 | 30 | 60 | 10 |
| 10. | Write a java program to connect to a database using JDBC and delete values from table. | CO-3 | 30 | 60 | 10 |
| 11. | Write a simple servlet program which maintains a counter for the number of times it has been accessed since its loading; initialize the counter Using deployment descriptor. | CO-4 | 30 | 60 | 10 |

| S. No. | Laboratory Practical Titles | Relevant COs Number(s) | PLA/ELA | | |
|---|---|---|---|---|---|
| | | | Performance | | Viva-Voce (%) |
| | | | PRA* (%) | PDA** (%) | |
| 12. | Create a web form which processes servlet and demonstrates use of Cookies and sessions. | CO-4 | 30 | 60 | 10 |
| 13. | Write a simple JSP program for user registration and then control will be transfer it into second page. | CO-5 | 30 | 60 | 10 |
| 14. | Write a simple JSP program for user login form with static and dynamic database | CO-5 | 30 | 60 | 10 |
| 15. | Write a JSP program to display the grade of a student by accepting the marks of five subjects. | CO-5 | 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. | Computer system | Processor Intel Core i5, 4 GB RAM, 15 GB free disk space | All |
| 2. | Integrated Development and Learning Environment (IDLE) | S/w to be downloaded for python 3.11.3 or higher | All |
| 3 | Package Distribution and IDE | Anaconda, Visual Studio Code, Pycharm, Conda, Spyder, RStudio etc. | All |
| 4 | Python-libraries | Numpy, Scipy, OpenCV | All |

## R) Suggested Learning Resources:

### (a) Books:

| S. No. | Titles | Author(s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 1 | Head First Servlets and JSP | Bryan Basham, Kathy Sierra, and Bert Bates | O'Reilly Media,2nd Edition, ISBN-13: 978-0596516680 |
| 2 | Core and Advanced Java, Black Book | Herbert Schildt | Dreamtech Press, Standard Edition, ISBN: 978-9386052216 |
| 3 | Complete Reference Java 2 | Herbert Schildt | Tata McGrawHill, 5th Edition, ISBN-13: **0070495431-979** |
| 4 | Unleashed Java 2 Platform | Jamie Jaworski | Sams Techmedia, ISBN: 978-0596004651 |

### (b) Online Educational Resources:

1. Java Applets http://docs.oracle.com/javase/tutorial/deployment/applet/index.html
2. Introduction to GUI Programming http://math.hws.edu/javanotes/c6/index.html
3. Creating a GUI using AWT http://www.tutorialspoint.com/awt/
4. JDBC Database Access https://docs.oracle.com/javase/tutorial/jdbc/
5. Servlet Technologies http://www.oracle.com/technetwork/java/index-jsp-135475.html
6. Java Server Pages http://www.oracle.com/technetwork/java/javaee/jsp/index.html

**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** **: 2400504B (T2400504B/P2400504B/S2400504B)**

**B) Course Title** **:** Artificial Intelligence (Basic)

**C) Pre- requisite Course(s)** **:**

**D) Rationale** **:**

Artificial intelligence is the theory and development of computer systems able to perform tasks such as, visual perception, speech recognition, decision-making etc. normally requiring human intelligence. Data analytics gives the basis of developing any artificial intelligence system.

The Python programming language is one of the most accessible programming languages, has several modules to write programs to solve Artificial Intelligence, Machine Learning, Data Analysis problems. Moreover, it has simplified syntax and versatile data structures and functions to speed up the code writing efficiently.

This course provides the basics for Artificial Intelligence problem solving techniques, data analytics and articulates the different dimensions of these areas. This course also provides the students the foundations for data analytics with python. The course explains data science techniques and the various Python programming packages required to prepare data for analysis, perform data analytics and create meaningful data visualization.

**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 Artificial Intelligence for the problem solving as Technological driver.

**CO-2** Write Python Programmes for solving problems.

**CO-3** Analyze given data by using NumPy package of Python.**CO-**

**4** Analyze given data by using Pandas package of Python.**CO-5**

Visualize given data set using Matplotlib.

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

| Course Outcomes (COs) | Programme Outcomes(POs) | | | | | | | Programme Specific Outcomes* (PSOs) | |
|---|---|---|---|---|---|---|---|---|---|
| | **PO-1** Basic and Discipline Specific Knowledge | **PO-2** Problem Analysis | **PO-3** Design/ Development of Solutions | **PO-4** Engineering Tools | **PO-5** Engineering Practices for Society, Sustainability and Environment | **PO-6** Project Management | **PO-7** Life Long Learning | **PSO- 1** | **PSO- 2** |
| **CO-1** | - | 2 | 2 | - | - | - | 1 | | |
| **CO-2** | - | 3 | 3 | 3 | - | - | 2 | | |
| **CO-3** | - | 3 | 3 | 3 | - | - | 2 | | |
| **CO-4** | - | 2 | 3 | 3 | - | - | 2 | | |
| **CO-5** | - | 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 | | | | |
| **2400504B** | Artificial Intelligence (Basics) | 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) | |
| **2400504B** | Artificial Intelligence (Basics) | 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: T2400504B

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number (s) |
|---|---|---|
| TSO 1a. Elaborate the use of Artificial IntelligenceTSO 1b. Explain various technological Drivers of Modern AI<br>TSO 1c. Describe Knowledge representation<br>TSO 1d. Classify Intelligent agents<br>TSO 1e. List the characteristics of agents<br>TSO 1f. Apply various search strategies for problem solving | **Unit-1.0. Artificial Intelligence**<br>**Artificial Intelligence:** What is AI?, Types of AI, History of AI, Turing Test, Symbol Systems and the scope of Symbolic AI, Structure of AI, Goals of AI, Importance of AI, Techniques used in AI, Perception, Understanding and Action**,** Technological drivers of modern AI<br>**Knowledge**: Definition, Knowledge Representation, objectives and requirements,practical aspects of representation, Components<br>**Intelligent Agents**: Agents and Environments, Properties of environments, characteristics ofagents, classification of agents<br>**Problem Solving:** Problem Formulation, Goal Formulation, State Space Search, Search Problem, Basic search algorithm, Search Tree, Search strategies–Uninformed and informed search, Breadth FirstSearch, Depth FirstSearch, Best FirstSearch, Constraint Satisfaction Problem (CSP), Back tracking Search. Problem Definitions: N Queen Problem, 8Puzzle Problem, Tic-tac-Toe. | **CO-1** |
| TSO 2a. Explain Python tokens and variables<br>TSO 2b. Use the concept of l-value and r -value<br>TSO 2c. Write python program using various data types<br>TSO 2d. Write Program using various operators inPython<br>TSO 2e. Write program using conditional statements<br>TSO 2f. Use various string functions for problem solving in python program<br>TSO 2g. Write programmes using various operations on list<br>TSO 2h. Write programmes by using various operations on Tuples and Dictionary<br>TSO 2i. Create user defined functions<br>TSO 2j. Write python programmes using built-in functions<br>TSO 2k. Describe the procedure to import module in the Python | **Unit-2.0 Python Programming**<br>Python character set, Python tokens, variables, concept of l-value and r-value, use of comments.<br>Data types: number (integer, floating point, complex), Boolean, sequence (string,list, tuple), none, mapping (dictionary), mutable and immutable data types Operators: arithmetic operators, relational operators, logical operators, assignment operator, augmented assignment operators. Expressions,statement, type conversion & input/output: precedence of operators, expression, evaluation of expression.<br>**Conditional and Iterative statements:** if, if-else, if-elif-else, for loop, range function, while loop, break and continue statements, nested loops<br>**String, List, Tuples and Dictionary:**<br>String: indexing, string operations (concatenation, | **CO-2** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number (s) |
|---|---|---|
| TSO 2l. Describe procedure to Import Library andfunctions in the Python<br>TSO 2m. Write program using Iterative statements. | repetition, membership & slicing), traversing a string using loops, built-in functions.<br>Lists: introduction, indexing, list operations (concatenation, repetition, membership & slicing), traversing a list using loops, built- in functions, linear search on list of numbers and counting the frequency of elements in a list<br>Dictionary: accessing items in a dictionary using keys, mutability of dictionary (adding a new item, modifying an existing item), traversing a dictionary, built-in functions<br>**Python Functions:** types of function (built- in functions, functions defined in module, user defined functions), creating user defined function, arguments and parameters, default parameters, positional parameters, function returning value(s), flow of execution, scope of a variable (global scope, local scope)<br>**Modules and Packages:** Importing module using 'import' Regular Expressions, Exception Handling, PyPI Python PackageIndex, Pip Python package manager, Importing Libraries and Functions | |
| TSO 3a. Explain Data Analytics and its elements<br>TSO3b. Differentiate Data Analysis and Data Analytics<br>TSO 3c. Explain the use of open source data<br>TSO 3d. Differentiate Qualitative and Quantitative data analysis<br>TSO 3e. Explain procedure to Install NumPy Library<br>TSO 3f. Use NumPy library to perform various operations and functions on array<br>TSO 3g. Write Programs using NumPy for array manipulations | **Unit-3.0 Data Analytics and Computing with NumPy**<br>**Data Analytics**: Data, Types of Data, Importance of Data, Data Analysis Vs Data Analytics, Types of Data Analytics, Elements of Analytics, Data Analysis Process, Qualitative and Quantitative analyses, Open Source Data.<br>**NumPy Library**: Introduction, Installation,<br>**ND array**: creating an array, intrinsic creation of an array, Data types, basic operations, aggregate functions, Indexing, slicing, Iterating,<br>Conditions and Boolean arrays, Array **manipulation:** Joining, splitting, shape changing, sorting, Structured arrays, Reading and Writing array data on a File. | **CO-3** |
| TSO 4a. Apply Pandas data structure for data analysis<br>TSO 4b. Write Programs using Pandas to perform various operations and functions on series.<br>TSO 4c. Perform various operation in a Data Frame columns and rows<br>TSO 4d. Write Programme to read and write on CSV, XLS and Text data files<br>TSO 4e. Apply various data cleaning operations and prepare data. | **Unit-4.0 Data Analysis with Pandas**<br>**Pandas data structures**: Series, Declaration, selecting elements, assigning values, Filtering values, operations, mathematical functions, evaluating values, handling missing data, creating series from dictionaries, adding two series.<br>**Data Frame:** Defining, selecting elements, assigning values, membership, deleting a column, filtering. Index Objects: Indexing, Re-indexing, Dropping, sorting and ranking, Descriptive Statistics<br>**Data Loading**: Reading and Writing csv, xls, text data files, Data Cleaning and Preparation: Handling missing data, removing duplicates, replacing values,Vectorized String Methods, | **CO-4** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number (s) |
|---|---|---|
| | Hierarchical Indexing, Merging and Combining, Data aggregation and Grouping. | |
| TSO 5a. Illustrate the use of Matplotlib and PyPlot package for showing plots and images<br>TSO 5b. Customize plots with Colors, Markers, Line Styles, Limits, Tics, Labels, Legends, Grids<br>TSO 5c. Differentiate various charts based on their applications | **Unit-5.0 Data Visualization with Matplotlib**<br>Data Visualization: Introduction to Matplotlib ,PyPlot package, Figures and Subplots, showingplots and images<br>Customizing Plots: Colors, Markers, Line Styles, Limits, Tics, Labels, Legends, Grids ,Annotating with text, Matplotlib<br>Configuration<br>Chart types: Line, Bar, stacked bar, Box plots, pie chart , Histogram and Density plots, Scatter plot, Saving Plots to a file,<br>Close and clear plots. | **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: P2400504B

| Practical/ Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment/Practical Titles | Relevant COs Number (s) |
|---|---|---|---|
| LSO 1.1 Use various data types and operators to solve given problem<br>LSO 1.2 Use conditional and iterative statements for solving given problem | 1 | **Conditional and Iterative statements**<br>1a. Write a program to generate random numbers between 5 and 10.<br>1b. Write a program to find the square root of a number.<br>1c. Write a python program to check if a number is positive, negative or 0.<br>1d. Write Python program to print all prime numbers between 0-50. | CO-2 |
| LSO 2.1 Use string functions for performing various string operations | 2 | **String Handling**<br>2a. Write a Programme that asks the user for a string with only single space between words, and return number of words in the string.<br>2b. Write a Program that inputs a line of text andprint the count of Vowels in it.<br>2c. Write a Program that inputs a line of text and print the biggest word in it.<br>2d. Write a Program that inputs a line of text andprint a new line of text where each word of input line is reversed. | CO-2 |
| LSO 3.1 Use list operations for concatenation, repetition & slicing<br>LSO 3.2 Perform various operation in the Tuples<br>LSO 3.3 Perform various operation in the dictionary | 3 | **List, Tuples and Dictionary**<br>3a. Write a python program to convert a string to a list.<br>3b. Write a program to print the largest number in a list.<br>3c. Given a tuple pairs = ((3,9), (8,4), (3,7), (24,18)), count the number of pairs (a, b) such that both a and b are odd.<br>3d. Write a program to input a list of numbers and swap elements at the even location with the elements at the odd location. | CO-2 |

| Practical/ Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment/Practical Titles | Relevant COs Number (s) |
|---|---|---|---|
| | | 3e. Write a program to merge two dictionaries. | |
| LSO 4.1 Use built-in functions to solve given problem<br>LSO 4.2 Create user defined functions to solve given problem | 4 | **Python Functions**<br>4a. Write a function to reverse a string.<br>4b. Write a function to calculate the factorial of a number. | CO-2 |
| LSO 5.1 use basic data structure using NumPy<br>LSO 5.2 Convert the list and tuple as NumPy array | 5. | **Basic data structures in NumPy**<br>5a. Create a List, set, tuple and dictionary which stores the details of a student (roll no, name, dept, branch, percentage of mark) in Python and print the values.<br>5b. Convert the list and tuple as NumPy array. | CO-3 |
| LSO 6.1 Create Arrays in Numpy using different intrinsic methods<br>LSO 6.2 Perform arithmetic operations and mathematical operations using arrange and ones intrinsic method. | 6 | **Arrays in NumPy**<br>6a. Create arrays using different intrinsic methods (ones, zeros, arange, linspace, indice) and print their values.<br>6b. Check the results of arithmetic operations like add(), subtract(), multiply() and divide() with arrays created using arrange and ones intrinsic method.<br>6c. Check the results of mathematical operations like exp(), sqrt(), sin(), cos(), log(), dot() on an array created using arrange intrinsic method. | CO-3 |
| LSO 7.1 Apply aggregate functions on data by using Built-in function s in Numpy | 7 | **Built-in functions in NumPy.**<br>7a. Load your class Mark list data from a csv (comma separated value) file into an array. Perform the following operations to inspect your array. Len(), ndim, size, dtype, shape, info()<br>7b. Apply the aggregate functions on this data and print the results. (Functions like min(), max(), cumsum(), mean(), median(), corrcoef(), std()) | CO-3 |
| LSO 8.1 Handle multiple arrays by applying various operations on arrays | 8 | **Handling Multiple Arrays**<br>8a. Create two python NumPy arrays (boys, girls) each with the age of student's in the class.<br>8b. Get the common items between two python NumPy arrays.<br>8c. Get the positions where elements of two arraysmatch.<br>8d. Remove from one array those items that exist in another.<br>8e. Extract all numbers between a given range froma NumPy array. | CO-3 |
| LSO 9.1 Apply indexing on the given set of data | 9 | **Indexing in NumPy**<br>9a. Load your class Mark list data from a csv file into an array.<br>9b. Access the mark of a student in a particular subject using indexing techniques.<br>9c. Select a subset of 2D array using fancy indexing (indexing using integer arrays | CO-3 |
| LSO 10.1 Create series using list and dictionary in pandas | 10 | **Working with a Series using Pandas**<br>10a. Create a series using list and dictionary. | CO-4 |

| Practical/ Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment/Practical Titles | Relevant COs Number (s) |
|---|---|---|---|
| LSO 10.2 Print different values from series. | | 10b. Create a series using NumPy functions in Pandas.<br>10c. Print the index and values of series.<br>10d. Print the first and last few rows from the series. | |
| LSO 11.1 Perform various operation in a Data Frame rows | 11 | **Working with Data Frame Rows**<br>11a. Slicing Data Frame using loc and iloc.11b. Filter multiple rows using is in.<br>11c. Select first n rows and last n rows<br>11d. Select rows randomly n rows and fractions of rows (use df. sample method)11e. Count the number of rows with each unique value of variables<br>11f. Select largest and smallest values.11g. Order/sort the rows | CO-4 |
| LSO 12.1 Apply different techniques to merge and combine data | 12 | **Merge and combine data**<br>12a. Perform the append, concate and combinefirst operations on Data Frames.<br>12b. Apply different types of merge on data.<br>12c. Use a query method to filter Data Frame with multiple conditions. | CO-4 |
| LSO 13.1 Create Linear Plot to identify various relation in the data using Matplotlib<br>LSO 13.2 Create Scatter Plot to identify various relation in the data using Matplotlib | 13 | **Consider the Salary dataset, which contains 30observations consisting of years of working experience and the annual wage. Download the data set from** https://www.kaggle.com/rohankayan/years-of-experience-and-salary-dataset<br>13a. Create a linear plot to identify the relationship between years of working experience and the annual wages with suitable title, legend andlabels.<br>13b. Create a scatter plot to identify the relationship between years of working experience and the annual wages with title, legend and labels.<br>13c. Also distinguish between observations that have more than 5 years of working experience and observations that have less than 5 years of working experience by using different colors in one single plot. | CO-5 |
| LSO 14.1 Plot Bar graph by Changing the color of each bar, Change the Edge color, Linewidth and Line style. | 14 | **Consider the Iris dataset, where observations belong to either one of three irisflower classes. Download the data set from** https://www.kaggle.com/arshid/iris-flower- dataset<br>14a. Visualize the average value for each feature of the Set osa iris class using a bar chart.<br>14b. Format the obtained bar graph by Changing thecolor of each bar, Change the Edge color, Line width and Line style. | CO-5 |

**L)** **Suggested Term Work and Self Learning**: **S2400504B** 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. **Handing Two-dimensional array in NumPy**
   **Download the data set from**
   https://archive.ics.uci.edu/ml/machine-learning-databases/iris/iris.datahttps://www.kaggle.com/arshid/iris-flower-dataset

   a. Import iris dataset with numbers and texts keeping the text intact into python NumPy.
   b. Convert the 1D iris to 2D array (iris2d) by omitting the species text field.
   c. Find the number and position of missing values in iris2d's sepal_length
   d. Insert np.nan values at 20 random positions in iris 2d dataset
   e. Filter the rows of iris2d that has petal_length> 1.5 and sepal_length< 5.0
   **Expected Outcome** (Use various operations on two dimensional arrays in NumPy)

2. **Handling missing data and duplicates in Pandas:**
   a. Identify rows with missing data ( isnull(), notnull()) and replace NA/Null data with a given value.
   b. Drop rows and columns with any missing data (dropna(), dropna(1))
   c. Find duplicate values and drop duplicates.
   d. Fill the missing values using forward filling and backward filling.
   e. Replace the missing value with new value and write the dataframe to a CSV file in the local directory.

   **Expected Outcomes** (a. Identify missing data, b. Find Duplicates values, c. Write the dataframe to a CSV file in the local directory.)

3. **Working with Data Frame Columns:**
   a. Create and print a Data Frame.
   b. Find the descriptive statistics for each column.
   c. Group the data by the values in a specified column, values in the index.
   d. Set Index and columns in a Data Frame.
   e. Rename columns and drop columns
   f. Select or filter rows based on values in columns.
   g. Select single and multiple columns with specific names

   **Expected Outcome (**Perform various operation in a Data Frame columns)

4. **Indexing & Sorting in NumPy:**
   a. Load your class Mark list data from a csv file into an array.
   b. Sort the student details based on Total mark.
   c. Print student details whose total marks is greater than 250 using Boolean indexing.
   **Expected Outcomes** (a. Sort the given set of data, b. Use indexing in an array)

5. **Array Slicing in NumPy:**
   a. Load your class Mark list data into an array called “marks” to store students roll num, subject marks and result.
   b. Split all rows and all columns except the last column into an array called “features”.
   c. Split the marks array into 3 equal-sized sub-arrays each for 3 different subject marks.
   d. Split the last column into an array “label”.
   e. Delete the roll num column from the marks array and insert a new column student name in its place.

   **Expected Outcome (**Use array slicing in Numpy for the given set of data)

6. Consider the Iris dataset, where observations belong to either one of three iris flower classes.
**Download the data set from**
https://www.kaggle.com/arshid/iris-flower-dataset

a. Visualize the Histogram for each feature (Sepal Length, Sepal Width, petal Length & petal Width) separately with suitable bin size and color.
b. Plot the histograms for all features using subplots to visualize all histograms in one single plot.Save the plot as JPEG file.
c. Plot the box plots for all features next to each other in one single plot. Perform 3D printing of plastic casing of inhaler used by Asthma patients and estimate the cost.

**Expected Outcomes** (a. Plot the Histogram for the various features using subplot, b. Plot the boxplots for all features next to each other in one single plot)

**c. Other Activities:**

**1. Lab Activities:**

- Install Python IDE and important Python Libraries
- Install Anaconda and find the features of Jupyter Notebook.
- Import various module using 'import '
- Use Pip Python package manager.
- Import Libraries and Functions in Python

**2. Seminar Topics:**

- Technological rivers of modern Artificial Intelligence
- Intelligent Agents and Environments in Artificial Intelligence
- Various Search Strategies
- Python for Data Science
- Python Libraries and Packages used in data Science
- Data Visualization
- Various data set available over Internet

**3. Self-Learning Topics:**

- Use of AI in Engineering and Technology
- Data Science and Machine Learning
- Problem and Goal Formulation
- Search strategies
- Breadth First Search and Depth First Search
- Back tracking Search
- N Queen and 8 Puzzle Problem

**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) 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% | -- | 30% | -- | -- |
| **CO-2** | 10% | 20% | 20% | -- | 20% | 20% | 25% |
| **CO-3** | 20% | 25% | 20% | 30% | 20% | 20% | 25% |
| **CO-4** | 30% | 25% | 20% | 20% | 30% | 30% | 25% |
| **CO-5** | 20% | 10% | 20% | 50% | -- | 30% | 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 cognitive domain of full course.

| Unit Title and Number | Total Classroom Instruction (Cl) Hours | Relevant COs Number (s) | Total Marks | ETA (Marks) | | |
|---|---|---|---|---|---|---|
| | | | | Remember (R) | Understanding (U) | Application & above (A) |
| **Unit-1.0**. Artificial Intelligence | 9 | CO-1 | 14 | 6 | 5 | 3 |
| **Unit-2.0**. Python Programming | 12 | CO-2 | 14 | 4 | 4 | 6 |
| **Unit-3.0**. Data Analytics and Computing with NumPy | 10 | CO-3 | 17 | 4 | 5 | 8 |
| **Unit-4.0**. Data Analysis with Pandas | 10 | CO-4 | 18 | 4 | 5 | 9 |
| **Unit-5.0.** Data Visualization with Matplotlib | 7 | CO-5 | 7 | 2 | 2 | 3 |
| **Total Marks** | **48** | | **70** | **20** | **21** | **29** |

**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. | Conditional and Iterative statements | CO-2 | - | 90 | 10 |
| 2. | String handling | CO-2 | - | 90 | 10 |
| 3. | List, Tuples and Dictionary | CO-2 | 20 | 70 | 10 |
| 4. | Python Functions | CO-2 | - | 90 | 10 |
| 5. | Basic data structures in NumPy | CO-3 | - | 90 | 10 |
| 6. | Arrays in NumPy | CO-3 | - | 90 | 10 |
| 7. | Built-in functions in NumPy. | CO-3 | 20 | 70 | 10 |
| 8. | Handling Multiple Arrays | CO-3 | 20 | 70 | 10 |
| 9. | Indexing in NumPy | CO-3 | - | 90 | 10 |
| 10. | Working with a Series using Pandas | CO-4 | - | 90 | 10 |
| 11. | Working with Data Frame Rows | CO-4 | 20 | 70 | 10 |
| 12. | Merge and combine data | CO-4 | 40 | 50 | 10 |
| 13. | Consider the Salary dataset, which contains 30 observations consisting of years of working experience and the annual wage. | CO-5 | 80 | 10 | 10 |
| 14. | Consider the Iris dataset, where observations belong to either one of three iris flower classes. | CO-5 | 80 | 10 | 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 Strategiesmay be appropriately selected, as per the requirement of the content/outcome. Some of them are ImprovedLecture, 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 14 |
| 2. | Online Python IDE | https://www.online-python.com/ | S. No. 1 to 14 |
| 3. | Jupyter Notebook | Download from https://jupyter.org/ | S. No. 1 to 14 |
| 4. | Pip Python package Manager | Download Pip 22.3 From https://pypi.org/project/pip/ | S. No. 1 to 14 |
| 5. | Various modules, Libraries and Packages | NumPy, Pandas, Matplotlib, PyPlot package | S. No. 1 to 14 |

## R) Suggested Learning Resources:

### (a) Books:

| S. No. | Titles | Author (s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 1. | Artificial Intelligence Basics - A Non-Technical Introduction | TomTaulli | Apress (2019) |
| 2. | Fundamentals of artificial Intelligence | Chowdhary K. R | Springer 2020 |
| 3. | Artificial Intelligence A Modern approach | Stuart J. Russell and Peter Norvig | PrenticeHall 2010, 3rdEdition |
| 4. | Introduction to Computing and Problem-Solving using Python | E. Balagurusamy | McGraw Hill Education (India)Pvt. Ltd. 1st Edition /2016 |
| 5. | Learning Python Programming | Jeffrey Elkner, Allan B.Downey, Chris Meyers | Samurai Media Limited. 2016 |
| 6. | Python Programming | Ashok Namdev Kamthane and Amit Ashok Kamthane | McGraw Hill Education (India) Pvt.Ltd.2020, 2nd Edition |
| 7. | Programming in Python | Dr. Pooja Sharma | BPB Publications 2017 |
| 8. | Taming Python by Programming | Jeeva ose | Khanna Book Publishing Co(P)Ltd, 2017, Reprinted2019 |
| 9. | Python Data Analytics | Fabio Nelli | Apress,2015 |
| 10. | Python for Data Analysis: Data Wrangling with Pandas, Numpy, and IPython | Wes McKinney | O'REILLY 2018, Second Edition |

### (b) Online Educational Resources:

1. NPTEL Web Content- Artificial Intelligence, Prof. P. Mitra, Prof. S. Sarkar, IIT Kharagpur URL:https://nptel.ac.in/courses/106/105/106105078/
2. https://www.learnpython.org
3. www.python.org
4. https://www.tutorialspoint.com/python

**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:

**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 :2400504C(T2400504C/P2400504C/S2400504C)**

**B) Course Title :** Internet of Things (Basic)

**C) Pre- requisite Course(s) :** Digital Electronics, Electronics Circuits, Fundaments of Computers and Computer networks

**D) Rationale :**

The Internet of Things (IoT) is the upcoming field that has the capability to connect everything on the earth. This course focuses on the development of IoT concepts such as sensing, actuation with implementation of communication protocols.

The course also focuses on real life aspects of IoT and how to integrate it in real life projects. The course will simplify the concept of IoT by using the Node MCU board for IoT application development. In this course students will learn about the use of Node MCU and its applications as a beginner/intermediate in the field of IoT. Apart from this, students will learn about the APIs, by using which integration of features like send Email, WhatsApp messages and notification based on certain events in projects is possible. Overall, this course covers both hardware and software aspects of IoT with practical exposure.

**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** Describe the functions of each block of the basic IoT system

**CO-2** Explain communication protocol used in IoT and its applications

**CO-3** Use appropriate sensors for the specific measurement through the IoT platform

**CO-4** Explain APIs, client-server connections and its integration in real life applications.

**CO-5** Build and test a complete, working IoT system involving prototyping, programming, and data analysis

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

| Course Outcomes (COs) | Programme Outcomes (POs) | | | | | | | Programme Specific Outcomes* (PSOs) | |
|---|---|---|---|---|---|---|---|---|---|
| | **PO-1** Basic and Discipline Specific Knowledge | **PO-2** Problem Analysis | **PO-3** Design/ Development of Solutions | **PO-4** Engineering Tools | **PO-5** Engineering Practices for Society, Sustainability and Environment | **PO-6** Project Management | **PO-7** Life Long Learning | **PSO-1** | **PSO-2** |
| **CO-1** | 3 | - | - | - | - | - | - | | |
| **CO-2** | 1 | 2 | 2 | 2 | 2 | - | - | | |
| **CO-3** | 1 | 3 | 2 | 2 | 2 | 2 | 2 | | |
| **CO-4** | 1 | 1 | 2 | 3 | - | 2 | 2 | | |
| **CO-5** | 1 | 1 | 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 | | | | |
| **2400504C** | IoT (Basic) | 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) | |
| **2400504C** | IoT (Basic) | 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: T2400504C

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| TSO.1. a. Describe the concept of IoT.<br>TSO.1. b. Explain the functions of each block of the Basic IoT system.<br>TSO.1. c. Compare features of various IoT platforms<br>TSO.1. d. List IoT Real time Applications.<br>TSO.1. e. Describe the functioning of given real-time applications | **Unit-1.0 Introduction to IoT**<br>1.1 Basics of IoT, concepts of IoT, History of IoT<br>1.2 Basic IoT System and its building blocks<br>1.3 Various platforms for IoT (e.g. AWS, AZURE, GCP)<br>1.4 Introduction to Python programming and IoT software<br>1.5 Applications of IoT | **CO-1 and CO-5** |
| TSO.2. a. Explain various communication protocols.<br>TSO.2. b. Explain working and application of blue tooth<br>TSO.2. c. Explain working and application of ZigBee<br>TSO.2. d. Explain working and application of LoRa<br>TSO.2. e. Explain working and application of Wi-fi | **Unit 2.0 IoT Communication Protocols**<br>2.1 Basics of given communication protocol along with itsapplications<br>2.2 Explain Communication Protocols MQTT<br>2.3 Bluetooth Low Energy<br>ZigBee<br>LoRa<br>Wi-fi | **CO-1 and C02** |
| TSO.3. a. Differentiate between sensor and Actuator.<br>TSO.3. b. Classify IoT sensors on the basis of their application.<br>TSO.3. c. Describe the function of each block of Node MCU.<br>TSO.3. d. Explain the procedure to connect sensors with Node MCU. | **Unit-3.0 Sensors and Hardware for IoT**<br>3.1 Sensors and Actuators, Transducers, Classifications of sensors, IoT Sensors<br>3.2 Development Boards, classifications, and basics of wireless networks, Wi-Fi libraries<br>3.3 Introduction to node MCU, block diagram, functions, interfacing with sensors and publishing data on webserver<br>3.4 Device integration with node MCU<br>3.5 Interfacing of sensors with boards | **CO-1, CO-3 and CO-5** |
| TSO.4. a. Define APIs and its uses<br>TSO.4. b. Explain working and application of REST.<br>TSO.4. c. Explain working and application of SOAP<br>TSO.4. d. Explain working and application of json<br>TSO.4. e. Explain the integration of API in IoT application development. | **Unit.4.0 IoT APIs and its Integration**<br>4.1 Explain APIs and its use<br>4.2 Explanation of given IoT APIs along with its applications<br>4.3 MQTT, Broker, subscriber, publisher<br>**4.4 REST**<br>**SOAP**<br>**4.5 JSON**<br>**4.6 Programming API using Python** | **CO-1 and CO-4** |
| TSO.5. a. Differentiate between industrial IoT and IoT. | **Unit. 5.0 IoT Applications**: - | **CO-1 and CO-5** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| TSO.5. b. Describe the applications of IoT in the medical field.<br>TSO.5. c. Describe the medical applications of IoT in the agriculture field.<br>TSO.5. d. Describe the innovative IoT applications. | 5.1 Industrial IoT and Internet of everything<br>5.2 IoT for consumer electronics products<br>5.3 IoT for Medical applications<br>5.4 IoT for Agriculture<br>5.5 IoT for security and Law enforcement | |

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

## K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400504C

| Practical/Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment/Practical Titles | Relevant CosNumber (s) |
|---|---|---|---|
| LSO 1.1 List various IoT platforms.<br>LSO 1.2 List Down broad features of given platforms.<br>LSO 1.3 List IoT based features in python language. | 1. | Prepare a list of platforms used for IoT.<br>Prepare a list of features of above IoT platforms.<br>Prepare a list of features provided by python language for IoT applications. | CO-1 |
| LSO 2.1 Arduino connection with Arduino IDE.<br>LSO 2.1 Connect Bluetooth with Arduino.<br>LSO 2.3 verification of data communication with Bluetooth. | 2. | Establish connectivity between various components of IoT.<br>Establish connection between Arduino and Bluetooth module.<br>Establish connection using Wi-Fi | CO-2 |
| LSO 3.1 Measure the temperature of the given sensor.<br>LSO 3.2 Measure the humidity of the given sensor.<br>LSO 3.3 Measure the pressure of the given sensor. | 3. | Publish data on the IoT platform.<br>Measure the temperature of a remotely located temperature sensor Using IOT based temperature data-monitoring system.<br>Measure the humidity of a remotely located humidity sensor Using IOT based humidity data-monitoring system.<br>Measure the pressure of a remotely located pressure sensor Using IOT based pressure data-monitoring system. | CO-3 |
| LSO 4.1 Working with APIs.<br>LSO 4.2 Implementation of APIs using POSTMAN Application. | 4 | Download and Configure POSTMAN Application<br>Verify REST APIs through POSTMAN.<br>Verify JSON APIs through POSTMAN.<br>Verify SOAP APIs through POSTMAN. | CO-4 |
| LSO 5.1 Identification of components for various applications.<br>LSO 5.2 Estimate the cost for components. | 5. | Identify components for given project<br>Estimate the cost to make Project working. | CO-5 |

**L) Suggested Term Work and Self Learning: S2400504C** 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 IoT Systems using Internet data.
2. Market survey to identify various types of IoT sensors and its pricing.
3. Interface IR sensor with Arduino and send the data to Arduino cloud.
4. Send IoT data using Node MCU to things Speak cloud.
5. Interface Bluetooth module with Arduino and send data using the Bluetooth module.

**c. Other Activities:**

1. Seminar Topics: - "Future of IoT"
   "Technologies for IoT ", "Smart City and IoT"
2. Visit to industry for latest IoT setup in industrial process.
3. Surveys of market for availability of various types of sensors and its pricing.
4. Product Development: Development of projects for real life problem solution using IoT.
5. Software Development: various open source platform operations.

**d. Self-Learning Topics:**

1. IoT hardware and their use for various applications
2. IoT sensors technical specifications
3. IoT enabled services

**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) 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 (Cl) Hours | Relevant COs Number (s) | Total Marks | ETA (Marks) | | |
|---|---|---|---|---|---|---|
| | | | | Remember (R) | Understanding (U) | Application & above (A) |
| **Unit-1.0**. Introduction to IoT | 5 | CO-1 | 7 | 3 | 4 | - |
| **Unit-2.0**. IoT Communication protocols | 5 | CO-2 | 7 | 3 | 2 | 2 |
| **Unit-3.0.** Sensors and Hardware for IoT | 14 | CO-3 | 21 | 6 | 7 | 8 |
| **Unit-4.0** IoT APIs and its Integration | 14 | CO-4 | 21 | 6 | 5 | 10 |
| **Unit-5.0**. IoT Applications | 10 | CO-5 | 14 | 2 | 4 | 8 |
| **Total Marks** | **48** | | **70** | **20** | **22** | **28** |

**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. | Prepare a list of platforms used for IoT. | CO-1 | 60 | 30 | 10 |
| 2. | Prepare a list of features of above IoT platforms. | CO-1 | 60 | 30 | 10 |
| 3. | Prepare a list of features provided by python language for IoT applications. | CO-1 | 60 | 30 | 10 |
| 4. | Establish connectivity between various components of IoT. | CO-2 | 60 | 30 | 10 |
| 5. | Establish connection between Arduino and Bluetooth module. | CO-2 | 60 | 30 | 10 |
| 6. | Establish connection using Wi-Fi | CO-2 | 70 | 20 | 10 |
| 7. | Publish data on the IoT platform. | CO-3 | 70 | 20 | 10 |
| 8. | Measure the temperature of a remotely located temperature sensor Using IOT based temperature data-monitoring system. | CO-3 | 60 | 30 | 10 |
| 9. | Measure the humidity of a remotely located temperature sensor Using IOT based temperature data-monitoring system. | CO-3 | 60 | 30 | 10 |
| 10. | Measure the pressure of a remotely located temperature sensor Using IOT based temperature data-monitoring system. | CO-3 | 60 | 30 | 10 |
| 11. | Publish the data using Mqtt | CO-4 | 60 | 30 | 10 |
| 12. | Download and Configure POSTMAN Applications | CO-4 | 60 | 30 | 10 |

| S. No. | Laboratory Practical Titles | Relevant COs Number(s) | PLA/ELA | | |
|---|---|---|---|---|---|
| | | | Performance | | Viva-Voce (%) |
| | | | PRA* (%) | PDA** (%) | |
| 13. | Verify REST APIs through POSTMAN. | CO-4 | 60 | 30 | 10 |
| 14. | Verify JSON APIs through POSTMAN. | CO-4 | 60 | 30 | 10 |
| 15. | Verify SOAP APIs through POSTMAN. | CO-4 | 60 | 30 | 10 |
| 16. | Identify components for given project | CO-5 | 50 | 40 | 10 |
| 17. | Estimate the cost to make Project working. | 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, 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 | Bluetooth Modem-BlueSMiRF Silver | Sparkfun Bluetooth modem | As mentioned above list |
| 2 | Postman Software | Open-source downloadable | |
| 3 | Node MCU board | Generic | |
| 4 | IoT free cloud | Arduino cloud/Thing Speak/Blynk | |
| 5 | ATAL Lab<br>Package-1<br>Package-2<br>Package-4 | As per the list as address below<br>ATAL Equipment list'<br>(http://aim.gov.in/guidelines-for-school.php). | |

## R) Suggested Learning Resources:

### (a) Books:

| S. No. | Titles | Author(s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 1 | Internet of Things Architectureand Design Principles | Raj Kamal | Mc Graw Hills, New Delhi ISBN 13: 978-93-90722-38-4 |
| 2 | Internet of things (IoT): technologies, applications, challenges and solutions | Edited By BK Tripathy ,J Anuradha | CRC Press, ISBN 9780367572921, June 30, 2020 |
| 3 | Internet-of-Things(IoT) Systems: Architectures, Algorithms, Methodologies | by Dimitrios Serpanos & Marilyn Wolf | Springer; 1st ed. 2018 edition (17 January 2018) |
| 4 | Custom Raspberry Pi Interfaces: Design and build hardware interfaces for the Raspberry | Pi by Warren Gay | Apress; 1st ed. edition (23 February 2017), ISBN- 10: 9781484224052, ISBN-13: 978-1484224052 |
| 5 | 'Learning Internet of Things', | Peter Waher | Packt Publishing, 2015, ISBN9781783553532, https://lib.hpu.edu.vn/handle/123456789/31693 |
| 6 | Sensors, Actuators and TheirInterfaces, | N. Ida | Scitech Publishers, 2014. |

### (b) Online Educational Resources:

1. nptel.iitm.ac.in/courses/.../IIT.../lecture%2023%20and%2024.htm
2. en.wikipedia.org/wiki/Shear and moment diagram
3. www.freestudy.co.uk/mech%20prin%20h2/stress.pdf
4. www.engineerstudent.co.uk/stress_and_strain.html
5. 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
9. https://www.iit.edu/arc/workshops/pdfs/Moment_Inertia.pdf
10. Amini, P. (2014). Sulley: Pure Python fully automated and unattended fuzzing frame- work.
11. https://github.com/OpenRCE/sulley

**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
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

******

**A) Course Code : 2400504D(T2400504D/P2400504D/S2400504D)**

**B) Course Title :** Drone Technology (Basic)

**C) Pre- requisite Course(s) :**

**D) Rationale :**

Rapid technological innovation has provided users cutting-edge products at affordable prices. Traditionally, drones had been limited to military use due to high costs and technical sophistication. In recent years, the drone has number of commercial uses and are also proving to be extremely beneficial in places where a man cannot reach or is unable to perform in a timely and efficient manner. Today, drones are used in construction, photography, agriculture, defense, environmental studies and monitoring and other industries to protect the skies, repopulate forests and accomplish much more on a huge scale. This course will acquaint the student with the basic drone technology and applicable drone rules and regulations in India. Considering that the main operational areas of diploma holders, it is essential that he should be exposed to basic drone designing, programming, operating, maintaining and using them safely.

**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** Operate a drone safely by applying appropriate drone rules and regulations.

**CO-2** Design the structure of drone with drone components and equipment.

**CO-3** Interface flight controller board with sensors, ESC and radio communication unit in drone technology.

**CO-4** Use drone simulator and identify different types of ports and connectors of drone.

**CO-5** Use python programming while drone designing.

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

| Course Outcomes (COs) | Programme Outcomes (POs) | | | | | | | Programme Specific Outcomes* (PSOs) | |
|---|---|---|---|---|---|---|---|---|---|
| | **PO-1** Basic and Discipline Specific Knowledge | **PO-2** Problem Analysis | **PO-3** Design/ Development of Solutions | **PO-4** Engineering Tools | **PO-5** Engineering Practices for Society, Sustainability and Environment | **PO-6** Project Management | **PO-7** Life Long Learning | **PSO-1** | **PSO-2** |
| **CO-1** | 2 | - | - | - | 3 | - | 2 | | |
| **CO-2** | 3 | 2 | 3 | 3 | - | - | - | | |
| **CO-3** | 3 | 2 | 3 | 3 | - | - | - | | |
| **CO-4** | 2 | - | - | 2 | - | 3 | 2 | | |
| **CO-5** | - | 2 | 2 | 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 | | | | |
| 2400504D | Drone Technology (Basics) | 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) | |
| 2400504D | Drone Technology (Basics) | 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:T2400504D

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| TSO 1a. Describe the various historical evolutionarysteps of drone technology<br>TSO 1b. Explain Drone motion based on principle of aerodynamics.<br>TSO 1c. Classify different types of drones and make chart of its application, advantages and disadvantages<br>TSO 1d. Develop attitude to follow proper rules and regulations of drones flying in India.<br>TSO 1e. Explore future prospects of drones in India. | **Unit-1.0Introduction to Drone Technology**<br><br>Introduction to Drones and UAV<br>• Definition<br>• History<br>• Drone in Indian aspect<br>Introduction to Flight Dynamics<br>Various types of Drones and their respective Applications<br>• Multirotor drones<br>• Fixed wing structure<br>Drone flights using an understanding of FAA<br>• DGCA<br>• Digital sky platform<br>• RPTO<br>Drone regulations-No drone zones | **CO-1** |
| TSO 2a. Explain the use and function of different types of Drone components.<br>TSO 2b. Select suitable drone frame and propellers for given application.<br>TSO 2c. Explain working principle and function of different sensors used in drone technology.<br>TSO 2d. Write use of Gyro sensor and Accelerometer in drone.<br>TSO 2e. Describe different types and capacity of Battery used in various drone applications.<br>TSO 2f. State the selection criteria of motor for given drone application.<br>TSO 2g. Write advantage of BLDC motors in making of Drones. | **Unit-2.0 Drone and its components**<br><br>Drones components<br>• Drone frame<br>• Propellers<br>Sensors<br>• Gyro sensor and Accelerometer<br>• Speed and Distance Sensor<br>• Temp sensor<br>• Barometer<br>• TOF Sensor<br>Battery<br>• Types and Capacity<br>Motors<br>• Motor types<br>• Motor capabilities<br>• Application of BLDC motors in drones | **CO-2** |
| TSO 3a. Explain four types of motion used in drone's operation.<br><br>TSO 3b. Describe the working and applications ofElectronic speed controller.<br>TSO 3c. Explain the working principle of Flight controller unit used in drone.<br>TSO 3d. Explain Radio communication unit used in drone.<br>TSO 3e. Explain the communication of Flight controller board with motor, ESC and sensors | **Unit-3.0 Drone controller and motion**<br><br>Propulsion and Vertical Motion<br>Controller and Flying Instructions<br>Electronic speed Controller (ESC)<br>Flight Controller Board (FCB)<br>Radio Communication<br>Transmitter and Receiver for radio signal | **CO-3** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| with suitable diagram | | |
| TSO 4a.Describe utility of different communication port used in drone.<br><br>TSO 4b. Identify different types of connectors and write their specifications<br><br>TSO 4c. Explain the use of drone simulator software and hardware. | **Unit-4.0Connections and Interfaces of Devicesin Drone and Drone Simulator**<br>Communication Port<br>• PWM<br>• RS232, RS422, RS485<br>• UART<br>• CAN<br>• I2C<br>Different types of connectors and its specification<br>Drone Simulator software<br>Drone simulator Hardware | **CO-4** |
| TSO 5a.Write basic code in Python.<br>TSO 5b. Explain structure and components of a Python program.<br>TSO 5c. write syntax of loops and decision statements in Python.<br>TSO 5d. Explain steps to create functions and pass arguments in Python. | **Unit-5.0 Introduction to Python for Drone**<br>Python programing refreshers for IoT, AI and Drone<br>Integration of devices with cloud services<br>Microsoft Azure, AWS | **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: P2400504D

| Practical/Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment/Practical Titles | Relevant COs Number(s) |
|---|---|---|---|
| LSO 1 Choose suitable materials for making drone frame. | 1. | Determine the strength of materials used in drones frame. | CO-2 |
| LSO 2 Select suitable materials for making drone propellers. | 2. | Determine the strength of materials used in drones Propellers. | CO-2 |
| LSO 3 Use appropriate battery as per need of flight time for specific drone application. | 3. | Test different parameters of batteries used in drones | CO-2 |
| LSO 4 Identify suitable motors as per payload of specific drone application. | 4. | Test motors suitable for specific Drone application. | CO-2 |
| LSO 5 Operate Gyro sensor and Accelerometer. | 5. | Test and measure Gyro sensor and Accelerometer and their characteristics. | CO-2 |
| LSO 6.1 Identify different sensors based on their characteristics.<br>LSO 6.2 Interface different types of sensor in drone. | 6. | Test different sensors and their characteristics with Microcontroller based Flight controller board. | CO-2, CO-3 |
| LSO 7 Demonstrate four type of drone motion. | 7. | Determine thrust/torque of motor by changing different drone motion | CO-2, CO-3 |
| LSO 8.1 Configure Flight control board (FCB)<br>LSO 8.2 Demonstrate use of Flight control board (FCB | 8. | Test and troubleshoot Flight control board (FCB). | CO-3 |
| LSO 9.1 Measure various parameters of sensor<br>LSO 9.2 Interface sensor with flight controller board. | 9. | Test and perform communication of Flight control board (FCB) with sensor | CO-3, CO-2 |
| LSO 10 Use motor with flight controller board. | 10. | Test and perform communication of Flight control board (FCB) with motor. | CO-3, CO-2 |

| Practical/Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment/Practical Titles | Relevant COs Number(s) |
|---|---|---|---|
| LSO 11 Interface ESC with flight controller board. | 11. | Test and perform communication of Flight control board with ESC. | CO-3 |
| LSO 12 Configure radio communication device to control drones | 12. | Test and perform communication of Flight control board with RF transceiver. | CO-3 |
| LSO 13.1 Identify different types of ports and connectors of drone.<br>LSO 13.2 Assemble drone component. | 13. | Test Hardware assembly for drone. | CO-4<br>CO-3 |
| LSO 14.1 Identify different motions in drone simulator.<br>LSO 14.2 Operate drone in simulator for specific task | 14. | Perform different motion in drone simulator. | CO-4 |
| LSO 15.1 Write code of loop and decision statement in python.<br>LSO 15.2 Interpret loop and decision statement<br>LSO 15.3 Debug code of loop and decision statement | 15. | Build and run loops and decision statements for specific application in Python. | CO-5 |
| LSO 16.1 Make function in python.<br>LSO 16.2 Interpret given function statement<br>LSO 16.3 Debug code of function in python | 16. | Build and Run functions for specific application and pass arguments in Python. | CO-5 |
| LSO 17.1 Identify python programming steps to interface drone components.<br>LSO 17.2 Identify error in python program<br>LSO 17.3 Debug the given python program | 17. | Write basic programming in python to interface different component of Drones | CO-5, CO-3 |

**L) Suggested Term Work and Self Learning: S2400504D** 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. Design drone for simple application.
2. Test different sensors, their characteristics and make chart which are used in different drones' applications.
3. Download 5 videos on drone design with different components. Watch them and write report on it.
4. Write report on Drone application for precision agriculture.
5. Survey nearby electronics shop and Prepare report of list of drone component and its specification.
6. Visit nearby tool room, small industry, Drone training institute facilities. Prepare report of visit with special comments of drone technology used, material used, cost of printed component.

**c. Other Activities:**

1. Seminar Topics-History of Drone, Drone regulations, Proximity sensor, Bernoulli's principle apply indrone, Radio communication used in drones, Drone Simulator, Python Programming.
2. Visits: Visit nearby tool room, small industry, Drone training institute facilities. Prepare report of visit with special comments of drone technology used, material used, cost of printed component.
3. Surveys: Survey nearby electronics shop and Prepare report of list of drone component and its specification and explore Drone simulator.
4. Product Development
5. Software Development

**d. Self-Learning Topics:**

1. History of Drones
2. Drone in Indian aspect
3. Drone regulations
4. Principle of aerodynamics for Drones
5. Drone simulator

**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) 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% | 10% | -- | 10% | -- | -- |
| **CO-2** | 30% | 30% | 30% | 33% | 30% | 30% | 30% |
| **CO-3** | 30% | 30% | 30% | 34% | 30% | 30% | 30% |
| **CO-4** | 15% | 10% | 15% | -- | 15% | 20% | 20% |
| **CO-5** | 15% | 20% | 15% | 33% | 15% | 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) |
| **Unit-1.0**. Introduction to Drone Technology | 6 | CO-1 | 08 | 03 | 02 | 03 |
| **Unit-2.0.** Drone and its component | 12 | CO-2 | 20 | 05 | 07 | 08 |
| **Unit-3.0.** Drone controller and motion | 12 | CO-3 | 20 | 05 | 07 | 08 |
| **Unit-4.0.** Connections and Interfaces of Devices in Drone and Drone Simulator | 8 | CO-4 | 08 | 03 | 02 | 03 |
| **Unit-5.0**. Introduction to Python for Drone | 10 | CO-5 | 14 | 04 | 04 | 06 |
| **Total Marks** | **48** | | **70** | **20** | **22** | **28** |

**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 the strength of materials used in drones frame. | CO-2 | 60 | 30 | 10 |
| 2. | Determine the strength of materials used in drones Propellers. | CO-2 | 60 | 30 | 10 |
| 3. | Test different parameters of batteries used in drones | CO-2 | 50 | 40 | 10 |
| 4. | Test motors suitable for specific Drone application. | CO-2 | 50 | 40 | 10 |
| 5. | Test and measure Gyro sensor and Accelerometer and their characteristics. | CO-2 | 50 | 40 | 10 |
| 6. | Test different sensors and their characteristics with Microcontroller based Flight controller board. | CO-2, CO-3 | 50 | 40 | 10 |
| 7. | Determine thrust/torque of motor by changing different drone motion | CO-2, CO-3 | 60 | 30 | 10 |
| 8. | Test and troubleshoot Flight control board (FCB). | CO-3 | 60 | 30 | 10 |
| 9. | Test and perform communication of Flight control board (FCB) with sensor | CO-3, CO-2 | 60 | 30 | 10 |
| 10. | Test and perform communication of Flight control board (FCB) with motor. | CO-3, CO-2 | 60 | 30 | 10 |
| 11. | Test and perform communication of Flight control board with ESC. | CO-3 | 60 | 30 | 10 |
| 12. | Test and perform communication of Flight control board with RF transceiver. | CO-3 | 60 | 30 | 10 |
| 13. | Test Hardware assembly for drone. | CO-4 CO-3 | 50 | 40 | 10 |
| 14. | Perform different motion in drone simulator. | CO-4 | 50 | 40 | 10 |
| 15. | Build and run loops and decision statements for specific application in Python. | CO-5 | 50 | 40 | 10 |
| 16. | Build and Run functions for specific application and pass arguments in Python. | CO-5 | 50 | 40 | 10 |
| 17. | Write basic programming in python to interface different component of Drones. | CO-5, CO-3 | 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 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 | 1-13 |
| 2. | Propellers | 10X4.5 CW/Others | 1-13 |
| 3. | Speed Sensor | 3.3 or 5.0Vdc | 1-13 |
| 4. | Distance Sensor | 5Volt operating voltage | 1-13 |
| 5. | Gyro sensor and Accelerometer | 5Volt operating voltage | 1-13 |
| 6. | Barometer | Altitude tracking, temp range from 25°C to 40°C | 1-13 |
| 7. | TOF Sensor | Accurate ranging up to 4 m, Fast ranging frequency up to 50 | 1-13 |
| 8. | Battery | Lithium Polymer Battery,2200mAH/others | 1-13 |
| 9. | Motor | BLDC,1000kv or 1000RPM/volt | 1-13 |
| 10. | Electronic speed Controller (ESC) | 30 Amp,2-4s or cell | 1-13 |
| 11. | Flight Controller Unit | KK 2.1.5/ ArdupilotAPM 2.8/ Pixhawk/others | 1-13 |
| 12. | Transmitter and Receiver for radio signal | 4 channels/6 Channels, 2.4 GHz & 5.8 GHz | 1-13 |
| 13. | Drone Simulator Software | RC flight simulator | 14 |
| 14. | Python Software | Hardware required-More than 4 GB RAM, 64-bitCPU preferable | 15,16,17 |

## R) Suggested Learning Resources:

### (a) Books:

| S. No. | Titles | Author (s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 1. | Make: Getting Started with Drones: Build and Customize Your Own Quadcopter | Terry Kilby&Belinda Kilby | Shroff/Maker Media, First edition 2016, ISBN-978-9352133147 |
| 2. | Agricultural Drones: A Peaceful Pursuit | K R Krishna | Apple Academic Press,1st edition 2018, ISBN-978-1771885959 |
| 3. | 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 |
| 4. | Building Multicopter Video Drones: Build andfly multicopter drones to gather breathtakingvideo 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 |

### (b) Online Educational Resources:

1. https://nptel.ac.in/courses/101104073
2. https://en.wikipedia.org/wiki/Unmanned_aerial_vehicle
3. https://www.scienceabc.com/innovation/what-is-drone-technology.html
4. https://www.dronezon.com/learn-about-drones-quadcopters/what-is-drone-technology-or-how-does-drone-technology-work/
5. https://www.youtube.com/watch?v=OWaXIK9sHeE
6. https://books.google.co.in/books?id=2M0hEAAAQBAJ&printsec=copyright&redir_esc=y#v=onepage&q&f=false

**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
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

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**A) Course Code : 2400504E (T2400504E/P2400504E/S2400504E)**

**B) Course Title :** 3D Printing and Design (Basic)

**C) Pre- requisite Course(s) :** Computer Aided Modeling

**D) Rationale :**

Additive manufacturing (AM) or Additive layer manufacturing (ALM) is the industrial production name for 3D Printing. 3D Printing is a process that makes solid objects from a digital model. It involves depositing material either metal, powdered plastic, or liquid in thin layers (2D) to get a 3D object. This basic course on 3D Printing tries to develop understanding of the process of making real object from digital model in the students. It also covers the software/hardware required, various materials used for FDM based 3D Printing and details about printing process parameters. The knowledge gained through this course will help the students to take up advanced course on 3D Printing in next 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** Develop CAD models for 3D Printing.
**CO-2** Import and Export CAD data in .STL file format to generate GCODE file.
**CO-3** Select suitable FDM based 3D Printing material for given applications.
**CO-4** Select suitable FDM based 3D Printing process parameters for given situations.
**CO-5** Produce products using FDM based 3D Printing processes.

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

| Course Outcomes (COs) | Programme Outcomes(POs) | | | | | | | Programme Specific Outcomes* (PSOs) | |
|---|---|---|---|---|---|---|---|---|---|
| | **PO-1** Basic and Discipline Specific Knowledge | **PO-2** Problem Analysis | **PO-3** Design/ Development of Solutions | **PO-4** Engineering Tools | **PO-5** Engineering Practices for Society, Sustainability and Environment | **PO-6** Project Management | **PO-7** Life Long Learning | **PSO-1** | **PSO-2** |
| **CO-1** | 3 | - | 3 | 2 | - | - | 2 | | |
| **CO-2** | 3 | 2 | - | 2 | - | - | - | | |
| **CO-3** | 3 | 3 | - | 2 | 3 | - | - | | |
| **CO-4** | 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 Credits (C) |
| | | L | T | | | | |
| **2400504E** | 3D Printing and Design (Basic) | 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) | |
| **2400504E** | 3D Printing and Design (Basics) | 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: T2400504E

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| *TSO 1a.* Explain CAD-CAM and related terminologies.<br>*TSO 1b.* Convert the given CAD file format into others.<br>*TSO 1c.* Transfer the given CAD data to CAM facilities.<br>*TSO 1d.* Classify 3D Printing processes.<br>*TSO 1e.* List the advantages of additive manufacturing processes over conventional manufacturing processes.<br>*TSO 1f.* List typical steps involved in 3D printing of an object from digital model.<br>*TSO 1g.* Explain reverse engineering steps for 3D Printing. | **Unit-1.0 Additive Manufacturing Introduction and CAD**<br>1.1 CAD-CAM and its integration.<br>1.2 CAD- Part and Surface modeling.<br>1.3 CAD file formats.<br>1.4 Additive v/s Conventional Manufacturing processes.<br>1.5 Process chain for 3D Printing.<br>1.6 Classification of 3D Printing Processes.<br>1.7 Product design and prototyping.<br>1.8 Reverse Engineering for 3D Printing. | **CO1** |
| *TSO 2a.* Explain the given STL interface terminology.<br>*TSO 2b.* Use the given alternative 3D printing interface.<br>*TSO 2c.* Generate STL file for the given CAD file.<br>*TSO 2d.* Repair the given STL file.<br>*TSO 2e.* Apply part orientation and support techniques for the given situation.<br>*TSO 2f.* Perform slicing of the given CAD model using the given slicing software.<br>*TSO 2g.* Generate tool path using simulation software for the given situation. | **Unit-2.0 Data Preparation for 3D Printing**<br>2.1 STL interface Specification, STL data generation, STL data Manipulation.<br>2.2 Advantages and limitations of STL file format, Open files, Repair of STL files,<br>2.3 Alternative 3D Printing interfaces.<br>2.4 Part orientation and support generation, Factors affecting part orientation, Various models for part orientation determination.<br>2.5 The function of part supports, Support structure design, Automatic support structure generation.<br>2.6 Model Slicing and Contour Data organization, Direct and adaptive slicing: Identification of peak features, Adaptive layer thickness determination.<br>2.7 Tool path generation. | **CO1, CO2** |
| *TSO 3a.* Explain the given 3D Printing process.<br>*TSO 3b.* Select FDM 3D Printing materials for the given application.<br>*TSO 3c.* Select FDM based 3D Printing processes parameters for given application with justification. | **Unit-3.0 Additive Manufacturing Techniques**<br>3.1 Fused Deposition Modeling (FDM), Stereo lithography (SLA), Selective Laser Sintering (SLS), Binder Jetting, Material Jetting, Direct Energy Deposition and Laminate Object Manufacturing.<br>3.2 FDM based 3D printing process details.<br>3.3 3D Printing materials and selection for FDM. | **CO3, CO4** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| | 3.4 FDM Process parameter for various applications. | |
| *TSO 4a.* Identify various Aerospace, Electronics, Health care, Automotive, Construction, Food processing, Machine tool components that can be 3D Printed.<br>*TSO 4b.* Estimate the cost and time of FDM based 3D printing of the given component. | **Unit-4.0 Application of 3D Printing**<br>4.1 Additive Manufacturing Application Domains: Aerospace, Electronics, Health Care, Defense, Automotive, Construction, Food Processing, Machine Tools | **CO3, CO4** |
| *TSO 5a.* Select suitable 3D Printer (FDM) and software for the given application with justification.<br>*TSO 5b.* Analyze the effect of given FDM based 3D printing process parameters using 3D printer software simulation.<br>*TSO 5c.* List steps to perform 3D scanning of the given object.<br>*TSO 5d.* Repair 3D scanned digital model.<br>*TSO 5e.* Set different FDM 3D printing process parameters to get a sound plastic component. | **Unit-5.0 3D Printers and Software and Scanners**<br>5.1 Construction details and working of established FDM based 3D printers for plastics parts.<br>5.2 Accuracy, Precision and Tolerance in 3D printing.<br>5.3 3D Printer software- Fusion 360, SolidWorks, Onshape, Tinkercad, Ultimaker Cura, MeshLab, Simplyfy 3D, Repetier host, Slic3r, etc. – use and operation of anyone.<br>5.4 3D Scanners and working.<br>5.5 Producing a part using FDM based 3D Printer. | **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: P2400504E

| Practical/Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment/Practical Titles | Relevant COs Number(s) |
|---|---|---|---|
| *LSO 1.1.* Use CAD software.<br>*LSO 1.2.* Prepare digital models of simple 3D entities. | 1. | Develop digital models of following simple components using any CAD software:<br>• Nut<br>• Bolt<br>• Network cable Jack<br>• Coat button<br>• Spoon | CO1 |
| *LSO 2.1.* Prepare digital models of complex 3D entities and assemblies. | 2. | Develop digital models of following assemblies using any CAD software:<br>• Connecting Rod<br>• Piston<br>• Electric switch<br>• Bathroom Tap<br>• Mouse | CO1 |
| *LSO 3.1.* Surf web for downloading readymade free CAD models.<br>*LSO 3.2.* Convert one CAD file format into another. | 3. | Download three digital CAD models freely available on web in different formats and then convert them into .stl/obj format. | CO1 |
| *LSO 4.1.* Use the given Slicing software for 3D Printing.<br>*LSO 4.2.* Perform slicing operation on the given digital model. | 4. | Perform slicing operation on one digital model available under each Pr. No.1, 2 and 3. | CO2 |
| *LSO 5.1.* Use the available 3D printing software.<br>*LSO 5.2.* Selection of 3D printing process and performance parameters. | 5. | Analyze the effect of different process parameters, materials on printing time, material required, surface finish, etc. through | CO3, CO4, CO5 |

| Practical/Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment/Practical Titles | Relevant COs Number(s) |
|---|---|---|---|
| | | simulation using 3D printing software on sliced models available from Pr. No. 4 | |
| *LSO 6.1.* Produce single plastic components using available 3D printer.<br>*LSO 6.2.* Perform post processing operations on printed component. | 6. | Print one single component on available FDM based 3D printer with PLA/ABS material | CO3, CO4, CO5 |
| *LSO 7.1.* Select appropriate layer thickness, tolerance, fit.<br>*LSO 7.2.* Produce an assembly of plastic components using available 3D printer. | 7. | Print one assembly on available FDM based 3D printer with PLA/ABS material | CO3, CO4, CO5 |
| *LSO 8.1.* Choose suitable material for printing flexible structure (assembly of same small pieces to give flexible fabric effect).<br>*LSO 8.2.* Choose suitable design/shape to create a flexible type structure.<br>*LSO 8.3.* Produce flexible plastic structure using available 3D printer. | 8. | Model and print a flexible fabric structure with PLA/ABS material (assembly of same small pieces to give flexible fabric effect) | CO3, CO4, CO5 |
| *LSO 9.1.* Selection of 3D printing process parameters. | 9. | Change printing process parameters and repeat experiment number 6. | CO4, CO5 |
| *LSO 10.1.* Use of available 3D scanner.<br>*LSO 10.2.* Develop 3D digital model using scanning approach.<br>*LSO 10.3.* Modeling of complex 3D objects using 3D scanning. | 10. | Scan the given complex component using available 3D Sanner. | CO5 |
| *LSO 11.1.* Produce a complex plastic structure using available 3D printer and scanner.<br>*LSO 11.2.* Apply Reverse Engineering approach to exactly 3D print an existing real object. | 11. | Print the 3D scanned digital model of Pr. No. 10 on available FDM based 3D printer with PLA/ABS material | CO5 |

**L) Suggested Term Work and Self Learning: S2400504E** 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. Perform 3D printing of plastic casing of inhaler used by Asthma patients and estimate the cost.
2. Download 5 videos on 3D printing of different components, 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. Print two pieces of same components using ABS and PLA and compare their strength, surface roughness, weight, cost.
4. Download two 3D printing free software and try to check their compatibility with your lab printer.

**c. Other Activities:**

1. Seminar Topics:
   - Commercially available 3D printers and software.
   - Strength of 3D printed Plastic components as compared to Die cast Plastic components.
   - Properties of PLA and ABS 3D printing materials.
   - Reverse engineering application of 3D Printing.

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 flexible plastic components.
   - 3D printing of micro/mini components.
   - Conversion of CAD file formats into IGES.
   - 3D scanning process.

**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) 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 (Cl) Hours | Relevant COs Number(s) | Total Marks | ETA (Marks) | | |
|---|---|---|---|---|---|---|
| | | | | Remember (R) | Understanding (U) | Application & above (A) |
| **Unit-1.0** Additive Manufacturing Introduction and CAD | 8 | CO1 | 10 | 3 | 3 | 4 |
| **Unit-2.0** Data Preparation for 3D Printing | 8 | CO1, CO2 | 10 | 3 | 2 | 5 |
| **Unit-3.0** Additive Manufacturing Techniques | 8 | CO3, CO4 | 10 | 5 | 2 | 3 |
| **Unit-4.0** Application of 3D Printing | 12 | CO3, CO4 | 20 | 5 | 6 | 9 |
| **Unit-5.0** 3D Printers and Software and Scanners | 12 | CO4, CO5 | 20 | 4 | 6 | 10 |
| **Total** | **48** | **-** | **70** | **20** | **19** | **31** |

**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 digital models of following simple components using any CAD software:<br>• Nut<br>• Bolt<br>• Network cable Jack<br>• Coat button<br>• Spoon | CO1 | 30 | 60 | 10 |
| 2. | Develop digital models of following assemblies using any CAD software:<br>• Connecting Rod<br>• Piston<br>• Electric switch<br>• Bathroom Tap<br>• Mouse | CO1 | 40 | 50 | 10 |
| 3. | Download three digital CAD models freely available on web in different formats and then convert them into .stl/obj format. | CO1 | 30 | 60 | 10 |
| 4. | Perform slicing operation on one digital model available under each Pr. No.1, 2 and 3. | CO2 | 30 | 60 | 10 |
| 5. | Analyse the effect of different process parameters, materials on printing time, material required, surface finish, etc. through simulation using 3D printing software on sliced models available from Pr. No. 4 | CO3, CO4, CO5 | 30 | 60 | 10 |
| 6. | Print one single component on available 3D based Printer with PLA/ABS material | CO3, CO4, CO5 | 30 | 60 | 10 |
| 7. | Print one assembly on available 3D based Printer with PLA/ABS material | CO3, CO4, CO5 | 30 | 60 | 10 |
| 8. | Model and print a flexible fabric structure with PLA/ABS material (assembly of same small pieces to give flexible fabric effect) | CO3, CO4, CO5 | 40 | 50 | 10 |
| 9. | Change printing process parameters and repeat experiment number 6. | CO4, CO5 | 40 | 50 | 10 |

| | | | | | |
|---|---|---|---|---|---|
| 10. | Scan the given complex component using available 3D Sanner. | CO5 | 40 | 50 | 10 |
| 11. | Print the 3D scanned digital model of Pr. No. 10 on available 3D based Printer with PLA/ABS material | 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. | 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 **OR** Available with CoE | 1,2 |
| 3. | 3D printer | Fused Deposition Modelling system with complete accessories; Build Volume-300 x 300 x 300mm or Higher; Layer Thickness-0.1 – 0.4 **OR** Available with CoE | 6, 7, 8, 10 |
| 4. | 3D Printing Material | ABS/PLA **OR** Available with CoE | 6, 7, 8, 10 |
| 5. | 3D Printing software | Latest version of software like: Cura/PrusaSlicer/ideaMaker/Meshmixer/MeshLab **OR** Available with CoE | 3,4 |
| 6. | 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 etc. | 6, 7, 8, 10 |
| 7. | 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 **OR** Available with CoE | 10 |

## R) Suggested Learning Resources:

### (a) Books:

| S. No. | Titles | Author(s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 1. | Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing | Andreas Gebhardt, | Hanser Publisher, 2011<br>ISBN: 156990507X, 9781569905074 |
| 2. | 3D Printing and Design | Sabrie Soloman | Khanna Publishing House, Delhi<br>ISBN: 9789386173768 |
| 3. | 3D Printing and Rapid Prototyping- Principles and Applications | C.K. Chua, Kah Fai Leong | World Scientific, 2017<br>ISBN: 9789813146754 |
| 4. | 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 |

### (b) Online Educational Resources:

1. https://onlinecourses.nptel.ac.in/noc21_me115/preview
2. https://archive.nptel.ac.in/courses/112/104/112104265/
3. https://www.youtube.com/watch?v=b2Od4YHcLAQ
4. https://www.youtube.com/watch?v=EF8CNR-gcXo
5. https://www.academia.edu/41439870/Education_Resources_for_3D_Printing
6. https://www.think3d.in/landing-pages/beginners-guide-to-3d-printing.pdf
7. https://all3dp.com/1/types-of-3d-printers-3d-printing-technology/

**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. 3D Printing Projects DK Children; Illustrated edition, 2017
2. The 3D Printing Handbook: Technologies, design and applications Ben Redwood, Filemon Schöffer, Brian Garret, 3D Hubs; 1st edition, 2017
3. 3D Printer Users' Guide
4. 3D Printer Material Handbook
5. Lab Manuals

******

**A) Course Code** : **2400504F(T2400504F/P2400504F/S2400504F)**

**B) Course Title** : Industrial Automation (Basic)

**C) Pre- requisite Course(s)** : Basic Mechanical Engineering, Basic Electrical Engineering, Digital Electronics and Basic programming skills

**D) Rationale** :

The technological education and research scenario, all over the world, is turning towards a multidisciplinary one. The present scenario is different as compared to the recent past in the sense that the engineering disciplines are now dilating instead of diverging. The primary reason being that the current technological designs are of highly complex and inter-interdisciplinary nature involving synergistic integration of many aspects of engineering knowledge base**.** Industrial automation has become an essential part of every modern industry. Automation helps industry to increase the productivity, quality, accuracy and precision of industrial processes. Stiff competition, higher quality standards and growing concerns of safety & environmental damage have pushed the Industrial sector to adapt state-of-the-art Automation Techniques for effective utilization of resources and optimized performance of the plants. Today engineer is needed to meet the requirements of designing appropriate automation systems. They should have the knowledge of different fields like PLC and PID based Controller, Instrumentation, Networking, Industrial Drives, SCADA/HMI, High speed data acquisition, etc., to become a successful automation engineer. The discipline Automation is enormous in magnitude. The students passing this course will gain basic understanding about industrial automation and will be prepared to take up the advance course in Industrial automation in next 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** Apply principles and strategies for automation for a given situation.

**CO-2** Use sensors and input devices as per given situation.

**CO-3** Test the given PLC for its functionality.

**CO-4** Use actuators and output devices as per given situation.

**CO-5** Test the working of various types of control system and controllers

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

| Course Outcomes (COs) | Programme Outcomes (POs) | | | | | | | Programme Specific Outcomes* (PSOs) | |
|---|---|---|---|---|---|---|---|---|---|
| | **PO-1** Basic and Discipline-Specific Knowledge | **PO-2** Problem Analysis | **PO-3** Design/ Development of Solutions | **PO-4** Engineering Tools | **PO-5** Engineering Practices for Society, Sustainability and Environment | **PO-6** Project Management | **PO-7** Life Long Learning | **PSO-1** | **PSO-2** |
| **CO-1** | 3 | 2 | - | 2 | 2 | - | 2 | | |
| **CO-2** | 3 | 2 | 2 | 2 | - | - | 2 | | |
| **CO-3** | 3 | 2 | 2 | 2 | 2 | - | 2 | | |
| **CO-4** | 3 | 2 | 2 | 2 | 2 | - | 2 | | |
| **CO-5** | 3 | 2 | 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 | | | | |
| **2400504F** | Industrial Automation (Basic) | 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) | |
| **2400504F** | Industrial Automation (Basic) | 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, Society connect, Multidisciplinary aspects, Indian Knowledge System (IKS) and others need to be integrated.

## J) Theory Session Outcomes (TSOs) and Units: T2400504F

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| TSO.1. a Describe Industry 4.0 and its component<br>TSO.1. b Explain different types of automation systems<br>TSO.1.c Identify the type of automation used in a given industry<br>TSO.1.d Analyze the working of industrial processes and products for automation.<br>TSO.1.e Select principles and strategies for automation for a given situation using 4R's and 1U<br>TSO.1. f Select criteria for factory automation and processes automation for a given industry.<br>TSO.1. g Describe briefly different systems used for industrial automation.<br>TSO.1.h Describe IOT, IIOT and role of robots with respect to automation. | **Unit-1.0 Overview of Industrial Automation**<br>Introduction to Industry 4.0 and its components, Issues and challenges in automation<br>Need of automation in industries, Principles and strategies of automation, factory automation, process automation<br>Basic elements of an automated system, Structure of Industrial Automation Advanced automation functions, Levels of automations<br>Industrial control Systems- Process and Discrete system<br>Types of automation system: Fixed, Programmable, Flexible Integrated Automation and its application<br>Different systems used for Industrial automation: PLC, HMI, SCADA, DCS, Drives.<br>Introduction to Internet of Things (IoT) and Industrial Internet of Things (IIOT) and its application in Automation.<br>Role of robots in automation and its components. | **CO1** |
| TSO.2. a Explain PLC and list its advantages over relay systems.<br>TSO.2.b Distinguish between PLC and a PC, PLC and dedicated controllers.<br>TSO.2.c List the types of PLCs and brands available in the market.<br>TSO.2.d Describe the function of each block of a PLC with the help of a block diagram.<br>TSO.2.e Describe the basic sequence of operation of a PLC with a simple example.<br>TSO.2.f Explain different PLC programming languages with simple examples.<br>TSO.2.g Describe a simple PLC programming using ladder logic specifying I/O addressing<br>TSO.2.h List the applications of PLC | **Unit-2.0 Fundamentals of PLC**<br>Introduction to PLC, evolution of PLC<br>• Comparison of PLC and Personal Computer(PC)<br>• Comparison of PLC and dedicated controllers like PAC and CNC<br>• Types of PLC – Fixed, Modular and their types<br>• Different brands of PLCs available in the market<br>Building blocks of PLC -CPU, Memory organization, Input-Output modules (Discrete and Analog) Specialty I/OModules, Power supply<br>PLC programming languages with simple examples:<br>• Functional Block Diagram (FBD),<br>• Instruction List.<br>• Structured text,<br>• Sequential Function Chart (SFC),<br>• Ladder Programming<br>PLC I/O addressing in ladder logic<br>Simple programming example using ladder logicApplications of PLC:<br>Traffic light control, Elevator control, Motor sequencing control, Tank level control, temperature | **CO2** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| | control, Conveyor system control | |
| TSO.3.a Identify the commonly used input field devices in PLC installations along with their symbols.<br>TSO.3.b Draw symbol of various switches used in PLC installations describing the function of each switch.<br>TSO.3.c Identify the various digital input devices used in a PLC installation.<br>TSO.3.d Identify the commonly used sensors as input field devices found in PLC installations.<br>TSO.3.e Describe the working of different types of discrete sensors giving their applications.<br>TSO.3.f Describe the working of different types of advanced sensors giving their applications.<br><br>TSO.3.g Select Sensors as per the given requirement for ecofriendly automation. | **Unit 3.0 – Sensors and Input field Devices**<br><br>Analog input devices-Electromagnetic relays, Contactors, Motor starters,<br>Manually operated Switches<br>Toggle switch, pushbutton switch, knife switch and selector switches<br>Mechanically operated switches, Limit switch, Temperature switch (Thermostat), Pressure switch, Level switch and their symbols<br>Discrete/Digital Input device, Construction and working of Sensors<br>• Proximity sensors- Inductive, Capacitive, Optical and ultrasonic<br>Advanced sensors- Construction and working of<br>• Temperature sensors- Thermistor, Thermocouple and Resistance temperature Detector (RTD)<br>• Liquid level sensor -Capacitive and Ultrasonic<br>• Force -Strain/Weight sensors<br>• Flow sensors – turbine flow sensor<br>• Pressure sensors- Linear Variable Differential Transformer (LVDT)<br>• Inclination sensor -Inclinometer<br>• Acceleration sensor- Accelerometer<br>Angular and linear position sensor | **CO3** |
| TSO.4.a Classify the actuators.<br>TSO.4.b Describe the construction and working of a given actuator.<br>TSO.4.c Explain the basic principle of operation of a given actuator.<br>TSO.4.d Differentiate between hydraulic and pneumatic actuators<br>TSO.4.e Explain the basic principle of operation of a given control valve.<br>TSO.4.f Select actuators and valves as per the given requirement for ecofriendly automation.<br>TSO.4.g Develop different hydraulic and pneumatic circuits for simple application.<br>TSO.4.h Identify the commonly used output field devices in PLC installations<br>TSO.4.i Draw the symbol of various output devices used in PLC installations describing the function of each.<br>TSO.4.j Select output devices for a PLC installation as per the requirement. | **Unit 4.0- Actuators and Output Devices**<br><br>Introduction to actuators, Classification of actuators<br>Mechanical actuators -Translational and rotation motion, kinematic chains, cams, gears, belt and chain drives, bearings<br>Hydraulic and Pneumatic actuators- linear and rotary actuators, single and double acting cylinder, directional, process and pressure control valves<br>Electrical actuators<br>• Electromechanical actuators<br>Construction, working and application of Stepper motors, AC/DC Servo motors, BLDC Motor (Very brief)<br>• Electrohydraulic actuators-Construction, working and application of Electro- hydrostatic actuator (EHA), ON/OFF Electro-hydraulic Rotary Actuator (E2H90, Control Valve Rotary Actuator (E2HR), Solenoid valve<br>Thermal actuators -Construction, working andapplication of Hot-And-Cold-Arm Actuators, Chevron-Type Actuators<br>Magnetic actuators- Construction, working principle and application of Moving coil actuators, moving magnet actuator, Moving iron actuator<br>Selection criteria of actuators | **CO4** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| | Other Output devices- Indicators, Alarms Pilot Lights, Buzzers, Valves, Motor starters, Horns and alarms, Stack lights Control relays, Pumps and Fans. | |
| TSO.5.a Describe the basic process control system with the help of a block diagram<br>TSO.5.b Explain the types of control available in a process control<br>TSO.5.c Describe the different types of controllers in a closed loop system withthe help of a block diagram<br>TSO.5.d Describe the construction, working and application of a given control system components. | **Unit 5.0– Control System**<br>Block diagram of a basic control system<br>Open and closed loop system, their transfer function<br>First order and second order system and their output response and parameters<br>Different types of inputs-step and ramp<br>Types of control – On-off, Feed forward, Open loop and closed loop control and Transfer function<br>Controllers in closed loop control<br>• Proportional Controller (P Controller)<br>• Integral Controller (I Controller)<br>• Derivative controller (D- Controller)<br>• P-I Controller<br>• P-D Controller<br>PID Controller | **CO5** |

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

## K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400504F

| Practical/Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment/Practical Titles | Relevant COs Number(s) |
|---|---|---|---|
| LSO 1.1 Identify various building blocks and major automation components in a given robotic system<br>LSO 1.2 Identify various building blocks and major automation components in a given electrical drives | 1. | Identify major automation components in a given system | CO1 |
| LSO 1.3 Analyze and plan the steps to automate the given system. | 2. | Analyze given traditional machine in the laboratory for and identify the steps and components required to automate it. | |
| LSO 1.4. Identify the building blocks of a given typical SCADA system<br>LSO 1.5. Identify the symbol library of SCADA software | 3. | Use Scada software for simple application | |
| LSO 2.1 Identify the various parts and front panel status indicators of the given PLC. | 4. | Observe various parts and front panelindicators of a PLC | CO2 |
| LSO 2.2 Identify different input and output devices that can be connected to a given PLC. | 5. | Observe different types of switches and their symbols sensors, lamp, alarm, motor, fan used in a PLC | |
| LSO 2.3 Test the analog input and output lines of the given PLC. | 6. | Identify Analog input and output linesof a PLC | |
| LSO 2.4 Test the digital input and outlines of the given PLC. | 7. | Identify digital input and output lines ofa PLC | |
| LSO 2.5 Use PLC to control the devices like Lamp, Alarm, motor using push button switches | 8. | Practice using PLC to control various digital and analog output devices | |
| LSO 3.1. Test the response of digital inductive proximity sense or used to detect different types of | 9. | Identify different types of digital inductive proximity sensor and its use | CO3 |

| Practical/Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment/Practical Titles | Relevant COs Number(s) |
|---|---|---|---|
| materials | | | |
| LSO 3.2. Test the response of digital capacitive proximity sensors used to detect o different materials | 10. | Identify different types of digital capacitive proximity sensor and its use | |
| LSO 3.3. Test the response of digital optical proximity sensor used to detect different materials | 11. | Identify different types of digital optical proximity sensor and its use | |
| LSO 3.4. Test the response of digital ultrasonic proximity sensors used to detect different materials | 12. | Identify different types of digital ultrasonic proximity sensor and its use | |
| LSO 3.5. Use thermistor to measure temperature of a given material | 13. | Identify different types of thermistorand its use | |
| LSO 3.6. Use Thermocouple to measure the temperature of a given liquid and plot the output voltage versus temperature | 14. | Observe the conversion of temperature to electric parameter conversion of a Thermocouple | |
| LSO 3.7. Use RTD to control the temperature of an oven | 15. | Observe different types of RTDs used inindustries for temperature measurement | |
| LSO 3.8. Use flow sensors to measure the flow of a given liquid or gas | 16. | Observe different types of flow sensors used in industries for flow measurement | |
| LSO 3.9. Use pressure sensors to measure the pressure of a liquid or gas | 17. | Observe different types of pressure sensors used in industries for pressure measurement | |
| LSO 3.10. Use load cell for measurement of mechanical force/weight. | 18. | Observe the different types of loadcell used in industries for force/weight measurement | |
| LSO 4.1 Design and actuate pneumatic circuit for lift control<br>LSO 4.2 Design a pneumatic system that rivets the pockets on jeans<br>LSO 4.3 Design pneumatic circuit to open and close the security gate and control the speed.<br>LSO 4.4 Design a circuit for speed control of hydraulic motor meter out circuit by using 4/3 DC valve.<br>LSO 4.5 Design a circuit for speed control of double acting cylinder meter in by using 4/2 dc solenoid valve.<br>LSO 4.6 Designing a circuit for speed control of double acting cylinder meter out by using 4/3 solenoid valve | 19. | Design and actuate pneumatic/ hydraulic circuit for the given situation | CO4 |
| LSO 4.7 Direct acting of hydraulic motor | 20. | Operate hydraulic motor | |
| LSO 4.8 Operate stepper motor and control the motor by changing number of steps, the direction of rotation and speed. | 21. | Operate stepper motor | |
| LSO 4.9 Identify the components of thermal and magnetic actuators available in the laboratory.<br>LSO 4.10 Use thermal and magnetic actuators | 22. | Thermal and magnetic actuators | |
| LSO 5.1 Test the output response of a open loop closed loop and feed forward path | 23. | Analyze the given system to studyopen loop, closed loop and feed forward path. | CO5 |

| Practical/Lab Session Outcomes (LSOs) | | S. No. | Laboratory Experiment/Practical Titles | Relevant COs Number(s) |
|---|---|---|---|---|
| LSO 5.2 | Build and test the output response of a first order system for a step input using a CRO | 24. | Analyze the given first order system andits transfer function and output response | |
| LSO 5.3 | Build and test the response of a second order system for a step input using CRO. Also mark various parameters | 25. | Analyze the given second order system and its transfer function and output response | |
| LSO 5.4 | Test the Output response of an on-off and Proportional control-based level control system. | 26. | Analyze the given water level control system with on-off, Proportional control. | |
| LSO 5.5 | Test the Output response pf a P+I+D based level control system. | 27. | Analyze the given water level control system with P+I+D control. | |

**L) Suggested Term Work and Self Learning: S2400504F** 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 inline with the targeted COs.

i. State three advantages of using programmed PLC timer over mechanical timing relay.
ii. Prepare a list of open source PLC software
iii. Prepare a list of open source SCADA software.
iv. List the practical applications of PLC systems
v. List the practical applications of SCADA systems.
vi. Compare the PLC and PC with regard to:
   - Physical hardware differences
   - Operating environment
   - Method of programming
   - Execution of program
vii. Prepare classification chart of different types of actuators.
viii. Differentiate between Nano and micro actuators.

**b. Micro Projects:**

1. Develop a relay-based motor control automation such that the motor reverses its direction when the limit switches are activated.
2. Develop a simulation to connect analog and digital input to the PLC.
3. Develop a simulation to connect analog and digital output to the PLC.
4. Develop a simple automatic water level controller using magnetic float switch.
5. Develop a simple automatic door system using optical sensor and linear actuator.
6. Troubleshoot the faulty equipment/kit available in automation laboratory
7. Select one industry and analyze the process and propose the automation strategies' that can be used for automation.
8. Develop a working model of a given application using given actuators and valves.

**c. Other Activities:**

1. Seminar Topics- PLC architecture, Different types of sensors, Industrial Applications of PLC and SCADA
2. Visits – Visit any industry with full or semi automation and prepare a report on type of automation used.
3. 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.
4. 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
5. Surveys – carry out market survey for different types of electrical actuators available and prepare the comparative technical specifications of electrical actuators used in industries.
6. Visit industry and prepare a report on different types of hydraulic and pneumatic circuits used by the industry in the given section, components used, power requirement, output achieved and maintenance activities required.

**d. Self-Learning Topics:**

1. Use of PLC for different industrial applications
2. Use of sensors in commercial field
3. Use of sensors in home automation
4. Compare Specifications of PLCs of different manufacturers of any one type 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 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) 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% | -- | 30% | 20% | 20% |
| **CO-2** | 20% | 25% | 20% | -- | 20% | 25% | 20% |
| **CO-3** | 25% | 20% | 20% | 30% | 20% | 20% | 20% |
| **CO-4** | 25% | 20% | 20% | 20% | 30% | 20% | 20% |
| **CO-5** | 15% | 20% | 20% | 50% | -- | 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 (Cl) Hours | Relevant COs Number (s) | Total Marks | ETA (Marks) | | |
|---|---|---|---|---|---|---|
| | | | | Remember (R) | Understanding (U) | Application & above (A) |
| **Unit-1.0** Overview of Industrial Automation | 8 | CO1 | 11 | 3 | 4 | 4 |
| **Unit-2.0** Fundamentals of PLC | 12 | CO2 | 17 | 5 | 5 | 7 |
| **Unit-3.0** Sensors and Input field Devices | 9 | CO3 | 14 | 4 | 6 | 4 |
| **Unit-4.0** Actuators and Output Devices | 10 | CO4 | 14 | 4 | 6 | 4 |
| **Unit- 5.0** Control System | 9 | CO5 | 14 | 4 | 5 | 5 |
| **Total Marks** | **48** | | **70** | **20** | **26** | **24** |

**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 major automation components in a given system | CO1 | 50 | 40 | 10 |
| 2. | Analyze given traditional machine in the laboratory for and identify the steps and components required to automate it. | CO1 | 50 | 40 | 10 |
| 3. | Use Scada software for simple application | CO1 | 50 | 40 | 10 |
| 4. | Observe various parts and front panel indicators ofa PLC | CO2 | 50 | 40 | 10 |
| 5. | Observe different types of switches and their symbols sensors,lamp, alarm, motor, fan used in a PLC | CO2 | 50 | 40 | 10 |
| 6. | Identify Analog input and output lines of a PLC | CO2 | 50 | 40 | 10 |
| 7. | Identify digital input and output lines of a PLC | CO2 | 50 | 40 | 10 |
| 8. | Practice using PLC to control various digital and analog output devices | CO2 | 50 | 40 | 10 |
| 9. | Identify different types of digital inductive proximity sensor andits use | CO3 | 50 | 40 | 10 |
| 10. | Identify different types of digital capacitive proximity sensor and its use | CO3 | 50 | 40 | 10 |
| 11. | Identify different types of digital optical proximity sensor and its use | CO3 | 50 | 40 | 10 |
| 12. | Identify different types of digital ultrasonic proximity sensorand its use | CO3 | 50 | 40 | 10 |
| 13. | Identify different types of thermistor and its use | CO3 | 50 | 40 | 10 |

| S. No. | Laboratory Practical Titles | Relevant Cos Number (s) | PLA /ELA | | |
|---|---|---|---|---|---|
| | | | Performance | | Viva-Voce (%) |
| | | | PRA* (%) | PDA** (%) | |
| 14. | Observe the conversion of temperature to electric parameterconversion of a Thermocouple. | CO3 | 50 | 40 | 10 |
| 15. | Observe different types of RTDs used in industries for temperature measurement | CO3 | 50 | 40 | 10 |
| 16. | Observe different types of flow sensors used in industries for flowmeasurement | CO3 | 50 | 40 | 10 |
| 17. | Observe different types of pressure sensors used in industries for pressure measurement | CO3 | 50 | 40 | 10 |
| 18. | Observe the different types of load cell used in industries for force/weight measurement | CO3 | 50 | 40 | 10 |
| 19. | Design and actuate pneumatic/ hydraulic circuit for the given situation | CO4 | 50 | 40 | 10 |
| 20. | Operate hydraulic motor | CO4 | 50 | 40 | 10 |
| 21. | Operate stepper motor | CO4 | 50 | 40 | 10 |
| 22. | Thermal and magnetic actuators | CO4 | 50 | 40 | 10 |
| 23. | Analyze the given system to study open loop, closed loop and feed forward path. | CO5 | 50 | 40 | 10 |
| 24. | Analyze the given first order system and its transfer function and output response | CO5 | 50 | 40 | 10 |
| 25. | Analyze the given second order system and its transfer function and output response | CO5 | 50 | 40 | 10 |
| 26. | Analyze the given water level control system with on-off, Proportional control. | CO5 | 50 | 40 | 10 |
| 27. | Analyze the given water level control system with P+I+Dcontrol. | CO5 | 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 beprepared by the course teacher for each experiment/practical to assess the student performance.

**P) Suggested Instructional/Implementation Strategies:** Different Instructional/ ImplementationStrategies 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. | SCADA software (reputed make like Allen Bradley, Siemens.,) | 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 | 3 |
| 2. | Universal PLC Training System with HMI (Of reputed make such as Allen Bradely, Siemens, etc.,) 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, LoggerPro simulator, Simple EDA tools can also be used | 4,5,6,7,8 |
| 3. | Proximity sensors kit | The kit should comprise of the following proximity sensor - Inductive Proximity Sensor, Capacitive Proximity Sensor, Magnetic Sensor, Optical Sensor, Audio and LED indicator for the object detection. Along with learning material | 9,10,11,12 |
| 4. | Temperature transducer kit | Temperature Transducers Test Bench includes different types of temperature sensors including bimetallic strip, RTD, thermocouple, thermistor, RTD/thermocouple temperature display and thermistor, temperature display, heater, fan, switches and its indicator. Separate heater and fan chamber withstand. On panel digital voltmeter, digital ammeter, RTD/thermocouple temperature display, NTC temperature display, toggle switch for heater and fan with indicator, experiments configurable through patch board, heavy duty Test bench, castor wheel (with locking mechanism) is provided at legs of Test bench so that it can be easily moved, enhanced electrical safety consideration. | 12,13,14 |
| 5. | Pressure transducer kit | Pressure transducer kit should include different types of pressure sensors including capacitive pressure transducer, load cell, bourdon tube pressure gauge, and pressure vessel. Pressure vessel with pressure gauge, safety valve, non-returning valve bourdon gauge and capacitive transducer and air compressor, on panel digital voltmeter, digital ammeter, 4-20ma display, 0-10V DC display, toggle switch for compressor, load cell | 16 |

| S. No. | Name of Equipment, Tools and Software | Broad Specifications | Relevant Experiment/Practical Number |
|---|---|---|---|
| | | with suitable weight, experiments configurable through patch board, self -contained, bench-mounting arrangement, castor wheel (with locking mechanism) is provided at legs of Test bench so that it can be easily moved, enhanced electrical safety consideration.<br>Detailed experiment manual should be supplied with the kit. | |
| 6. | Flow sensor kit | Turbine flow sensor kit | 15 |
| 7. | Strain Gauge kit | The kit should provide study of Strain Gauge and their application for measurement of Strain. It should help to study bridge configuration of Strain Gauge and the signal conditioning circuits required to measure strain. It should use cantilever beam arrangement to produce strain on Strain Gauge. The Strain Gauges are firmly cemented to the cantilever at the point where the strain is to be measured. Weights are placed on free end of cantilever. Strain developed changes the resistance of Strain Gauge which is detected by full bridge configuration. It should comprise of Seven-segment LED display showing strain in micro strain units. Different weights should be provided to perform linearity and sensitivity experiments. Detailed experiment manual should be supplied with the kit. Test-points to observe input output of each block, onboard gain and offset null adjustment, built in DC Power Supplies, 3½ digits LED display, onboard Cantilever arrangement, high repeatability and reliability<br>The kit should be capable of performing following experiments:<br>• Measuring strain using strain gauges and cantilever assembly.<br>• Determination of linear range of operation of strain measurement.<br>Determination sensitivity of the kit | 17 |
| 8. | Cut sections of pumps, actuators, valves and accessories used in hydraulic systems | Suitably cut and mounted on a sturdy base to show the internal details. | 18 |
| 9. | Working models of pumps, actuators, valves and accessories used in hydraulic systems | Working models mounted on sturdy base to demonstrate the operation. | 18 |
| 10. | Working models of pumps, actuators, valves and accessories used in pneumatic systems | Working models mounted on sturdy base to demonstrate the operation. | 18 |
| 11. 8 | Oil Hydraulic trainer | Mounted on sturdy base fitted with all standard units and accessories to create various hydraulic circuits.<br>Hydraulic trainer with simulation software Pneumatic trainer with simulation software<br>• Filter Regulator Combination with Lubricator (FRL Unit) with pressure gauge, Junction Box with slide valve, Push Button Valve, 3/2 NC Roller lever valve ,3/2 NC Roller lever valve ,5/2 Double external pilot operated valve, 5/2 External pilot operated valve with spring return, 5/2 | 18 |

| S. No. | Name of Equipment, Tools and Software | Broad Specifications | Relevant Experiment/Practical Number |
|---|---|---|---|
| | | Hand lever with spring return, 5/2 Hand lever valve with detent – for maintained pilot operation of a SAC, 5/2 Valve with Lever head, 5/2 Value with Mushroom head, Flow control valve – Metering IN & OUT, Shuttle Valve (OR valve), Quick Exhaust Valve with Quick coupler plug<br>• Double Acting Cylinder (DAC) with Quick coupler socket (with accessories: Screw driver – for cushioning adjustment),Single Acting Cylinder (SAC), Swivel fitting assembly with Quick coupler plug, Multi distributor fittings (for cascading circuit designing)<br>• Single Solenoid Valve with Spring Return (with LED), Double Solenoid Valve (with LED), Magnetic Reed Switch, Magnetic Reed Switch, Relay Logic Unit – 2C/0-3 relays, Electrical<br>Push Button Unit, Electrical Selector Switch Unit, Timer | |
| 12. | Pneumatic Trainer | Mounted on sturdy base fitted with all standard units and accessories to create various Pneumatic circuits.<br>Pneumatic trainer with simulation software<br>• Filter Regulator Combination with Lubricator (FRL Unit) with pressure gauge, Junction Box with slide valve<br>• Push Button Valve, 3/2 NC Roller lever valve, 3/2 NC Roller lever valve, 5/2 Double external pilot operated valve (Memory valve)<br>• 5/2 External pilot operated valve with spring return, 5/2 Hand lever with spring return, 5/2 Hand lever valve with detent, 5/2Valve with Lever head ,5/2 Value with Mushroom head,<br>Flow control valve, Shuttle Valve (OR valve), AND valve<br>• Quick Exhaust Valve with Quick coupler plug, Double Acting Cylinder (DAC) with Quick coupler socket, Single Acting Cylinder (SAC), Swivel fitting assembly with Quick coupler plug<br>• Aluminum Profile Table Top, Profile Table Top, Miniature Double Acting Cylinder (DAC), Single Solenoid Valve with Spring Return, Double Solenoid Valve (with LED)<br>• Magnetic Reed Switch, Relay Logic Unit – 2C/0-3 relays, Electrical Push Button Unit, Electrical Selector Switch Unit (Black Selector – 1 no, Green Push Button – 1 no), Timer, Simulation software | 18 |
| 13. | Advanced Electro - Hydraulic and Electro - Pneumatic Hardware systems with work stations and simulationsoftware | • Electro - Hydraulic and Electro - Pneumatic Hardware systems with PLC and simulation software<br>Profile plate, Frame with Castor Wheels, Filter, Lubricator, Regulator with pressure gauge, Hand Slide Valve, Connection component set, Plastic Tubing, Power Supply & cables, Pressure Gauge, 3/2 Way double solenoid valve | 18 |
| 14. | Output devices | Servomotor, DC motor, AC motor, stepper motor, Conveyer Belt<br>control by PLC, water level control etc. | 18,19,20 |
| 15. | Thermal actuators | Hot-And-Cold-Arm Actuators, Chevron-Type Actuators | 21 |
| 16. | Magnetic actuators | Moving Coil Controllable Actuators, Moving Iron Controllable Actuator | 21 |

| S. No. | Name of Equipment, Tools and Software | Broad Specifications | Relevant Experiment/Practical Number |
|---|---|---|---|
| 17. | Open and closed loop control system kit | Open and closed loop system kit should be able to measure the output response using CRO | 22 |
| 18. | First and second order control system | First and second order system with input and output terminals provision | 23,24 |
| 19. | Process control system with feed forward path kit | Process control system with feed forward path kit with input and output terminals provision | 22 |
| 20. | PID Controller Test Bench | PID Controller Test Bench is a complete setup to control process through two-point (on/off) and three-point (PID) controllers. Industrial PID controller with RS485 communication facility, Thermocouple temperature sensor, Float switch for detection of water level, Temperature measurement and control, User friendly software, USB Interface, Heavy duty Test bench, Electrical control panel, Leak proof sturdy piping and tanks, SS Sump tank for inlet and outlet of water, Enhanced electrical safety considerations, Caster wheel (with locking mechanism) at the legs of Testbench for easy movement. | 25,26 |

## 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,ISBN13: 9781401884260 |
| 2. | Programmable Logic Controllers | Petruzella, F.D. | McGraw Hill India, New Delhi, 2010, ISBN:9780071067386 |
| 3. | Programmable Logic Controllers | Hackworth, John; 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, Madhu Chandra;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. Process Automation Control- online Tutorial: www.pacontrol.com
2. PLC product: www.seimens.com
3. www.ab.rockwellautomation.com
4. PLC product: www.abb.co.in
5. Different product of PLC and Peripherals, Smart Tile CPU Board, All in one lighting energy controller, Classic PLC www.triplc.com
6. Simulation software:http://plc-training-rslogix-simulator.soft32.com/free-download/
7. Simulator :www.plcsimulator.net/
8. https://www.youtube.com/watch?v=y2eWdLk0-Ho&list=PLln3BHg93SQ_X5rPjqP8gLLxQnNSMHuj-
9. https://www.youtube.com/watch?v=86CrhxgAKTw

**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
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

*****

**A) Course Code : 2400504G(T2400504G/P2400504G/S2400504G)**

**B) Course Title :** Electric Vehicle (Basic)

**C) Prerequisite Course(s) :**

**D) Rationale :**

Fossil fuel consumption and its adverse impact on the environment have led most nations in the world to adopt electric vehicles for mobility. Most automobile companies are switching from internal combustion engines to electric, a cleaner, and more sustainable alternative. But, in the present scenario, the automobile industries are facing a shortage of skilled technicians needed for the transition to electric drives as the primary source of motive power. There is a huge skill gap between industry and academia when it comes to the task of taking the entire automobile industry towards electric mobility. Therefore, this basic course on an electric vehicle is included in the curriculum of the diploma programme as an open elective course to fill this gap and gain a basic understanding of the importance and necessity of electric vehicles. This course tends to enable participants with multidisciplinary exposure and give them a brief idea about electric vehicles, and their importance. This course gives some basic technical foundations regarding electric vehicles to help them move on to advanced electric vehicle courses.

**E) Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of the 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 student will be able to-**

**CO-1** Classify the EVs based on configurations.

**CO-2** Identify relevant Motors for the given EV application.

**CO-3** Test the performance of batteries used for EV applications.

**CO-4** Distinguish between the EV Charging stations based on their Configurations.

**CO-5** Follow regulatory requirements and policies for EV Industry.

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

| Course Outcomes (COs) | Programme Outcomes (POs) | | | | | | | Programme Specific Outcomes* (PSOs) | |
|---|---|---|---|---|---|---|---|---|---|
| | **PO-1** Basic and Discipline-Specific Knowledge | **PO-2** Problem Analysis | **PO-3** Design/ Development of Solutions | **PO-4** Engineering Tools | **PO-5** Engineering Practices for Society, Sustainability and Environment | **PO-6** Project Management | **PO-7** Life Long Learning | **PSO-1** | **PSO-2** |
| **CO-1** | 3 | 2 | - | 2 | 2 | - | 3 | | |
| **CO-2** | 3 | 2 | 2 | 2 | 2 | 1 | 3 | | |
| **CO-3** | 2 | 2 | 3 | 3 | 2 | 2 | 3 | | |
| **CO-4** | 2 | 2 | 1 | 2 | 2 | 1 | 2 | | |
| **CO-5** | 1 | 1 | - | - | 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 | | | | |
| **2400504G** | Electric Vehicles (Basic) | 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) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory Assessment (TA) | | Term Work & Self-Learning Assessment (TWA) | | Lab Assessment (LA) | | Total Marks (TA+TWA+LA) |
| | | Progressive Theory Assessment (PTA) | End Theory Assessment (ETA) | Internal | External | Progressive Lab Assessment (PLA) | End Laboratory Assessment (ELA) | |
| **2400504G** | Electric Vehicles(Basic) | 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: T2400504G

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number (s) |
|---|---|---|
| TSO 1a. Identify the types of the vehicle based on the physical features, specification data and information.<br>TSO 1b. State the advantages of EVs over Conventional IC Engine Vehicles.<br>TSO 1c. Identify different components of Electric Vehicle systems<br>TSO 1d. Explain the functions of different components of the EV | **Unit-1.0 Introduction to Electric Vehicle**<br><br>Review of Conventional Vehicle Engine System<br>Electric Vehicle (EV)<br>• The necessity of Electric Vehicle<br>• Types of Electric Vehicles<br>- Plug-in hybrid<br>- Battery electric vehicle<br>- Hybrid electric vehicle<br>- Fuel Cell Electric Vehicle<br>• Advantages of Electric Vehicles<br>Electric Vehicle Components: Motor, Motor Controller, Battery, Battery Management System, and Charging System. | **CO1** |
| TSO 2a. Explain the general characteristics of motors used in EV<br>TSO 2b. List different types of motors used in EV<br>TSO 2c. Explain the working principles of motors used in EV applications<br>TSO 2d. Interpret the nameplate ratings of the motors for EV applications.<br>TSO 2e. Explain the motor selection criteria for particular EV applications.<br>TSO 2f. Describe the Mechanical and Electrical Connections of Motors. | **Unit-2.0 Electric Motors used in EVs**<br><br>Electric Motors for EV applications<br>• General Characteristics of motors<br>• Types of Motors: DC, Brushless DC, Induction, Permanent Magnet Synchronous Motors, Switched ReluctanceMotors<br>Rating of Motors<br>Selection Criteria<br>Physical Location<br>Connection of Motors: Mechanical Connections and Electrical Connections | **CO2** |
| TSO 3a. List the batteries used in EVs for energy storage<br>TSO 3b. State various parameters related to batteries used in EV applications.<br>TSO 3c. Explain the charging and discharging process of the given batteries.<br>TSO 3d. Explain the salient features of Lithium Ion batteries<br>TSO 3e. Explain the Fuel Cell Storage System.<br>TSO 3f. Identify various sensors installed for monitoring Battery condition.<br>TSO 3g. Explain Battery Management System in EV using Block Diagram.<br>TSO 3h. **Describe the procedure of battery Disposal andRecycling** | **Unit- 3.0 EV Batteries and Energy Storages**<br><br>Types of Batteries: Lead Acid, Nickel Based, Lithium Based<br>Battery Parameters<br>Charging (AC) and Discharging (DC) Process<br>Lithium Ion Batteries<br>Fuel Cells, Fuel Cell Storage System<br>Battery Condition Monitoring<br>Battery Management System (BMS)<br>• Need of BMS<br>• Block Diagram of BMS<br>**Battery Disposal and Recycling** | **CO3** |
| TSO 4a. Identify different types of diodes and transistors.<br>TSO 4b. Describe the testing procedure for the given Diode and Transistor.<br>TSO 4c. Explain the working principles of the given power electronic converter circuit.<br>TSO 4d. Describe the types of Charging Systems<br>TSO 4e. Describe different Components of the Charging System | **Unit- 4.0 EV Charging Systems**<br><br>Power electronics in EV<br>• Power electronics components<br>• Rectifiers<br>• DC to DC Converter<br>• DC to AC Converter<br>Charging System<br>• Types of charging Systems | **CO4** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number (s) |
|---|---|---|
| TSO 4f. Explain the working of the Charging System using a single-line diagram. | • Components of Charging Systems<br>• Single line Diagram of Charging System | |
| TSO 5a. Understand the Rules and Regulations set by the Government for selecting and manufacturing various components of an electric vehicle.<br>TSO 5b. Understand the Policies for E-Vehicles.<br>TSO 5c. **Appreciate the importance of the reduction of greenhouse gases in the environment.** | **Unit- 5.0 Regulatory Requirements and Policiesfor EV Industry**<br>Rules and Regulations set by the Indian government for the designer/manufacturer of EVs.<br>Policies in India<br>Global Policies for E- Vehicles.<br>**Carbon Footprint Issues** | **CO5** |

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

## K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400504G

| Practical/Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment/Practical Titles | Relevant COs Number (s) |
|---|---|---|---|
| LSO 1.1 Use the relevant digital meter for the given application.<br>LSO 1.2 Use a measuring instrument for the given application.<br>LSO 1.3 Use safety kits while working in the laboratory. | 1. | • Practice using digital meters such as AC, DC Clamp Meters, Digital Multimeters, Lux Meters, etc.<br>Practice using Screw Driver Kit, Vernier Caliper, Micrometer, Ampere Meter, Voltage Meter, andTechno-meter.<br>Practice using safety kits. | CO1 |
| LSO 2.1 Identify the motors used in EV applications<br>LSO 2.2 Identify the given motor terminals | 2. | • Identification of motors used in EVs | CO2 |
| LSO 3.1 Identify the batteries available in the laboratory.<br>LSO 3.2 Measure an open circuit voltage of the given battery.<br>LSO 3.3 Determine the Ampere -Hour Capacity of the given battery with a given load.<br>LSO 3.4 Test the performance of the given battery with different charging rates and at different ambient temperatures<br>LSO 3.5 Demonstrate the effect on the state of health of the battery after several charge/ discharge cycles.<br>LSO 3.6 Evaluate the temperature cut-off point for the given BMS. | 3. | • Testing of Batteries used in EVs<br>• Battery Management System | CO3 |
| LSO 4.1 Identify the Electrical & Electronics components available in the laboratory using Digital Multimeters.<br>LSO 4.2 Test the given power electronic components using digital meters<br>LSO 4.3 Identify the given Power Electronic Circuits used in EVs<br>LSO 4.4 Identify the components of the Charging System<br>LSO 4.5 Recognize the types of Charging Systems available in the Laboratory | 4. | • Power electronic circuits<br>• Identification of Charging systems | CO4 |

**L)** **Suggested Term Work and Self-Learning: S2400504G** 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. Collect the information related to the performance of different types of electric vehicles and prepare a comparative report on economic and environmental analysis.
2. Collect specifications of different EVs available in the market.
3. Build and test a prototype circuit of converters used in an electric vehicle.
4. Visit a nearby Electric vehicle showroom or service centre & collect information on different types of motors used in electric vehicles and prepare a comparative report on their performance,
5. Visit a nearby charging station and prepare a report describing the layout and components of the charging station.

**c. Other Activities:**

1. **Seminar Topics**:
   - Communication Systems, Sensors and batteries used in EVS.
   - Technological advances in Evs
   - Comparison of EVs manufactured by different companies.

2. **Surveys** – Survey the market and gather information on the electric vehicle manufacturers and submit the report.

3. **Product Development**- Develop an electric vehicle prototype using locally procured hardware components.

**d. Self-Learning Topics:**

- Global Manufacturers of EV
- Indian Manufacturers of EV
- Motors used in EV
- Batteries used in EV
- Cost comparison of EVs in market

**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) 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% | -- | 33% | 10% | 20% |
| **CO-2** | 20% | 20% | 20% | -- | 33% | 15% | 20% |
| **CO-3** | 20% | 30% | 20% | -- | 34% | 15% | 20% |
| **CO-4** | 20% | 25% | 20% | 50% | -- | 30% | 20% |
| **CO-5** | 20% | 10% | 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 (Cl) Hours | Relevant COs Number (s) | Total Marks | ETA (Marks) | | |
|---|---|---|---|---|---|---|
| | | | | Remember (R) | Understanding (U) | Application & above (A) |
| **Unit-1.0** Introduction to Electric Vehicle | 8 | CO1 | 12 | 3 | 5 | 4 |
| **Unit-2.0** Electric Motors used in EVs. | 10 | CO2 | 14 | 4 | 5 | 5 |
| **Unit- 3.0** EV Batteries and Energy Storages. | 14 | CO3 | 20 | 5 | 7 | 7 |
| **Unit- 4.0** EV Charging Systems | 10 | CO4 | 15 | 5 | 6 | 4 |
| **Unit- 5.0** Regulatory Requirements and Policies for EV Industry | 6 | CO5 | 9 | 3 | 4 | 3 |
| **Total Marks** | **48** | | **70** | **20** | **27** | **23** |

**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. No. | Laboratory Practical Titles | Relevant COs Number(s) | PLA/ELA | | |
|---|---|---|---|---|---|
| | | | Performance | | Viva-Voce (%) |
| | | | PRA* (%) | PDA** (%) | |
| 1 | Practice using digital meters such as AC, DC Clamp Meters, Digital Multimeters, Lux Meters, etc. | CO1 | 90 | - | 10 |
| 2 | Practice using Screw Driver Kit, Vernier Caliper, Micrometer, Ampere Meter, Voltage Meter, andTechno-meter. | | | | |
| 3 | Practice using safety kits. | | | | |
| 4 | Identification of motors used in EV | CO2 | 60 | 30 | 10 |
| 5 | Testing of Batteries used in EVs | CO3 | 60 | 30 | 10 |
| 6 | Battery Management System | | | | |
| 7 | Power electronic circuits | CO4 | 30 | 60 | 10 |
| 8 | Identification of Charging systems | | | | |

**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 beprepared 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, Labs, and 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. | AC, DC Clamp Meters | Application: Non-contact AC/DC Voltage and Current measurement<br>**AC Application:** Current: 0-200Amp, Voltage: 0-600Volt<br>**DC Application:** Current: 4-20mA, Voltage: 0-30Volt. | 1 |
| 2. | Digital Multimeters | Display: 4 ½ digit<br>Indications: overload protection, polarity indication, over range indication.<br>Auto range change and auto polarity change facility, auto display of polarity and decimal point.<br>**DC**: Volt: 200mV-600V, Current: 200mA-2A<br>**AC**: Volt: 200mV-1000V, Current: 200mA-2A<br>Resistance: 200W-20mW, Power supply: 230V, 50Hz<br>Battery operation: 9 Volt battery<br>Electronic components testing facility should be provided in the Multimeter.<br>A provision for an A.C. adaptor(eliminator) must be available along with the multimeter. | 1, 3 |
| 3. | Lux Meters | Functions: MAX / MIN, Backlight, Auto Power Off<br>Range: 0 ~ 200,000 lux 0 ~ 20,000 fc<br>Accuracy: ± 5% rdg + 10 dgt (< 10.000 lux / fc) ± 10% rdg + 10 dgt (>10.000 lux / fc)<br>Resolution: 0.1 lux or 0.1 fc<br>Accessories: Carrying Case, Installation Manual, 9V Battery (installed). | 1 |
| 4. | Screw Driver toolbox | All types of screw drive sets. | 1 |
| 5. | Vernier Caliper | **Range:**<br>Lower scale: 0-200mm, Upper Scale: 0-12inch<br>**Vernier Resolution:**<br>Lower Scale: 0.02mm, Upper Scale: 0.001inch | 1 |
| 6. | Micrometer | 0-25mm (inside/outside) | 1 |
| 7. | Ampere Meter | Moving iron and Moving Coil | 1 |
| 8. | Voltmeter | AC(0-250V)/DC(0-24V) | 1 |

| S. No. | Name of Equipment, Tools and Software | Broad Specifications | Relevant Experiment/Practical Number |
|---|---|---|---|
| 9. | Tachometer | For speed measurement (0-3000rpm) | 1 |
| 10. | Resistors | Low-value Resistors of different types | 1,4 |
| 11. | Capacitors | Low-value electrolyte Capacitors. | 1,4 |
| 12. | Inductors | Low-value inductors. | 1,4 |
| 13. | Safety Kit | First Aid Kit, Helmet, Face Mask, Gloves etc. | 1 |
| 14. | Motors for Electric Vehicle application | Brushless DC, Induction, Permanent Magnet Synchronous Motors, Switched Reluctance Motors | 2 |
| 15. | EV Machine Cut-out section | for demonstration & training | 2 |
| 16. | EV mock layout | for demonstration & training | 2 |
| 17. | Lithium Ion Battery | 12V, 7Ah | 3 |
| 18. | Lead-acid battery | 12V, 7Ah | 3 |
| 19. | Nickel-based batteries (metal hydride and cadmium battery). | 12V, 7Ah | 3 |
| 20. | Battery internal resistance meter | For O.C. voltage & internal battery resistance of each cell | 3 |
| 21. | Cell Capacity tester | Up to 15V batteries and 3A load current,<br>10mV voltage and 1mA current resolution,<br>Automatic detection of termination voltage,<br>LED display with a 3-button interface. | 3 |
| 22. | BMS setup | For Demonstration & training | 3 |
| 23. | DC power supply | 0-32V | 3 |
| 24. | Power diodes | Power diodes of different current values. | 1, 4 |
| 25. | Transistors | Power Transistors (NPN, PNP) for Low-frequency high-power applications. | 1,4 |
| 26. | Voltage Sensors | 0-12 Volts. | 1,3,4 |
| 27. | Current Sensors | Volts: + 15v, 0-5v, Current: 4-20mA. | 1,3,4 |
| 28. | Converter Models | DC to DC and DA to AC converter model | 4 |
| 29. | Charging Station Simulator | For Demonstration & training purposes. | 4 |
| 30. | EV Technology layout 3D posterwith frame | Fuel cell, EV- Charging Systems, HEV, FCEV, Motors & Controllers etc. | 3,4 |

## R) Suggested Learning Resources:

### (a) Books:

| S. No. | Titles | Author (s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 1. | Handbook on Electric Vehicles Manufacturing (E-Car, Electric Bicycle, E- Scooter, E-Motorcycle, Electric Rickshaw, E- Bus, Electric Truck with Assembly Process, Machinery Equipment's &Layout) | P.K. Tripathi | Niir Project Consultancy Services; 1st edition (1 January 2022) ISBN-13: 978-8195676927 |
| 2. | Electric Vehicles: And the End of the ICE age | Anupam Singh | Kindle Edition ASIN: B07R3WFR28 |
| 3. | 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) ISBN-13: 978-9811683473 |
| 4. | Modern Electric, Hybrid Electric, and Fuel Cell Vehicles | EHSANI | CRC Press; Third edition (1 January 2019) ISBN-13: 978-0367137465 |
| 5. | 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) ISBN-13: 978-1119063643 |
| 6. | New Perspectives on Electric Vehicles | Marian Găiceanu (Editor) | IntechOpen (30 March 2022) ISBN-13: 978-1839696145 |

### (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

**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
2. Users' Guide
3. Manufacturers' Manual
4. Lab Manuals

******

**A) Course Code : 2400504H(T2400504H/P2400504H/S2400504H)**

**B) Course Title :** Robotics (Basic)

**C) Pre- requisite Course(s) :**

**D) Rationale :**

Currently, industries demand non-stop and fine quality work in different processes used. It is difficult for the human beings to give same quantity and quality of work with respect to time, environment and complexity of the work in any process industry. To get quality and quantity of work in toughest environment or the environment which is not suitable for the humans to work, industries demand for robots and its operator. Operators who w i l l operate these robots need some basic knowledge of robotics. To fulfill the need of industries and looking to the advancement in technology, this course aims for the diploma engineers to have knowledge and skills in robotics.

**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 robots for given applications employing basic concepts of design and functions of robots.

**CO-2** Interpret co-ordinate systems and degree of freedom for robots.**CO-**

**3** Use sensors and drives in context of various robotic applications.**CO-4**

Select appropriate robot control techniques,

**CO-5** Use programs to operate robots.

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

| Course Outcomes (COs) | Programme Outcomes(POs) | | | | | | | Programme Specific Outcomes* (PSOs) | |
|---|---|---|---|---|---|---|---|---|---|
| | **PO-1** Basic and Discipline Specific Knowledge | **PO-2** Problem Analysis | **PO-3** Design/ Developmentof Solutions | **PO-4** Engineering Tools | **PO-5** Engineering Practices for Society, Sustainability and Environment | **PO-6** Project Management | **PO-7** Life Long Learning | **PSO-1** | **PSO-2** |
| **CO-1** | 3 | - | 3 | - | 2 | 2 | 2 | | |
| **CO-2** | 3 | 2 | 1 | 2 | - | - | - | | |
| **CO-3** | 3 | 2 | 1 | 2 | 2 | - | 2 | | |
| **CO-4** | 3 | 1 | 1 | 2 | - | - | - | | |
| **CO-5** | 3 | 2 | 3 | 3 | 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 | | | | |
| **2400504H** | Robotics (Basics) | 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) | |
| **2400504H** | Robotics (Basic) | 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: T2400504H

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number (s) |
|---|---|---|
| TSO 1a. Explain the basic terms used in robotics<br>TSO 1b. Identify components used in robots.<br>TSO 1c. Explain various types of movements.<br>TSO 1d. Distinguish various robots' configurations and their workspace.<br>TSO 1e. Evaluate the degrees of freedom of the given robot.<br>TSO 1f. Specify the methods of conversion of the given linear motion into rotary motion and vice-versa.<br>TSO 1g. List the criteria for selecting robot for the given simple application with justification. | **Unit-1.0 Basics of Robotics Systems**<br>1.1 Definition, need, brief history of robotics<br>1.2 Basic Robot terminology, configuration and its working<br>1.3 Robot components overview - Manipulator, End effecters, Drive system, Controller, Sensors<br>1.4 Basic structure of a Robot and Classification – Cartesian, Cylindrical, Spherical, Horizontal articulated (SCARA), Parallel; Mechanic al arm, Degree of freedom, Links and joints, Wrist rotation, Mechanical transmission- pulleys, belts, gears, harmonic drive (gear box)<br>1.5 Linear and Rotary motion and its devices<br>1.6 Selection criteria for robots | **CO1, CO2** |
| TSO 2a. Explain the working of various types of End effecters used in robots with diagram.<br>TSO 2b. Explain with sketches the function of the given sensing device used in a robot.<br>TSO 2c. Describe working of the given sensor used in robot.<br>TSO 2d. Explain the given robot configuration.<br>TSO 2e. Select relevant robot sensors for a given application with justification.<br>TSO 2f. Describe robot machine vision concepts along with block diagram of robot vision system.<br>TSO 2g. Select vision equipment for a given robotic application. | **Unit– 2.0 Robot Components**<br>2.1 End effecters: types, sketches, working and applications<br>2.2 Sensing and Feedback devices: Optical sensors, Proximity sensors, LVDT, Thermocouple, RTD, Thermistor, Force sensing – strain gauge, Piezoelectric, Acoustic sensing Feedback devices; Potentiometers; Optical encoders; DC tachometers;<br>2.3 Robot machine vision: Block diagram of robot vision system, Vision equipment- camera, Imaging Components: Point, Line, Planar and Volume Sensors, Image processing, Part recognition and range detection | **CO3** |
| TSO 3a. Explain with sketches the function of the specified actuator used in a robot.<br>TSO 3b. Differentiate between open loop and closed loop systems.<br>TSO 3c. Explain various robotic controls.<br>TSO 3d. Describe block diagrams of the given control system.<br>TSO 3e. Specify drive system used for robotic control as per requirement.<br>TSO 3f. Differentiate the various robot path | **Unit– 3.0 Robotic Drive System and Controller**<br>3.1 Actuators; Hydraulic, Pneumatic and Electrical drives; linear actuator; Rotary drives<br>3.2 Control systems: Open loop and close loop with applications and its elements, Servo and non-servo control systems – Types, basic principles and block diagram Robot controller; Level of Controller | **CO4** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number (s) |
|---|---|---|
| controls.<br>TSO 3g. Justify the selection of actuators, drives, control system, AC servo motor and path control for making of a robot. | 3.3 AC servo motor; DC servo motors and Stepper motors;<br>3.4 Robot path control: Point to point, Continuous path control and Sensor based path control | |
| TSO 4a. Explain various robot programming languages.<br>TSO 4b. Programme robot for a given simple job.<br>TSO 4c. Describe the procedure to simulate the given robot movements using the relevant software. | **Unit– 4.0 Introduction to Robot Programming**<br>4.1 Need and functions of programming<br>4.2 Methods of robot programming: Manual Teaching, Teach Pendant, Lead through, Programming languages. Programming with graphics.<br>4.3 Programming languages: Types, features and applications<br>4.4 Controller programming<br>4.5 Simulation for robot movement | **CO5** |
| TSO 5a. Select a robot for the given application.<br>TSO 5b. Describe various applications of Robotics.<br>TSO 5c. Explain safety norms in robot handling.<br>TSO 5d. Describe maintenance procedure for the given robot.<br>TSO 5e. Describe common problems in robot operations and suggest remedial action. | **Unit– 5.0 Robotics Applications and Maintenance aspects**<br>5.1 Application robots including special types<br>5.2 Robot maintenance: Need and types<br>5.3 Common troubles and remedies in robot operation.<br>5.4 General safety norms, aspects and precautions in robot handling | **CO1, CO2, CO3, CO4** |

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

## K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400504H

| Practical/Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment/Practical Titles | Relevant COs Number (s) |
|---|---|---|---|
| LSO 1.1 Identify parts of Robot on the basis of function.<br>LSO 1.2 Identify joint type & link parameters (link length, link twist, and Link offset), rotational vs. linear motion, used in robot. | 1. | Identify components and different configurations of robots. | CO1 |
| LSO 2.1Identify different types of robot end effecters.<br>LSO 2.2 Use Mechanical grippers to hold objects.<br>LSO 2.3 Use Vacuum grippers to hold objects. | 2. | Pick/hold different objects (shape/weight/stiffness) using robot end effecters. | CO1, CO2 |
| LSOs 3.1 Assemble the complete robot using the components as per the procedure<br>LSO 3.2 Apply the functionalities available in rotor trainer kit.<br>LSO 3.3 Test for various configurations.<br>LSO 3.4 Test for various degrees of freedom. | 3. | Assemble robot to test various configurations and degrees of freedom using robot trainer kit. | CO1, CO2 |
| LSO 4.1 Identify various types of sensors used in robotic application.<br>LSO 4.2 Measure angular motion using Synchro's.<br>LSO 4.3 Detect objects using optical sensors. | 4. | Use different types of robotic sensors for a specific situation. | CO3 |

| Practical/Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment/Practical Titles | Relevant COs Number (s) |
|---|---|---|---|
| LSO 5.1 Interface stepper motor.<br>LSO 5.2 Control robot with stepper motor interfacing. | 5. | Perform robot control with stepper motor interfacing | CO3 |
| LSO 6.1 Draw the labelled sketch of individual parts and robot arm.<br>LSO 6.2 Assemble the arm using the parts as per the procedure.<br>LSO 6.3 Interface the motor drive and operate. | 6. | Assemble robot arms using mechanical transmission components and interface motor drive. | CO2, CO3 |
| LSO 7.1 Use open source or available relevant software to develop pick and place programme.<br>LSO 7.2 Perform simulation. | 7. | Perform pick and place operation using Simulation Control Software. | CO5 |
| LSO 8.1 Develop programme for using a robot arm with three degrees of freedom.<br>LSO 8.2 Execute the programme. | 8. | Perform 2D simulation of a 3 DOF robot arm. | CO2, CO4, CO5 |
| LSO 9.1 Apply stepper motor control with direction control and step control logic simulation.<br>LSO 9.2 Perform basic PLC programming<br>LSO 9.3 Develop ladder logic programs<br>LSO 9.4 Use programming timers | 9. | Programme 5-axis Robotic arm to control various motions. | CO3, CO4, CO5 |
| LSO 10.1Develop a program for a simple application.<br>LSO 10.2 Execute the robot programme. | 10. | Program to execute a simple robot application (like painting, straight welding) using a given configuration. | CO4, CO5 |

**L) Suggested Term Work and Self Learning: S2400504H** 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 stair climb robot using robotic components.
2. Develop RF controller robot using robotic components.
3. Develop robot for metal detection application using robotic components.
4. Develop line follower robot using robotic components.
5. Develop solar floor cleaner robot using robotic components.
6. Develop solar tracker system using robotic components.
7. **Develop a greenhouse managing robot for a horticulture application.**

**c. Other Activities:**

1. Seminar Topics: Recent developments in the field of robotics
2. Visits: Visit an automation industry and prepare report for various types of robots employed there and details of any one type of special purpose robot used
3. Case Study: Identify a robotic application in automobiles and present a case study
4. Self-Learning Topics:
   - History of industrial robot
   - Sociological consequences of Robots

**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) 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% | 29% | 20% | 10% | 25% | 10% | 20% |
| **CO-2** | 20 % | 23% | 20% | 10% | 25% | **20%** | 20% |
| **CO-3** | 20% | 17% | 20% | 25% | 25% | **20%** | 20% |
| **CO-4** | 20% | 14% | 20% | 15% | 25% | **20%** | 20% |
| **CO-5** | 15% | 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 (Cl) Hours | Relevant Cos Number (s) | Total Marks | ETA (Marks) | | |
|---|---|---|---|---|---|---|
| | | | | Remember (R) | Understanding (U) | Application & above (A) |
| **Unit-1.0** Basics of Robotics Systems | 10 | CO1, CO2 | 20 | 7 | 8 | 5 |
| **Unit– 2.0** Robot Components | 12 | CO2, CO3 | 16 | 3 | 9 | 4 |
| **Unit– 3.0** Robotic Drive System and Controller | 10 | CO3, CO4 | 12 | 4 | 4 | 4 |
| **Unit– 4.0** Introduction to Robot Programming | 8 | CO5 | 10 | 2 | 5 | 3 |
| **Unit– 5.0** Robotics Applications and Maintenance aspects | 8 | CO1, CO2, CO3, CO4 | 12 | 4 | 4 | 4 |
| **Total Marks** | **48** | | **70** | **20** | **30** | **20** |

**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 components and different configurations of robots. | CO1 | 30 | 60 | 10 |
| 2. | Pick/hold different objects (shape/weight/stiffness) using robot end effecters. | CO1, CO2 | 60 | 30 | 10 |
| 3. | Assemble robot to test various configurations and degrees of freedom using robot trainer kit. | CO1, CO2 | 70 | 20 | 10 |
| 4. | Use different types of robotic sensors for a specific situation. | CO3 | 60 | 30 | 10 |
| 5. | Perform robot control with stepper motor interfacing | CO3 | 70 | 20 | 10 |
| 6. | Assemble robot arms using mechanical transmission components and interface motor drive. | CO2, CO3 | 60 | 30 | 10 |
| 7. | Perform pick and place operation using Simulation Control Software. | CO5 | 70 | 20 | 10 |
| 8. | Perform 2D simulation of a 3 DOF robot arm. | CO2, CO4, CO5 | 60 | 30 | 10 |
| 9. | Programme 5-axis Robotic arm to control various motions. | CO3, CO4, CO5 | 60 | 30 | 10 |
| 10. | Program to execute a simple robot application (like painting, straight welding) using a given configuration. | CO4, 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, 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 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. | Programmable Robot trainer kit | Trainer kit with - Minimum 3 linkages, Minimum 4 degree of freedom, Mechanical end effecter with servo control, interfacing card (RC servo output, sensors input) | 1,2,3 |
| 2. | Robotic Arm Control Trainer Kit | Robotic Arm with five axis control application through PLC.; PLC; Digital Inputs: 8 Nos with 4mm banana sockets for getting the external inputs; Digital Outputs: 6 Nos with 4mm banana sockets for applying the inputs; Digital Input Controls: On board Toggle switches, Push Buttons & input potentiometers; Digital Outputs Controls: 6 nos. | 8,9 |

| S. No. | Name of Equipment, Tools and Software | Broad Specifications | Relevant Experiment/ Practical Number |
|---|---|---|---|
| | | on board LED indicators; PC interfacing facility through RS-232. | |
| 3. | Proximity trainer kit | Indicator Type:LED; PCB Type Glass Epoxy SMOBC PCB; Interconnections**:** 2mm banana Patch cords; On board DC motor to see the application of Proximity sensor. Test points to analyse the signal On board variable supply to vary the speed of DC motor. ON/OFF switch and LED for power indication. All interconnections to be made using 2mm banana Patch cords. User manual and patch cords. Built-in power supply. Robust enclosure wooden/plastic box. | 4 |
| 4. | Robot - Line Tracking Mouse Kit | Product Dimensions (20.3 x 11.4 x 8.9 cm); programmed IC, 2 unassembled gear motors, printed circuit boards, mouse-shaped plastic body, necessary components and wires, step-down power converter | 3, 4,5 |
| 5. | Intelligent Robot Actuator Modu | 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 aluminium, 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 |
| 6. | 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 programs. NV330; 8 bit microcontroller to ARM processors**;** Record and Play capability**;** Optional interfacing with PL**C;** Touch operated ON/OFF switch**;** Auto set to home position**;** Applications can be developed**;** Data acquisition using USB | 3, 4, 5 |
| 7. | Robotic Drive System | AC servo motor; DC servo motors, Stepper motors; DC tachometers, etc. | 1,3,5,6,7,10 |
| 8. | Robot simulator for Robotics | Educational networking licensed Robotic system with simulation software | 8, 10 |
| 9. | Assorted sensors | Optical encoders, Acoustic sensors ,IR, Potentiometer, RTD, Thermistor, strain gauge, piezoelectric, etc | 4 |
| 10. | Vision equipment | Camera, Imaging Components: Point, Line, Planar and Volume Sensors | 1, 4,10 |

## 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; 978-9356062191 |
| 2. | Industrial Robotics -Technology, Programming and Applications | Nicholas Odrey Mitchell Weiss, Mikell Groover Roger Nagel, Ashish Dutta | McGraw Hill Education; 2nd Edition; 978 -1259006210 |
| 3. | Robotic engineering: an integrated approach | Richard D. Klafter, Thomas A. Thomas A. Chmielewski, Michael Negin | Prentice Hall of India, N.Delhi , 978-8120308428 |
| 4. | Industrial Robotics Technology, Programming and Applications | Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey | McGraw-Hill Education, Second Edition, 978-1259006210 |
| 5. | Robotics | Appuu Kuttan K. K. | Dreamtech Press, First Edition, 2020, 978-9389583281 |
| 6. | Introduction to Robotics: Analysis, Control, Applications | Saeed B. Niku | Wiley; Second Edition, 978-8126533121 |
| 7. | Essentials of Robotics Process Automation | S. Muhkerjee | Khanna Publication, First edition, 978-9386173751 |
| 8. | Robotics | R R Ghorpade, M M Bhoomkar | Nirali Prakashan 978-9388897020 |

### (b) Online Educational Resources:

1. https://archive.nptel.ac.in/courses/112/105/112105249/
2. https://openlearning.mit.edu/mit-faculty/residential-digital-innovations/task-centered-learning-intro-eecs-robotics
3. http://www.mtabindia.com/
4. http://www.robotics.org/
5. https://en.wikipedia.org/wiki/Industrial_robot
6. http://www.servodatabase.com
7. https://www.youtube.com/watch?v=fH4VwTgfyrQ
8. https://www.youtube.com/watch?v=aW_BM_S0z4k
9. https://uk.rs-online.com/web/generalDisplay.html?id=ideas-and-advice/robotic-parts-guide
10. https://www.automate.org/industry-insights/smarter-robot-grasping-with-sensors-software-the-cloud
11. https://www.iqsdirectory.com/articles/machine-vision-system.html

**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**

- 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/9a0dacfdec8aa03dc12578ca003bfd2a/Learn%20with%20ABB.%20Robotic%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
- https://www.jnec.org/labmanuals/mech/be/sem1/Final%20Year%20B.Tech-ROBOTICS%20LAB%20%20MANUAL.pdf

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**A) Course Code** : **2400504I(T2400504I/P2400504I/S2400504I)**

**B) Course Title** : Transformer Manufacturing and Repairing (Basics)

**C) Pre- requisite Course(s)** : Electric Motors and Transformers

**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 course will pave the way to understand the concepts of manufacturing and repair of transformers. The knowledge gained through this course will help the students choose their career in transformer 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** Explain the fundamental working principles of a transformer.

**CO-2** Explain the different types of construction and cooling mechanism.

**CO-3** Analyze the different vector groups in practical power transformers and their connections.

**CO-4** Illustrate the different types of transformer protection.

**CO-5** Analyze the different types of tests required for a transformer.

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

| Course Outcomes (COs) | Programme Outcomes (POs) | | | | | | | Programme Specific Outcomes* (PSOs) | |
|---|---|---|---|---|---|---|---|---|---|
| | **PO-1** Basic and Discipline Specific Knowledge | **PO-2** Problem Analysis | **PO-3** Design/ Development of Solutions | **PO-4** Engineering Tools | **PO-5** Engineering Practices for Society, Sustainability and Environment | **PO-6** Project Management | **PO-7** Life Long Learning | **PSO-1** | **PSO-2** |
| **CO-1** | 3 | 3 | - | - | - | - | 3 | | |
| **CO-2** | 3 | 1 | - | - | 2 | - | 3 | | |
| **CO-3** | 3 | 2 | 2 | - | - | - | 3 | | |
| **CO-4** | 3 | 3 | 2 | 2 | 1 | - | 3 | | |
| **CO-5** | 3 | 3 | - | 2 | 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 | | | | |
| 2400504I | Transformer Manufacturing and Repairing (Basic) | 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) | |
| 2400504I | Transformer Manufacturing and Repairing (Basic) | 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: T2400504I

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| *TSO 1a.* Explain the use of transformers in power systems.<br>*TSO 1b.* List the various types of transformers.<br>*TSO 1c.* Explain the exact and approximate equivalent circuits of a transformer.<br>*TSO 1d.* Explain the relations between input and output quantities through phasor diagrams.<br>*TSO 1e.* List the necessity of open and short circuit tests and explain how they should be performed.<br>*TSO 1f.* Explain the concept of voltage regulation and efficiency and list the ways to improve them in transformers. | **Unit-1.0 Transformer Fundamentals**<br>1.1 Use of Transformers.<br>1.2 Types of Transformers.<br>1.3 The equivalent circuit of a transformer.<br>1.4 Phasor Diagrams<br>1.5 Open circuit and short circuit tests.<br>1.6 Voltage regulation and efficiency. | **CO1** |
| *TSO 2a.* Explain the different constructional parts of a transformer.<br>*TSO 2b.* List the different types of core and its construction and sections.<br>*TSO 2c.* Explain the different types of windings and the necessity of insulation.<br>*TSO 2d.* Explain the different types of cooling.<br>*TSO 2e.* List the different tank structure.<br>*TSO 2f.* Explain the necessity of transformer oil. | **Unit-2.0 Transformer Construction**<br>2.1 Constructional Parts.<br>2.2 Core Construction and Core Sections.<br>2.3 Windings and Insulation.<br>2.4 Cooling: Natural Cooling, Forced Oil cooling and Internal Cooling.<br>2.5 Tanks.<br>2.6 Transformer oil. | **CO1, CO2** |
| *TSO 3a.* Explain the different connections and vector groups.<br>*TSO 3b.* Explain the three phase to two phase and three phase to single phase connection.<br>*TSO 3c.* List the different types of tap changing positions.<br>*TSO 3d.* Explain the open delta configuration. | **Unit-3.0 Transformer Operation**<br>3.1 Connection for transformers: star/star, star/delta, delta/star. Zig-zag/star.<br>3.2 Three phase to two phase connections: Scott connection.<br>3.3 Three phase to one phase connection.<br>3.4 Tap changing: On-load and off-load tap changing positions.<br>3.5 Three phase banks of single phase transformers: Open delta configuration. | **CO3, CO4** |
| *TSO 4a.* List the classification of transformer protection.<br>*TSO 4b.* Explain the Buchholz relay and its use in transformers.<br>*TSO 4c.* Explain the different types of transformer protection and the use of indicators in transformers. | **Unit-4.0 Transformer Protection**<br>4.1 Classification of transformer protection.<br>4.2 Buchholz Relay<br>4.3 Differential protection<br>4.4 Over current, Over voltage and surge protection.<br>4.5 Temperature indicators, oil level indicators, oil preservation systems, silica gel breather, gas sealed conservators. | **CO3, CO4** |
| *TSO 5a.* Explain the objectives of testing of transformers.<br>*TSO 5b.* List the different types of tests.<br>*TSO 5c.* Explain different transformer | **Unit-5.0 Transformer Testing**<br>5.1 Objectives of transformer testing.<br>5.2 Polarity Test, DC Resistance and voltage ratio tests. | **CO4, CO5** |

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| tests including the Sumpner's test.<br>*TSO 5d.* Explain the insulation and impulse tests. | 5.3 Magnetizing current and core loss tests.<br>5.4 Temperature rise test, back to back connection.<br>5.5 Insulation and Impulse Tests. | |

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

## K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400504I

| Practical/Lab Session Outcomes (LSOs) | S. No. | Laboratory Experiment/Practical Titles | Relevant COs Number(s) |
|---|---|---|---|
| *LSO 1.1.* Knowledge of performing these tests on LV and HV sides.<br>*LSO 1.2.* Determine the equivalent circuit parameters of a transformer. | 1. | Conduct open circuit and short circuit tests on a transformer | **CO1** |
| *LSO 2.1.* Explain the concept of regulation and efficiency at different loads. | 2. | Perform load tests on a transformer. | **CO1** |
| *LSO 3.1.* Perform Heat run test on a transformer without being subjected to physical load.<br>*LSO 3.2.* Explain the concept of applying rated voltage and rated current through phantom loading. | 3. | Perform the Sumpner's test on two identical transformers. | **CO1** |
| *LSO 4.1.* Understand various three phase transformer connections and vector groups. | 4. | Perform various connections on three phase transformers and understand vector groups. | **CO2** |
| *LSO 5.1.* Explain the Scott connection.<br>*LSO 5.2.* Understand the necessity of conversion. | 5. | Three phase to Two phase connection | **CO3, CO4, CO5** |
| *LSO 6.1.* Understand the necessity of conversion. | 6. | Three phase to single phase connection. | **CO3, CO4, CO5** |
| *LSO 7.1.* Explain the concept of open delta configuration in case of any single phase transformer failure. | 7. | Perform open delta connection from banks of single phase transformers. | **CO3, CO4, CO5** |
| *LSO 8.1.* Explain the concept of CT connections in differential protection.<br>*LSO 8.2.* Understand the working principle of Buchholz Relay. | 8. | Understand the differential protection with different CT connections and the working of Buchholz relay. | **CO3, CO4, CO5** |
| *LSO 9.1.* Explain the concept of dot convention. | 9. | Perform a polarity test on a transformer. | **CO4, CO5** |
| *LSO 10.1.* Understand the transformer's failures. | 10. | Perform the impulse test on a transformer. | **CO5** |

**L) Suggested Term Work and Self Learning: S2400504I** 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.

- Discuss the role of insulation in transformer reliability and longevity.
- Outline the steps involved in the construction of power transformers.
- Discuss the testing procedures to ensure quality and performance standards.
- Explore how environmental factors (temperature, humidity, pollution) affect transformer operation.
- Investigate modern monitoring techniques, including online monitoring systems and diagnostic tools.
- Compare different cooling methods (oil-immersed, air-cooled, water-cooled) and their effectiveness.
- Review recent advancements in transformer protection technologies.
- Discuss the importance of testing for ensuring reliability, efficiency, and safety.

**b. Micro Projects:**

- Simulate and analyze the operation of overcurrent protection relays in a transformer protection system.
- Implement a Buchholz relay for gas detection in oil-filled transformers.
- Design an earth fault protection system for transformers.
- Measure the insulation resistance of transformer windings to ensure insulation integrity.
- Measure the resistance of transformer windings to detect winding issues such as short circuits or open circuits.
- Assess the dielectric strength of transformer oil to ensure effective insulation.
- Build a simple step-up and step-down transformer.
- Investigate the impact of core material and shape on transformer efficiency.

**c. Other Activities:**

1. Seminar Topics:
    - Advancements in Transformer Core Materials
    - Winding Techniques in Transformer Construction
    - Temperature Management and Cooling Techniques
    - Protection Against Transformer Overheating
    - Transformer Oil Testing and Analysis
2. Visits: Visit to nearby transformer repair station and prepare technical report on transformer repair process, observe diagnostic techniques, repair procedures, and quality assurance practices.
3. Self-learning topics:
    - Phenomenon of inrush current in transformers.
    - Causes, effects, and methods to mitigate inrush currents.
    - Arc flash incidents in transformers.
    - Strategies and equipment used to mitigate arc flash hazards.
    - Impact of harmonics on transformer protection systems.
    - Partial discharge testing

**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) 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 (Cl) Hours | Relevant COs Number(s) | Total Marks | ETA (Marks) | | |
|---|---|---|---|---|---|---|
| | | | | Remember (R) | Understanding (U) | Application & above (A) |
| Unit-1.0 **Transformer Fundamentals** | 12 | CO1 | 10 | 3 | 3 | 4 |
| Unit-2.0 **Transformer Construction** | 8 | CO1, CO2 | 10 | 3 | 2 | 5 |
| Unit-3.0 **Transformer Operation** | 8 | CO3, CO4 | 10 | 5 | 2 | 3 |
| Unit-4.0 **Transformer Protection** | 8 | CO3, CO4 | 20 | 5 | 6 | 9 |
| Unit-5.0 **Transformer Testing** | 12 | CO4, CO5 | 20 | 4 | 6 | 10 |
| **Total** | **48** | **-** | **70** | **20** | **19** | **31** |

**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-Voce (%) |
| | | | PRA* (%) | PDA** (%) | |
| 1. | Conduct open circuit and short circuit tests on a transformer | CO1 | 30 | 60 | 10 |
| 2. | Perform load tests on a transformer. | CO1 | 40 | 50 | 10 |
| 3. | Perform the Sumpner's test on two identical transformers. | CO1 | 30 | 60 | 10 |
| 4. | Perform various connections on three phase transformers and understand vector groups. | CO2 | 30 | 60 | 10 |
| 5. | Three phase to Two phase connection | CO3, CO4, CO5 | 30 | 60 | 10 |
| 6. | Three phase to single phase connection. | CO3, CO4, CO5 | 30 | 60 | 10 |
| 7. | Perform open delta connection from banks of single phase transformers. | CO3, CO4, CO5 | 30 | 60 | 10 |
| 8. | Understand the differential protection with different CT connections and the working of Buchholz relay. | CO3, CO4, CO5 | 40 | 50 | 10 |
| 9. | Perform a polarity test on a transformer. | CO4, CO5 | 40 | 50 | 10 |
| 10. | Perform the impulse test on a transformer. | 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. | Transformer, Auto Transformer, Ammeter, Voltmeter, Wattmeter, Multi-meter. | Transformer (1 Phase, 1 kVA HV Side-0-230V & LV:0-115V)-1 QTY Auto-Transformer (0-270 V,5 kVA), Multi-Meter, Voltmeter (0-300 V,0-150 V 0-50 V: -3 Qty), Ammeter (0-5 A,0-10 A,0-1 A:3Qty), Wattmeter (0-300 V,5/10A-3 Qty), Wattmeter (0-150 V,1/2 A-3 QTY), Connecting Wire. | Conduct open circuit and short circuit tests on a transformer |
| 2. | Transformer, Auto Transformer, Ammeter, Voltmeter, Wattmeter, Multi-meter, Load Box | Transformer (1 Phase, 1 kVA HV Side-0-230V & LV:0-115V)-1 QTY Auto-Transformer (0-270 V,5 kVA), Multi-Meter, Voltmeter (0-300 V,0-150 V: -2 Qty), Ammeter (0-5 A,0-10 A,: 2 Qty), Wattmeter (0-300 V,5/10A-2 Qty), Connecting Wire. | Perform load tests on a transformer. |
| 3. | Transformer, Auto Transformer, Ammeter, | Transformer (1 Phase, 1 kVA HV Side-0-230V & LV:0-115V)-2 QTY Auto-Transformer (0-270 V,5 kVA:-2 QTY), Multi-Meter, Voltmeter | Perform the Sumpner's test on two identical |

| S. No. | Name of Equipment, Tools and Software | Broad Specifications | Relevant Experiment/Practical Number |
|---|---|---|---|
| | Voltmeter, Wattmeter, Multi-meter. | (0-300 V,0-150 V 0-50 V: -3 Qty), Ammeter (0-5 A,0-10 A,0-1 A:3Qty),Wattmeter(0-300 V,5/10A-3 Qty),Wattmeter(0-150 V,1/2 A-3 QTY), Connecting Wire. | transformers. |
| 4. | Transformer, Auto Transformer, Ammeter, Voltmeter, Wattmeter, Multi-meter, Load Box | Transformer (1 Phase, 1 kVA ) - 3 Qty, multi-meter, Series Bulb, Connecting Wire, 3 Phase Auto transformer-1 Qty, Connecting Wire. | Perform various connections on three phase transformers and understand vector groups. |
| 5. | Transformer, Auto Transformer, Ammeter, Voltmeter, Wattmeter, Multi-meter, Load Box | 3 Phase Auto transformer, Transformer (1 kVA, 1 Phase)-3 Qty, Ammeter (0-20 A)-5 Qty, Voltmeter (0-500)-2 Qty, Wattmeter (0-300 V,5/10A-2 Qty), 1 Phase Electric Load-2 Qty, Connecting Wire. | Three phase to Two phase connection |
| 6. | Transformer, Auto Transformer, Ammeter, Voltmeter, Wattmeter, Multi-meter, Load Box | 3 Phase Auto transformer-1 Qty, Transformer (1 kVA, 1 Phase)-3 Qty, Ammeter(0-10A)-2 Qty, Voltmeter (0-300/500)-2 Qty, Wattmeter (0-300 V,5/10A-2 Qty), 1 Phase Load, Connecting Wire. | Three phase to single phase connection. |
| 7. | Transformer, Auto Transformer, Ammeter, Voltmeter, Wattmeter, Multi-meter, Load Box | Transformer (1 kVA, 1 Phase)-3 Qty, 3 Phase Load-1 Qty, 3 Phase Auto Transformer -1 Qty. Ammeter(0-10A)-2 Qty, Voltmeter (0-300/500)-2 Qty, Wattmeter (0-300 V,5/10A-2 Qty), | Perform open delta connection from banks of single phase transformers. |
| 8 | Power Transformer, Differential relay, CT, Buchholz Relay | 3 Phase Differential relay, Current transformer-3 Qty, Power Transformer with Buchholz relay -1 Qty, Connecting Wire. | Understand the differential protection with different CT connections and the working of Buchholz relay. |
| 9 | Transformer, Auto Transformer, Ammeter, Voltmeter, Multi-meter. | 1 Ph Transformer (same rating)-2 Qty,1 Ph Autotransformer -1 Qty, Ammeter (0-2 A)-1 Qty, Voltmeter(0-300V), Voltmeter(0-150V)-1 Qty, Connecting Wire. | Perform a polarity test on a transformer. |
| 10 | Transformer, Impulse test Kit | 3 Phase transformer -1 Qty, High voltage generating kit (rating in kV), Connecting Wire. | Perform the impulse test on a transformer. |

## R) Suggested Learning Resources:

### (a) Books:

| S. No. | Titles | Author(s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 1. | The Performance and Design of Alternating Current Machines | M. G. Say | CBS Publishers, 2002<br>ISBN: 81-239-1027-4 |
| 2. | Electrical Machines | D. P. Kothari and I. J. Nagrath | Tata McGraw Hill India, 2004<br>ISBN: 0070583773, 9780070583771 |

### (b) Online Educational Resources:

1. https://nptel.ac.in/courses/108105017
2. https://nptel.ac.in/courses/108106071

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

### (b) Others:

******

**A) Course Code** : 2400504J(T2400504J/P2400504J/S2400504J)

**B) Course Title** : **Optical Fiber and 5G Communication (Basics)**

**C) Pre- requisite Course(s)** : Principle of Electronics Communication, Digital Communication

**D) Rationale** :

An optical fiber and 5G communication course is essential for interpreting 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 fiber optic networks, which are integral to both wired and wireless communication infrastructures. The course also covers the principles andtechnologies behind 5G, the latest generation of mobile networks, enabling enhanced connectivity, low latency, and greater capacity. By combining these fields, students gain comprehensive insights into how advanced communication systems operate and interact and preparing them for careers in telecommunicationsand networking field.

**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 Describe EM wave propagation through an optical fiber.

CO-2 Measure different types of losses of a given optical fiber cable.

CO-3 Perform optical fiber power launching and slicing.

CO-4 Test the performance of the Optical fiber source and detector.

CO-5 Compare mobile communication generations (2G, 3G, 4G and 5G).

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

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

## G) Teaching & Learning Scheme:

| Course Code | CourseTitle | 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 | | | | |
| 2400504 J | Optical Fiber and 5G Communication(Basics) | 03 | - | 04 | 02 | 09 | 06 |

**Legend:**

CI: Classroom Instruction (Includes different instructional/implementation strategies i.e. Lecture (L), Tutorial (T), Casemethod, 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 feedbackof 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) | |
| 2400504 J | Optical Fiberand 5G Communication (Basics) | 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%)** aswell 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 ofinternal 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: T2400504J

| Major Theory Session Outcomes (TSOs) | Units | Relevant COs Number(s) |
|---|---|---|
| *TSO 1a.* Explain the need for Optical fiber and 5G Technologies.<br>*TSO 1b.* Define numerical aperture.<br>*TSO 1c.* Classify optical fiber modes with proper sketch.<br>*TSO 1d.* Explain with examples modes of wave propagation through an optical fiber.<br>*TSO 1e.* Classify optical fiber | **Unit-1.0 Introduction of Optical Fibers**<br>1.1 Introduction to general optical fibercommunication (OFC) system<br>1.2 Basic optical laws and definitions<br>1.3 Structure of optical cable- core, cladding, cover<br>1.4 Numerical aperture<br>1.5 Optical fiber modes and configurations–mode analysis for optical propagation through fibers<br>1.6 Classification of optical fiber, single mode fiber,graded index fiber | **CO1** |
| *TSO 2a.* Explain the reason for attenuation in the optical fiber cable.<br>*TSO 2b.* Describe fiber losses with examples.<br>*TSO 2c.* Explain various aspects of dispersion<br>*TSO 2d.* Describe how to optimize the dispersion<br>*TSO 2e.* Describe how to generate R-I profile<br>*TSO 2f.* calculate cut-off wavelength, and modefield diameter | **Unit-2.0 Transmission Characteristics of OpticalFiber**<br>2.1 Attenuation in Optical Fiber<br>2.2 Fiber Losses (Material, Scattering, Splice,Absorption, Radiative)<br>2.3 Dispersion (Chromatic, Modal, Material, Waveguide, Polarization mode)<br>2.4 Dispersion optimization of single mode fiber,characteristics of single mode fiber<br>2.5 R-I Profile<br>2.6 Cut off wavelength, dispersion calculation, and mode field diameter | **CO2** |
| *TSO 3a.* Explain the need for a source and detector in an optical fiber system.<br>*TSO 3b.* Describe about direct and indirect bandgap materials used for | **Unit-3.0 Optical Sources and Detectors**<br>3.1 Sources- Intrinsic and extrinsic material,direct and indirect band gaps<br>3.2 LED structures- Surface-emitting | **CO3** |

| | | |
|---|---|---|
| make fiber sources.<br>*TSO 3c.* Describe the basic operating principle of optical sources such as LED and Lasers in detail.<br>*TSO 3d.* Describe the detection process and noise inthe optical detectors. | and Edgeemitting LED<br>3.3 Optical Source: Laser diodes, Laser source driver circuit,modes and threshold conditions, Rate equations, external quantum efficiency, resonant frequencies, single-mode laser,external modulation, temperature effort<br>3.4 Detectors: PIN photodetector, Avalanchephotodiodes, Photodetector noise, noisesources, SNR, detector response time, Avalanche multiplication noise, and temperature effects | |
| *TSO 4a.* Describe the basic operations of the given type of optical preamplifier.<br>*TSO 4b.* Analyze the performance of the given optical receiver in detail.<br>*TSO 4c.* Describe the power launching and lensing with respect to the optical fiber system.<br>*TSO 4d.* Describe the fiber splicing process with the help of a suitable sketch.<br>Describe the procedure of optical power measurement. | **Unit-4.0 Optical Receiver, Coupling andMeasurements**<br>4.1 Basic receiver operation, preamplifiers, digital signal transmission, error sources,Front-end amplifiers, probability of error, and receiver sensitivity.<br>4.2 Power Launching, Lensing Schemes for Coupling Management, coupling losses,<br>4.3 Fiber Splicing, and Optical power measurement | **CO4** |
| *TSO 5a.* Explain the historical development and technological advancements of wireless communication.<br>*TSO 5b.* Compare different wireless communication systems on the basis of technology, data rate, spectrum, QoS, advantages, and services.<br>*TSO 5c.* Describe WLAN principle, standards, and their practical applications.<br>*TSO 5d.* Describe the concept, architecture, and applications of WLL systems, and their role in telecommunications. | **Unit-5.0 Fundamentals of 5G Communication**<br>5.1 Evolution of mobile radio systems<br>5.2 Types of Wireless Communication Systems<br>5.3 Overview of modern mobile communication system (2G, 3G, 4G, 5G)<br>5.4 Wireless Local Area Network<br>5.5 Wireless Local Loop<br>5.6 Service Requirement: Data Rate, Number of users, mobility, energy consumption, spectrum, service quality | **CO5** |

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

## K) Suggested Laboratory (Practical) Session Outcomes (LSOs) and List of Practical: P2400504J

| Practical/Lab Session Outcomes (LSOs) | Sl. No. | Laboratory Experiment/Practical Titles | Relevant COs Number(s) |
|---|---|---|---|
| *LSO 1.1.* Identify the fiber cable, optical source, detector and other components of the given optical fiber system. | 1. | Identification of various components of Optical fiber communication system | **CO1** |
| *LSO 2.1.* Measure the numerical aperture of the given optical fiber cable. | 2. | Measurement of Numerical aperture | **CO1** |
| *LSO 3.1.* Measure the attenuation and signal loss in optical fiber using optical time-domain reflectometry (OTDR).<br>*LSO 3.2.* Measure the signal loss in optical fibers using optical time-domain reflectometry (OTDR). | 3. | Attenuation and Signal Loss Measurement | **CO2** |
| *LSO 4.1* Perform tests on fiber optic cables to identify faults using tools like visual fault locators and OTDR.<br>*LSO 4.2* Troubleshoot faults using tools like visual fault locators and OTDR. | 4. | Fiber Optic Cable Testing and Troubleshooting | **CO2, CO3** |
| *LSO 5.1* Test the performance of the given optical source. | 5 | Performance of optical source (LED, LASER) | **CO3** |
| *LSO 6.1.* Test the performance of the given optical detector. | 6 | Performance of optical doctor (Photo diode, PIN diode) | **CO3** |
| *LSO 7.1.* Learn techniques for splicing optical fibers.<br>*LSO 7.2.* Install connectors, crucial for network deployment and maintenance. | 7 | Optical Fiber Splicing and Monitorization | **CO4** |
| *LSO 8.1.* Conduct BER test.<br>*LSO 8.2.* Evaluate the performance of optical communication links.<br>*LSO 8.3.* Evaluate the reliability of optical communication links. | 8 | Analyze the optical communication system. | **CO4** |
| *LSO 9.1.* Noise Modelling and its effect on Wireless Data Transmission | 9. | Characterization and Impact of Noise on Wireless Data Transmission: A Comprehensive | **CO5** |
| *LSO 10.1* Effect of fading on wireless data transmission in terms of outage probability | 10. | Evaluating Fading Effects on Wireless Data Transmission: Outage Probability Analysis | **CO5** |

**L) Suggested Term Work and Self Learning: S2400504J** Some sample suggested assignments, micro project and otheractivities are mentioned here for reference.

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

**b. 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 and Implementation of a Basic Fiber Optic Network:
2. Perform splicing and monetarization on actual fiber optic cables.
3. Test the network for signal loss and attenuation using OTDR.
4. Prepare a report detailing the design, implementation process, and test results.
5. Simulation and Analysis of Wavelength Division Multiplexing (WDM) Systems: Objective: Simulate a WDM system and analyze its performance. Tasks: Use simulation software (e.g., Opti System or MATLAB) to design a WDM system. Simulate the transmission of multiple wavelengths through a single optical fiber. Analyze the system's performance in terms of signal quality, crosstalk, and data capacity.
6. Development of a Simple 5G NR Base Station

   Objective: Develop and test a simple 5G NR base station using software-defined radios (SDRs).

**c.** Other Activities:

1. Seminar Topics: here are 5 seminar topics

   **I.** "Advancements in Optical Fiber Technology "
   **II.** "The Future of Wireless Communication: 5G and Beyond"
   **III.** "Integrating Optical Fiber with 5G Networks: Opportunities and Challenges"
   **IV.** "Security Strategies for 5G Networks: Ensuring Robust Protection"
   **V.** "Smart Cities Powered by 5G and Optical Fiber: Innovations and Implementation"

2. 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) 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 relatedto 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(Cl) Hours | Relevant COs Number(s) | Total Marks | ETA (Marks) | | |
|---|---|---|---|---|---|---|
| | | | | Remember (R) | Understanding (U) | Application & above (A) |
| Unit-1.0 **Introduction of Optical Fibers** | 8 | CO1 | 10 | 2 | 4 | 4 |
| Unit-2.0 **Transmission Characteristics of Optical Fiber** | 8 | CO2 | 10 | 4 | 2 | 4 |
| Unit-3.0 **Optical Sources and Detectors** | 8 | CO3 | 14 | 4 | 4 | 6 |
| Unit-4.0 **Optical Receiver, Coupling and Measurements** | 12 | CO4 | 16 | 4 | 6 | 6 |
| Unit-5.0 **Fundamentals of 5G Communication** | 12 | CO5 | 20 | 4 | 6 | 10 |
| **Total** | **48** | **-** | **70** | **18** | **22** | **30** |

**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. | Identification of various components of Optical fiber communication system | **CO1** | 30 | 60 | 10 |
| 2. | Measurement of Numerical aperture | **CO1** | 40 | 50 | 10 |
| 3. | Attenuation and Signal Loss Measurement | **CO2** | 30 | 60 | 10 |
| 4. | Fiber Optic Cable Testing and Troubleshooting | **CO2, CO3** | 30 | 60 | 10 |
| 5. | Performance of optical source (LED, LASER) | **CO3** | 30 | 60 | 10 |
| 6. | Performance of optical doctor (Photo diode, PIN diode) | **CO3** | 30 | 60 | 10 |
| 7. | Optical Fiber Splicing and Monitorization | **CO4** | 30 | 60 | 10 |
| 8. | Analyze the optical communication system. | **CO4** | 30 | 60 | 10 |
| 9. | Characterization and Impact of Noise on Wireless Data Transmission: A Comprehensive | **CO5** | 30 | 60 | 10 |
| 10. | Evaluating Fading Effects on Wireless Data Transmission: Outage Probability Analysis | **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 beprepared 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**

| S.No. | Name of Equipment,Tools, and Software | Relevant Experiment/Practical Number |
|---|---|---|
| 1. | Optical Time-Domain Reflectometer (OTDR)<br>Used for measuring the length, loss, and faults in optical fiber cables. | 1-3 |
| 2. | Fusion Splicer (For splicing optical fibers with minimal loss). | 1-3 |
| 3. | Optical Power Meter and Light Source (For measuring the power levels in fiber optic links and testing signal loss). | 1-3 |
| 4. | Visual Fault Locator (VFL):<br>Helps to identify faults, breaks, and bending in optical fibers. | 1-3 |
| 5. | Optical Spectrum Analyzer (OSA): Used for analyzing the wavelength and spectral characteristics of light in fiber optics. | 1-3 |
| 6. | Software-Defined Radio (SDR): Allows for the implementation and testing of 5G communication protocols. | 4-7 |
| 7. | 5G NR Testbed: Complete test setups for developing and testing 5G NR systems. | 4-7 |
| 8. | Vector Signal Analyzer (VSA) and Vector Signal Generator (VSG): For generating and analyzing complex modulated signals used in 5G communication. | 4-7 |
| 10. | MIMO (Multiple Input Multiple Output) Test System: For testing MIMO technology, which is essential for 5G networks. | 7 |
| 11. | Optical Fiber Cables and Connectors: Various types of single-mode and multi-mode fibers, along with connectors and adapters. | 1-3 |
| 12. | Network Simulators: Software tools like Opti System for simulating optical networks and NS-3 for 5G network simulations. | 1-3 |
| 13 | MATLAB/Mathematica | 1-7 |

## R) Suggested Learning Resources:

### (a) Books

| S. No. | Titles | Author(s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 1. | Fiber-Optic Communication Systems | Govind P. Agrawal | John Wiley & Sons, 2012, ISBN 97804705113 |
| 2. | Optical Fiber Communications | Gerd Keiser | McGraw-Hill Science, Engineering & Mathematics, 1983. ISBN: 0-07-064810-7 |
| 3. | 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 |
| 4. | Principles of Optical Fiber Measurements | Dietrich Marcuse | Elsevier, 2012. ISBN:012470980X |

### (b) Online Educational Resources: (Please provide link also if available)

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

1. edX - PurdueX: Fiber Optic Communications: This advanced course covers wave propagation, optical transmitters and receivers, optical communication network architectures, and future optical networks. It's ideal for gaining in-depth knowledge of fiber optic systems and their applications in modern communication networks (edX).
2. Johns Hopkins Engineering - Fiber-Optic Communication Systems: This online course explores the fundamentals of fiber-optic communication systems, including the properties of optoelectronic components and system design issues for both terrestrial and submerged point-to-point optical links (Johns Hopkins Engineering Online).
3. Purdue University - Fiber Optics Communications Course: This course provides a comprehensive overview of the key components and system-level interactions in fiber optic communication systems, with a focus on current technologies and future advancements in the field (Purdue Eng.).
4. 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).
5. 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).

**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

********

**A) Course Code** : **2400505(P2400505/S2400505)**

**B) Course Title** : Entrepreneurship Development & Start-ups
(Common for all Programmes)

**C) Pre-requisite Course(s)** :

**D) Rationale** :

A fast-growing economy provides ample opportunities for diploma engineers to succeed in entrepreneurship and start-ups. Start-up ecosystem and Entrepreneurship Development skills are fully developed providing many opportunities to the youths. Diploma engineers can be their own masters and provide jobs to others by starting their service-industry / assembly/ marketing/ consultancy/ manufacturing enterprises. Entrepreneurship requires a distinct set of skills that will be developed in this course. This course aims at developing competencies in the diploma engineer for becoming an entrepreneur, a successful entrepreneur, or a startup Co-Founder. After successfullycompleting this course students who develop the qualities of a successful entrepreneur can establish their own manufacturing industry/business startup or be self-employed. Those who prefer jobs can become entrepreneurs and share profits with their company.

**E) Course Outcomes (COs):** After the completion of the course, teachers are expected to ensure the accomplishment of the 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 the classroom/laboratory/workshop/field/industry.

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

**CO-1** Demonstrate traits of a successful intrapreneur/ entrepreneur/ start-up co-founder.
**CO-2** Innovate products and services using creativity and innovation techniques.
**CO-3** Manage critical resources from support institutions.
**CO-4** Prepare sustainable small business plans.

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

| Course Outcomes (COs) | Programme Outcomes (POs) | | | | | | | Programme Specific Outcomes* (PSOs) | |
|---|---|---|---|---|---|---|---|---|---|
| | **PO-1** Basic and Discipline Specific Knowledge | **PO-2** Problem Analysis | **PO-3** Design/ Development of Solutions | **PO-4** Engineering Tools | **PO-5** Engineering Practices for Society, Sustainability and Environment | **PO-6** Project Management | **PO-7** Life Long Learning | **PSO-1** | **PSO-2** |
| **CO-1** | 3 | - | - | - | 2 | 3 | 2 | | |
| **CO-2** | 3 | 2 | 3 | - | 2 | 3 | 2 | | |
| **CO-3** | 3 | 3 | 3 | - | 2 | 3 | 2 | | |
| **CO-4** | 3 | 3 | - | - | 2 | 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 | | | | |
| **2400505** | Entrepreneurship Development & Startups | - | - | 04 | 02 | 06 | 03 |

**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) | |
| **2400505** | Entrepreneurship Development & Startups | - | - | 20 | 30 | 20 | 30 | 100 |

**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: (Not Applicable)

## K) Suggested Laboratory (Practical) Session Outcomes (LSOs)and List of Practical: P2400505

| Practical/Lab Session Outcomes (LSOs) | | S. No. | Laboratory Experiment / Practical Titles | Relevant Cos Number(s) |
|---|---|---|---|---|
| *LSO1.1* | Identify the skills of a Successful Entrepreneur. | 1. | Profile summary (about 500 words) of a successful entrepreneur indicating milestone achievements. | CO1 |
| *LSO1.2* | Determine the charms of entrepreneurship and start-ups | 2. | Discussion session with your institute's pass-out students who are successful entrepreneurs. | CO1 |
| *LSO1.3* | Perform strength, weakness, opportunity, and threat analysis. | 3. | SWOT analysis to arrive at your business idea of a product/service. | CO1 |
| *LSO1.4* | Develop sales & marketing skills | 4. | Sale of products to different customers | CO1 |
| *LSO2.1* | Use creativity and put up a stall in a funfair and write a report of profit/loss. | 5. | Creativity and Innovation in Business | CO2 |
| *LSO2.2* | Innovate a point of sale for a product. | 6. | Exhibition cum sale of products prepared out of waste. | CO2 |
| *LSO2.3* | Generate different business opportunities. | 7. | Business ideas (product/service) for intrapreneurial and entrepreneurial opportunities through brainstorming. | CO2 |
| *LSO1.5* | Discover entrepreneurial potential. | 8. | Self–assessment test to discover entrepreneurial traits. | CO1 |
| *LSO2.4* | Classify domain-specific industries on business parameters. | 9. | Survey industries (your stream), and grade them according to the level of scale of production, investment, turnover, and pollution to prepare a report on it. | CO2 |
| *LSO3.1* | Identify entrepreneurship support institutions beneficial for the enterprise. | 10. | Compile the information from the government agencies that will help you set up your business enterprise. | CO3 |
| *LSO3.2* | Select a suitable funding scheme for the enterprise. | 11. | Visit a bank / financial institution to enquire about various funding schemes for small-scale enterprises. | CO3 |
| *LSO3.3* | Analyze the assessment procedure of bank loans. | 12. | Collect loan application forms of nationalized banks / other financial institutions. | CO3 |
| *LSO3.4* | Compute the financial needs of the business enterprise | 13. | Compile the information from financial agencies that will help you set up your business enterprise. | CO3 |
| *LSO2.5* | Select a business opportunity. | 14. | Identify the business opportunity suitable for you. | CO2 |

| Practical/Lab Session Outcomes (LSOs) | | S. No. | Laboratory Experiment / Practical Titles | Relevant Cos Number(s) |
|---|---|---|---|---|
| *LSO3.5* | Carry-out market survey for a product. | 15. | Market Survey for an Enterprise | CO3 |
| *LSO4.1* | Find out rates of industrial lands and buildings in different industrial areas. | 16. | Industrial land and building for Entrepreneurship. | CO4 |
| *LSO4.2* | Craft a vision statement and enabling mission statements for your chosen enterprise. | 17. | Vision statement and mission statement for a Startup. | CO4 |
| *LSO4.3* | Select a suitable name and brand for the business enterprise. | 18. | Branding for a product and a Company. | CO4 |
| *LSO4.4* | Design a logo, letterhead, and visiting card for the business. | 19. | Marketing communication for business. | CO4 |
| *LSO4.5* | Prepare a techno-feasibility report | 20. | A techno-feasibility report of a chosen product/service. | CO4 |
| *LSO4.6* | Prepare a business plan for the enterprise. | 21. | Business plan for the enterprise. | CO4 |
| *LSO4.7* | Develop a website for the business | 22. | Online Marketing for Business. | CO4 |
| *LSO3.6* | Prepare a set of short-term, medium, and long-term goals for starting a chosen small-scale enterprise. | 23. | Goal setting for an enterprise. | CO3 |
| *LSO3.7* | Prepare an advertising campaign for your chosen product/service. | 24. | Marketing management for an enterprise. | CO3 |
| *LSO3.8* | Establish a supply chain network for the enterprise. | 25. | Supply Chain Management | CO3 |
| *LSO3.9* | Establish a Market intelligence mechanism. | 26. | Market Intelligence for Entrepreneurship | CO3 |
| *LSO4.8* | Compile information about various insurance schemes covering different risk factors. | 27. | Risks in business | CO4 |
| *LSO4.9* | Calculate the breakeven point for the business idea chosen by you. | 28. | Breakeven point for a business | CO4 |

**L)** **Suggested Term Work and Self-Learning: S2400505** 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.

i. Prepare a list of successful Entrepreneurs in the city.
ii. Prepare a list of startups in the city.
iii. Prepare a list of the nearest incubators.
iv. Prepare a list of Angel Investors and Venture Capitalists.

i. Choose any product and study its supply chain.
ii. Arrange brainstorming sessions for improvement of any product.
iii. Choose any advertisement and analyses its good and bad points.
iv. Visit industrial exhibitions, trade fairs and observe nitty-gritty of business.
v. Study schemes for entrepreneurship promotion of any bank.

**b. Micro Projects:**

i. Interview successful entrepreneurs and startup co-founders in the city and innovate their products/services, pricing, packaging, advertisements, propositions, etc.
ii. Identify different entrepreneurship support institutions in the city.
iii. Prepare a collage for specific entrepreneurship development institutions.
iv. Conduct a market survey for a specific product idea.

**c. Other Activities:**

**1. Seminar Topics:**

- Charms of entrepreneurship.
- Challenges of entrepreneurship.
- Startup ecosystem in India.
- One district one product scheme
- Setting up of a business.
- Market study of specified business.
- Prepare a business plan for your chosen small scale enterprise.
- Business opportunity suitable for you.

**2. Visits:** Visit DIC, MSME, NSIC, NABARD, KVIC, IDBI, SBI, State Consultancy Organization, Industrial Development Center, Trade Exhibitions, Export Fairs, Trade Shows, etc.

Visit nearby tool room/industry and learn to prepare budget of that industry. Also learn to grow low scale business and marketing. Prepare list of advertisement to grow business.

**3. Self-Learning Topics:**

- Achievement Motivation.
- Need for achievement.
- Calculated risk.
- CSR (Corporate Social Responsibility)
- MSME Development Institute.
- Marketing their business.
- Growing their business.
- Financial management.
- Dealing with the pressure and stress

**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) 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 | - | - | 30% | - | - | 30% | 25% |
| CO-2 | - | - | 10% | 33% | - | 10% | 25% |
| CO-3 | - | - | 30% | 33% | 50% | 30% | 25% |
| CO-4 | - | - | 30% | 34% | 50% | 30% | 25% |
| Total Marks | - | - | 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: (NOT APPLICABLE)

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

| S. No. | Laboratory Practical Titles | Relevant Cos Number (s) | PLA/ELA | | |
|---|---|---|---|---|---|
| | | | Performance | | Viva-Voce (%) |
| | | | PRA* (%) | PDA** (%) | |
| 1. | Profile summary (about 500 words) of a successful entrepreneur indicating milestone achievements. | CO1 | 50 | 40 | 10 |
| 2. | Discussion session with your institute's pass-out students who are successful entrepreneurs. | CO1 | 50 | 40 | 10 |
| 3. | SWOT analysis to arrive at your business idea of a product/service. | CO1 | 50 | 40 | 10 |
| 4. | Sale of products to different customers | CO1 | 50 | 40 | 10 |
| 5. | Creativity and Innovation in Business | CO2 | 50 | 40 | 10 |
| 6. | Exhibition cum sale of products prepared out of waste. | CO2 | 50 | 40 | 10 |
| 7. | Business ideas (product/service) for intrapreneurial and entrepreneurial opportunities through brainstorming. | CO2 | 50 | 40 | 10 |

| S. No. | Laboratory Practical Titles | Relevant Cos Number (s) | PLA/ELA | | |
|---|---|---|---|---|---|
| | | | Performance | | Viva-Voce (%) |
| | | | PRA* (%) | PDA** (%) | |
| 8. | Self–assessment test to discover entrepreneurial traits. | CO1 | 50 | 40 | 10 |
| 9. | Survey industries (your stream), and grade them according to the level of scale of production, investment, turnover, and pollution to prepare a report on it. | CO2 | 50 | 40 | 10 |
| 10. | Compile the information from the government agencies that will help you set up your business enterprise. | CO3 | 50 | 40 | 10 |
| 11. | Visit a bank / financial institution to enquire about various funding schemes for small-scale enterprises. | CO3 | 50 | 40 | 10 |
| 12. | Collect loan application forms of nationalized banks / other financial institutions. | CO3 | 50 | 40 | 10 |
| 13. | Compile the information from financial agencies that will help you set up your business enterprise. | CO3 | 50 | 40 | 10 |
| 14. | Identify the business opportunity suitable for you. | CO2 | 50 | 40 | 10 |
| 15. | Market Survey for an Enterprise | CO3 | 50 | 40 | 10 |
| 16. | Industrial land and building for Entrepreneurship. | CO4 | 50 | 40 | 10 |
| 17. | Vision statement and mission statement for a Startup. | CO4 | 50 | 40 | 10 |
| 18. | Branding for a product and a Company. | CO4 | 50 | 40 | 10 |
| 19. | Marketing communication for business. | CO4 | 50 | 40 | 10 |
| 20. | A techno-feasibility report of a chosen product/service. | CO4 | 50 | 40 | 10 |
| 21. | Business plan for the enterprise. | CO4 | 50 | 40 | 10 |
| 22. | Online Marketing for Business. | CO4 | 50 | 40 | 10 |
| 23. | Goal setting for an enterprise. | CO3 | 50 | 40 | 10 |
| 24. | Marketing management for an enterprise. | CO3 | 50 | 40 | 10 |
| 25. | Supply Chain Management | CO3 | 50 | 40 | 10 |
| 26. | Market Intelligence for Entrepreneurship | CO3 | 50 | 40 | 10 |
| 27. | Risks in business | CO4 | 50 | 40 | 10 |
| 28. | Breakeven point for a business | CO4 | 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: (Not Applicable)

## R) Suggested Learning Resources:

**(a) Books**:

| S. No. | Titles | Author(s) | Publisher and Edition with ISBN |
|---|---|---|---|
| 1. | Entrepreneurial Development | Khanka S.S. (2006) | S. Chand Publishing, 20068121918014, |
| 2. | Un-Boxing Entrepreneurship<br>Your self-help guide to setup a successful business | Dr. Nishith Dubey<br>Aditya Vyas, Annu Soman, Anupam Singh, Charu Chaturvedi, Praveen Shukla | Indra Publishing House, 2023, ISBN- 978-93-93577-70-2 |
| 3. | Skill Development and Entrepreneurship in India | Rameshwari Pandya | Ingram 2016, 8177084186 |
| 4. | Production and Operations Management | SV Deshmukh, A K Chitale and Nishith Rajaram Dubey, | Archers & Elevators Publishing House, Bangalore<br>ISBN 9789386501197 |
| 5. | Entrepreneurship Development | Sapna Jarial | New India Publishing Agency-Nipa 2022, 9395319240 |
| 6. | The Entrepreneurial Instinct: How Everyone Has the Innate Ability to Start a Successful Small Business | Monica Mehta | Tata McGraw Hill Education, New Delhi, 2012, ISBN 978-0-07-179742-9 |
| 7. | The Learn Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses | Eric Ries | Penguin UK ISBN-978-0670921607 |
| 8. | Entrepreneurship and Start-ups | Ekta Sharma | FPH |
| 9. | The Innovator's Dilemma: The Revolutionary Book That Will Change the Way You Do Business | Clayton M. Christensen | Harvard business ISBN: 978-142219602 |

**Online Educational Resources:**

1. Coir Board http://coirboard.gov.in/
2. National Institute for Micro, Small and Medium Enterprises (ni-msme) https://www.nimsme.org/
3. MSME / Udyam Registration https://udyamregistration.gov.in/Government-India/Ministry-MSME-registration.htm
4. CHAMPIONS https://champions.gov.in/Government-India/Ministry-MSME-Portal-handholding/msme-problem-complaint-welcome.htm
5. Prime Minister Employment Generation Programme and Other Credit Support Schemes https://msme.gov.in/prime-minister-employment-generation-programme-and-other-credit-support-schemes
6. Marketing Promotion Schemes https://msme.gov.in/marketing-promotion-schemes
7. Start-up India https://www.startupindia.gov.in/
8. DPIIT Recognition https://www.startupindia.gov.in/content/sih/en/startup-scheme.html
9. Startup India Seed Fund Scheme https://seedfund.startupindia.gov.in/
10. STARTUP INDIA INVESTOR CONNECT https://investorconnect.startupindia.gov.in/
11. Startup Funding https://www.startupindia.gov.in/content/sih/en/funding.html
12. Women Entrepreneurship in India https://www.startupindia.gov.in/content/sih/en/women_entrepreneurs.html
13. Incubators https://www.startupindia.gov.in/content/sih/en/incubator-framework.html
14. Start-up Mentors https://www.startupindia.gov.in/content/sih/en/search.html?roles=Mentor&page=0
15. NEN https://nen.org/
16. TIE https://tie.org/
17. MoE Innovation Cell https://www.mic.gov.in/
18. https://youtu.be/8iKsZZYv90k
19. https://youtu.be/Tzzfd6168jk
20. https://youtu.be/9-O15gDqebg

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

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**A) Course Code : 2418506(P2418506/S2418506)**

**B) Course Title :** Summer Internship -II / Industrial training

**C) Pre- requisite Course(s) :**

**D) Rationale :**

With the advancement in technology and skill requirements of industry 4.0, we need to prepare our young Indian technical talent to meet the present demand. Our diploma pass outs are either supposed to work as supervisor in the industries or start their own enterprise, hence upon the completion of diploma programme, they need to be adequately equipped with knowledge, skills and attitude required by the world of work in their relevant field. To attain this, students need to be sent for internship, industrial visit and industrial training during the course of study. One or two mandatory internships are placed in the programme structure to equip the students with practical knowledge, problem solving attitude and also provide the exposure to real time industrial environments. It also helps the students to understand the industrial requirements, develop expertise through hands on experience and take up project work relevant to industry. With these provisions of industrial exposures relevant practical and professional skills are developed in the students and as a result they are readily employed and widely accepted by industries, even sometimes during such trainings itself.

In the context of above after having gone through the summer internship-I (after the second semester), the summer internship-II/ industrial training is planned after the completion of fourth 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** Develop the comprehensive view of industry 4.0 elements and 21st century skills requirements in the relevant diploma engineering programme through Summer Internship-II.

**CO-2** Outline the importance of industrial training and Internship for gaining direct practical skills on their relevant domain area of industrial equipment, automation, machinery, processes, product, management, operations, software development etc.

**CO-3** Use the knowledge and skills gained during industrial training or world of work.

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

| Course Outcomes (COs) | Programme Outcomes(POs) | | | | | | | Programme Specific Outcomes* (PSOs) | |
|---|---|---|---|---|---|---|---|---|---|
| | **PO-1** Basic and Discipline Specific Knowledge | **PO-2** Problem Analysis | **PO-3** Design/ Developmen tof Solutions | **PO-4** Engineering Tools | **PO-5** Engineering Practices for Society, Sustainability and Environment | **PO-6** Project Management | **PO-7** Life Long Learning | **PSO-1** | **PSO-2** |
| **CO-1** | 2 | - | - | 3 | - | 2 | 1 | | |
| **CO-2** | - | - | - | 3 | - | 2 | 1 | | |
| **CO-3** | 3 | 2 | 2 | 3 | - | 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 & 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 | | | | |
| **2418506** | Summer Internship - II | - | - | 02 | 04 | 06 | 03 |

**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) | |
| **2418506** | Summer Internship - II | - | - | 20 | 30 | 20 | 30 | 100 |

**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) Guidelines to Teachers for Implementation & Assessment of Industrial Internship/Training:

### 1. Rationale:

During implementation of the curriculum, industrial exposure in the form of industrial internship/training is very important for developing and reinforcing many concepts and principles and also to get exposure of industrial environment, working culture, latest developments in relevant field, layout, management, culture, hierarchy, discipline, safety norms, different department/sections, quality control/assurance in processes, services and products, demonstration and operation of specific equipment/machinery, rules and procedures and many other aspects of the industries, where diploma holders are going to work. Students also get exposed to the different kinds of problems which can be brought into the institutional laboratories or workshop. Organizing industrial training of students is essentially required to enhance the prospects of employability, after undergoing industrial training, students get the direct exposure to the world of work in their relevant field. They get hands on experience in the industries.

Planning before Industrial internship/training is essentially required to be done for effective implementation of the same.

### 2. Planning for industrial internship/training:

Following points need to be planned and briefed by the teachers to the students before proceeding for industrial training. Student should take into consideration these points and carry the relevant format/data/log book with them.

- Analyze curriculum analysis and identify curricular gaps and topics which need industrial intervention;
- Objectives /Purposes of the industrial internship/training
- Outcomes targeted before proceeding to industrial internship/training.
- Pre-requisite knowledge or skills required to be developed in the students in the form of demonstration or classroom sessions.
- Identification and planning for demonstration of any equipment or experiments, concepts, under the content beyond syllabus.
- Preparation of database of nearby relevant industries.
- Good rapport needs to be developed and maintained with the industries by the teachers, so that the students are ultimately benefitted by the industrial internship/training.
- Industrial policy of the state also needs to be taken care of while planning of industrial training
- For assessing the students on various dimensions of industrial internship/training, assessment rubric may be prepared by the implementing teachers in advance.
- Make arrangements for student insurance during the industry internship/training
- Prepare instructions to be followed by students in the industries.
- Following formats need to be developed by the teachers and briefed to the students before proceeding to industrial internship/training –
  - Formats of observations on layout, ambience, and work culture to be developed, and briefed to the students.
  - Formats of outcome attainment, related to observation on relevant technical area also need to be developed by the teachers and briefed to the students.
  - Formats and contents of report writing and presentation.
  - Formats and contents on assessment of industrial training.
  - Continuous observation formats on many points such as behavioral aspects related to soft skills development such as initiativeness, observation, notes taking skills, inquisitiveness, obedience, sincerity, follow the instructions, positive attitude and many other aspects.

**Formats of Assessment Rubric on different parameters of both behavioral aspects and technical aspects of the programme.**

**3. Major outcomes expected to be attained and assessed:**

Outcomes expected from the industrial internship/training should be clearly defined and briefed to the students. Evaluation criteria for assessing students, need to be prepared for different outcomes set, during the planning stage. The list of major outcomes expected to be attained are –

- Development and reinforcement of Basic knowledge
- Development and reinforcement of Engineering knowledge through reinforcement of concepts or principles.
- Gaining Engineering Knowledge i.e operations, performance, maintenance, demonstrations of specific skills relevant to the content of the programme.
- Experiment and practice – Development of experimental practical skills and technical skills relevant to the course programme.
- Development of learning to learn skills and lifelong teaching skills for latest advancement in technology.
- Outcome attainment through content beyond syllabus
- Development of positive attitude, professional ethics and etiquettes.
- Development of skills for individual and team work during performance and otherwise.
- Maintaining Business Secrecy
- Development of Communication Skills
- Ability to follow the instructions
- Ability to follow the safety precautions
- Ability to supervise the task
- Ability to coordinate with subordinates and higher ups
- Development of Interpersonal skills
- **Environmental Consciousness and Sustainability**
- Development of Observational Skills
- Development of Self-discipline and Integrity
- Development of Time Management habits
- Development of generic skills such as pro-activeness, commitment
- Development of Problem-Solving abilities
- Achievement of target
- **Concern for Environment, Sustainability Society**
- Communication ability
- Industrial System and its development
- Safety Awareness
- Systematic Operations and Productions
- Quality control
- Management of work place and work force
- Development of positive attitude
- Work culture/Quality Culture
- Development of Professional Ethics
- Industrial Management
- Systematic planning, Implementation & Evaluation
- Use of engineering tools, techniques, software's and Procedures
- Development of Lifelong learning skills

It is important to note that outcomes attained during industrial visit are at the awareness level only.

**4. Actions to be taken by the Students and Teachers:**

Students are sent to Industrial training after briefing on various aspects. During industrial training, observational skills in students are required to a great extent -

- Students need to be alert, meticulous and record the data, as briefed to them before the industrial training.
- Record of observations on safety precaution to be followed, any special point during performance and handling of equipment, performance on technical aspects and other related aspects need to be taken care of.
- Continuous observation, monitoring and assessment on various behavioral and performance of technical aspects of each student need to be critically observed and recorded by the teachers using different assessment tools.

**5. Post Training Assessment:**

The students need to be assessed on report writing, presentation and interpretation of data recorded, on various dimensions, planned and performed, after the industrial training. The actions are required to be taken for assessment during report writing, analysis, interpretation, presentation of data and its assessment.

## J) Initiatives by Govt. of India and other Agencies for Industrial Internship/ Training/Visit for Skills Development:

**1. Initiatives by Govt. of India, GOI**

**a. Initiatives by Ministry of Skills Development and Entrepreneurship**: Many efforts are initiated by different agencies in this direction as per our Prime Minister's Skills Development Mission. Make in India, Skills India etc are such initiatives taken by ministry for the benefit of the students. The Ministry is responsible for co-ordination of all Skill Development efforts across the country, removal of disconnect between demand and supply of skilled manpower, building the vocational and technical training framework, skill up-gradation, building of new skills and innovative thinking not only for existing jobs but also jobs that are to be created. The Ministry aims to skill on a large scale with speed and high standards in order to achieve its vision of a 'Skilled India'.

**b. Initiatives by Ministry of Education, Govt. of India**

i. Ministry of Education, Government of India is providing students a platform to inculcate a culture of product innovation and a mindset of problem solving to solve some of pressing problems solving to solve some of pressing problems we face in our daily lives through Smart India Hackathon (SIH) 2019.
SIH 2023 brings the next generation evolution by inclusion of new methodology to inculcate the culture of startup and innovation ecosystem across different age groups i.e. are as follows: -

- SIH Junior (Jr) School students from 6th to 12th class will be able to showcase their talent and generate out-of-the-box open innovation ideas.
- SIH Senior (Sr) Regular Students of HEI's pursuing "Graduate/Post-Graduate/Ph.D." will be able to showcase their talent and generate out-of-the-box open innovation ideas

ii. **Internshala**: Internshala is India's largest internship and training platform where more than 80,000 companies look for interns in various profiles (Engineering, management, media, arts etc.) AICTE has also partnered with Internshala for providing internship opportunities to every student in AICTE approved colleges. This facility is created to provide a platform for hands on experience to our future technicians on the relevant industries. With this experience, they are updated with the latest advances in their field of work.

Government of India through, AICTE is engaged in promoting the concept of industrial training through its various scheme, such as Internshala. The teachers now have the responsibility to understand in depth and implement such schemes in the institution for the benefit of students. At institute level also, there is need to develop policy for sending the students for industrial training.

**c. Initiatives by All India Council for Technical Education (AICTE)**

All India Council for Technical Education (AICTE) has been actively promoting various schemes to enhance internship, industrial training, and industrial visit opportunities for students pursuing technical education. These schemes aim to provide practical exposure, industry-relevant skills, and hands-on experience to students enrolled in AICTE-approved institutions. Since the schemes are reviewed continuously, the latest update can be referred through AICTE website.

i. **AICTE Training and Learning (ATAL) Academy**: The ATAL Academy provides opportunities for faculty and students to participate in various skill development programs, including internships and industrial training, to enhance their technical knowledge and expertise.
ii. **AICTE Doctoral Fellowship Scheme**: This scheme offers financial support to full-time Ph.D. scholars to undertake internships, research visits, or collaborative work with industry and research organizations in India and abroad.
iii. **Margdarshan Scheme**: The Margdarshan Scheme encourages faculty members to interact with industries and update their technical knowledge, which, in turn, benefits the students through better industry exposure and guidance. The National Education Policy (NEP) 2020 has also stressed on accreditation and it forms one of the four pillars for benchmarking and ensuring quality. The creation of National Accreditation Council as envisaged under NEP is thus only a matter of time after the suitable legislation is enacted. As per the NEP, accreditation shall be the sole driver for all future educational restructuring and changes. Hence it has become much more essential for an institute to strive and obtain accreditation for their programmes. This Margdarshan Initiative was last revised in May 2022. While the scheme has progressed, a need was felt to undertake a review and amplify the guidelines based on the feedback from the environment and other developments.
iv. **AICTE Training and Learning (ATAL) FDP Internship**: Under this scheme, faculty members have the opportunity to undergo internships at reputed industries to gain practical insights and update their teaching methodologies.
v. **AICTE Internship Policy**: AICTE has laid down an Internship Policy to encourage students to undertake internships as part of their academic curriculum. This policy aims to enhance their employability and bridge the gap between industry and academia.
vi. **AICTE-MODROBS (Modernization and Removal of Obsolescence) Scheme**: The MODROBS scheme supports the modernization of laboratories and workshops in technical institutions to enhance students' hands-on training experience. The scheme aims to modernize and remove obsolescence in the Laboratories / Workshops / Computing facilities (Libraries are excluded), so as to enhance the functional efficiency of Technical Institutions for Teaching, Training and Research purposes. It also supports new innovations in Class Room and Laboratory / Teaching Technology, development of Lab Instructional Material and appropriate Technology to ensure that the practical work and project work to be carried out by students is contemporary and suited to the needs of the Industry.

vii. **AICTE Vocational Education Programs**: AICTE supports vocational education programs that incorporate practical training, internships, and apprenticeships to make students industry-ready.

viii. **Industrial Visits and Training by Institutions**: While not a specific AICTE scheme, AICTE-approved institutions often organize industrial visits and training programs as part of their curriculum to provide practical exposure to students.

**d. Initiatives by Ministry of Labour and Employment, Govt. of India**

Ministry of Labour and Employment, Government of India launched a National ICT based job portal known as National Career Service (NCS) portal to connect the opportunities with the aspirations of youth. This portal facilitates registration of job seekers, job providers, and skill providers. Career counsellors, etc. The portal provides job matching services in a highly transparent and user-friendly manner. These facilities along with career counselling content are delivered by the portal through multiple channels like career centres, mobile devices, CSCs, etc.

The portal provides information on over 3000 career options from 53 key industry sectors. Job seekers also have access to industry trends in a user-friendly way. The NCS portal links job-seekers, employers, counsellors and training providers all through Aadhaar-based authentication. Registration to NCS portal is online and free of charge. The salient feature of NCS portal includes the following:

- Career counselling and Guidance
- Enabling Skill Development
- Empowering Job Seekers to find the right job
- Enabling employers to pick the right talent
- Enhancing capabilities of students through training
  Information's related to Job Fairs/Placements

**Employment Exchanges Mission Mode Project (EE - MMP)**

The Employment Exchange Mission Mode project is one of the 31 Mission Mode Projects under National e-Governance Plan (Ne-GP). Budget of INR 148.70 crore has been approved for 12$^{th}$ Five Year Plan for this project in December, 2013. The aim of EE-MMP is to provide career options and facilitate informed choice to the job seekers by providing a national platform for interface between stakeholders for responsive, transparent and efficient career services in order to meet the skill needs of a dynamic economy. The objective of EE-MMP is to take up process

Re-engineering and convert NES (National Employment Service) into NCS (National Career Service).

**National Career Service (NCS)**

NCS is proposed to have variety of services like information about skill development courses, apprenticeship, internship, career counseling, etc. along with all employment related services. It is expected that the NCS would be accessible to all stakeholders, based on partnerships and would provide larger number of services supported by call centers/helpdesk and through network of new nodes like CSC (common service centers), etc.

The main stakeholders for the NCS would include:

- Unemployed candidates seeking jobs
- Students seeking career counseling
- Candidates seeking vocational / occupational guidance
- Illiterate, under-privileged sections of society, blue-collar workers seeking placements and guidance
- Person with different abilities (PWDs), ex-servicemen, veterans / senior citizens, etc.
- Employers seeking suitable candidates

**e. Initiatives by Telecom Sector Skill Council (TSSC)**

TSSC has taken a step towards fulfilling the emerging requirements of the industry by partnering with key stakeholders in order to bring the latest content to the forefront. TSSC have got into partnership with All India Council for Technical Education (AICTE) for summer internship programme and various other MNCs to impart Skilling in new emerging technologies. Some of the prime courses in new emerging technologies being offered by TSSC in addition to TSSC Qualification packs are as under:

- Artificial Intelligence & Data Science
- Cyber Security
- Internet of Things
- Android
- AR/VR

In addition to this certain course on life skills/soft skills, employability related skills are also planned for the students such as

- Problem solving and analytic
- Communication skills
- Lifelong learning
- Behavioural Skills
- Professional Behavioural etc.

The main objectives of TSSC are as follows

- Bridge the gap and enhance employability of our students
- Training young minds towards 21st Century skills assisting industry cross-sector
- Meet the needs of school leavers and graduates, employers, government educational institutions and society.
- Address the need for quality, skill training for human resources to complement the large goal of accomplishing the include growth.
- Address the limited capacity of skills development facilities in India
- To develop extensive placement linkages with employers in all sectors to provide gainful entry-level employment opportunities to youth undergoing the skill training.
- Industry participation in developing the skill training solutions to address critical skill gaps by standardization of training content, delivery and assessment process o improve overall competitiveness of the industry.
- Set up a comprehensive pan- India Labour Market Information System (LMIS) i.e. preparing a web-based compendium of job roles and skill types to assist in planning for re-skilling, delivery of training and employability.
- Undertake occupational mapping and skill gap analysis i.e. identification of skill development needs based on LMIS and emerging technologies.
- Rationalize and maintain a skill inventory.
- Create a skill development plan in coordination with Electronic and IT sector skill councils.
- Review and identify emerging skill gaps by trend analysis.

- Develop National Occupational Standards (NOS) that feature skill competency standards and qualifications.
- Refine the existing curricula to align it with NOS, obtain approval from an industry led body of experts and facilitate building of delivery capacity.
- Plan and institutionalise an effective system for training of trainers.
- Steer the affiliation and accreditation processes to enable quality assurance in training in par with international standards. Steer the affiliation and accreditation processes to enable quality assurance in training in par with international standards.
- Create an assessment framework to award tamper proof certifications to trainees.
- Promote academies of excellence by nurturing state of vocational training.
- Manage resources efficiently to achieve results and value for money.

**2. Initiatives by other agencies**

**a. Initiatives by Engineering Council of India (ECI)**

(ECI has also taken initiatives to organize series of interactive workshops to update and apprise the students about the products and services being offered by respective corporate house. This interaction will definitely bring the institute and industry closer and help in planning for effective implementation of industrial training.

**b. Others**

Many public sector and private organizations are also contributing to the course of quality improvement in technical education system by way of arranging industrial visit of providing industrial training to the students as a part of their corporate social responsibility and also for the growth of technical education system of the country.

**K)** **Assessment Rubric for Internship, Industrial Visit & Industrial Training:** Assessment Rubric for Internship, Industrial visit and industrial training should be prepared based on the objectives set and type of industries where internship/visit or training has been planned. Specific criteria of performance/assessment before, during and after the internship, industrial visit and industrial training should be identified by the implementing teachers for designing the rubric. For objective, valid and reliable assessment of Industrial Training, Industrial Visit and Internship, different tools of assessment such as a checklist, rating scale, assessment rubric, observation schedule, portfolio assessment, incidental records etc. need to be prepared by teachers. Even the students may be encouraged to adopt self-assessment techniques using the assessment rubrics.

**L)** **CO-PO, PSO Mapping:** Based on the requirement of programme, objectives set and type of internship, industrial visit and industrial training placed at different semesters, CO-PO, PSO mapping need to be done. This mapping will vary at different semesters for same programme. Implementing teachers play very important role in developing the CO-PO, PSO matrix.

## M) References:


- **AICTE Internship Policy: Guidelines & Procedures (Nelson Mandela Marg, Vasant Kunj, New Delhi-110070)-** https://aicte-india.org/sites/default/files/AICTE%20Internship%20Policy.pdf

- **AICTE Internship Policy Guidelines & Procedures-** https://www.aicte-india.org/sites/default/files/Aicte%20Internship%20Policy-%2002.04.2019.pdf

- **AICTE Quality Initiatives In Technical Education-** https://www.aicteindia.org/sites/default/files/AICTE%20QUALITY%20INITIATIVES%20IN%20TECHNICAL%20EDUCATION.pdf
- **AICTE Internship Portal-** https://internship.aicte-india.org/
- **Industrial Visit-** https://www.dsu.edu.in/commerce-management/scms-industrial-visit
- **AICTE Idea (Idea Development)-** https://idealnet.aicte-india.org/assets/data/scheme_doc.pdf
- **AICTE Initiative-** https://aicte-india.org/initiatives
- **Draft Guidelines for Research Internship with Faculty and Researchers at Higher Education Institutions/Research Institutions-** https://www.ugc.gov.in/pdfnews/1887287_Rsearch-Internship-Guidelines-120522.pdf
- **AICTE internship 2022: Everything you need to know-** https://ischoolconnect.com/blog/aicte-internship-everything-you-need-to-know/
- **Industrial Visits Policy and Analysis-** https://www.sggs.ac.in/home/page/Industrial-Visits-Policy-and-Analysis
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- **Industry Interaction Initiatives-**https://sjbit.edu.in/industry-interaction-initiatives-ise/
- **Internship Policy: Guidelines and Procedures 2021-22 Onwards-** https://scetngp.com/wp-content/uploads/2023/04/Internships-Training.pdf
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- **UG Internship/Industrial Training/Project Work Guidelines (w.e.f. Academic Session 2020-21**)- https://nitkkr.ac.in/wp-content/uploads/2021/09/UG-Internship-Guidelines_final-08042021.pdf
- **Internship Policy-** https://iar.ac.in/wp-content/uploads/2022/02/IAR-Internship-Policy.pdf
- **Industry Institute Interaction Policy-** http://www.gcekarad.ac.in/Placement/III_Policy_2021_Main.pdf
- **Internship Policy August 2021-** https://ksrct.ac.in/wp-content/uploads/2022/12/Internship-Policy.pdf
- **Summer Internship Programme (Sip) Policy: Guidelines & Procedures-** https://www.ipeindia.org/wp-content/uploads/2021/12/SIP-Guidelines-EDITED-21st-MAR-2021-Inline with- AICTE-Internship-Policy-2019-1.pdf
- **Internship Policy: Guidelines and Procedures with Effect from Academic Year 2020-2021-** https://www.kitcoek.in/documents/academics/internship-policy/kit-internship-policy-2020.pdf
- **Internship / Industrial Training-** https://www.dkte.ac.in/placement/internship
- **Ministry of Commerce and Industry (DPIIT Internship Scheme)**- https://www.myscheme.gov.in/schemes/dpiit-is

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**A) Course Code : 2418507(P2418507/S2418507)**

**B) Course Title :** Minor 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 a higher level of cognitive, psychomotor and affective domain skills. It encourages the critical thinking process in the students. Project work is normally done when students have acquired sufficient knowledge, skills and attitude and are able to integrate all these, entirely in a new situation or task to solve the problems of the industries/real world. Project work 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.

In diploma programme of state of Bihar, minor project is being carried out at 5$^{th}$ semester where all aspects of project planning will be deal in detail.

**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** Identify a real-world problem in the form of a project to be developed.
**CO-2** Perform literature survey related to the identified area/problem.
**CO-3** Identify preliminary resource requirements (Equipment, Tools, Software, Manpower, Services)
**CO-4** Prepare project synopsis for the identified problem/project title within stipulated time period.

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

| Course Outcomes (COs) | Programme Outcomes (POs) | | | | | | | Programme Specific Outcomes* (PSOs) | |
|---|---|---|---|---|---|---|---|---|---|
| | **PO-1** Basic and Discipline Specific Knowledge | **PO-2** Problem Analysis | **PO-3** Design/ Development of Solutions | **PO-4** Engineering Tools | **PO-5** Engineering Practices for Society, Sustainability and Environment | **PO-6** Project Management | **PO-7** Life Long Learning | **PSO-1** | **PSO-2** |
| **CO-1** | 3 | 2 | - | - | - | - | 1 | | |
| **CO-2** | 3 | 2 | - | - | - | 2 | 1 | | |
| **CO-3** | 3 | 2 | - | 2 | - | 2 | 1 | | |
| **CO-4** | 3 | - | - | - | - | 3 | 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 | | | | |
| **2418507** | Minor Project | - | - | 02 | 02 | 04 | 02 |

**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) | |
| **2418507** | Minor Project | - | - | 10 | 15 | 10 | 15 | 50 |

**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 Plan of Minor Project:

Suggested implementation plan of minor project along with guidelines to teachers and students are mentioned below. For effective implementation of the project work in totality, different steps are to be carried out at different stages of the comprehensive project work.

- Project Planning. (**Minor Project**)
- Design, development and execution of the project. (**Major Project**)
- Quality of report writing and presentation.

In this semester, under the minor project work, the students are guided and monitored to under take Project planning steps as mentioned below. While, the remaining steps of project implementation will be carried out during major project work in next the semester.

### 1.0 Guidelines to Students for Implementation of Minor Project.

Students are guided to undergo following steps under the minor project. Teacher are advised to guide the students on each and every step.

**1.1** Identification of Area/Problem and Project Titles
**1.2** Literature Survey
**1.3** Identification of Outcomes of the Project
**1.4** Identification of the recourses required.
**1.5** Preparation of Synopsis
**1.6** Presentation of Synopsis

### 1.1 Identification of Project Titles and Allocation Methodology:

Though the teachers and students, both are involved in identification of project titles, but the prime responsibility of identification of project titles goes to the respective teachers involved in implementing the course or programme. Teachers are fully aware of course/programme curriculum and they are also aware of related industrial problems hence, they try to explore the possibility of identification of project titles through these problems.

These small industrial problems in the form of project titles may be brought into the laboratories or workshop of institutions of a specific programme, which are equipped with all necessary facilities and resources to carry out the project work. These labs or workshop can function as miniature industry to solve the industrial problems in the form of simulated industrial projects. These projects may be integrated problem of courses or programme.

**Criteria for Identification of Project Titles**.

The identification of problem statement must be based on the following criteria:

- 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

### 1.2 Literature Survey:

Literature survey on the project title needs to be done through journals, websites, open source technologies available, discussion with the practicing engineers/industry persons and other relevant sources available.

### 1.3 Outcomes of the Project:

The project guide should ensure that the project outcomes are written properly as clear, specific, measurable and attainable statements. The outcomes formulated will decide the overall scope or course of action, depth and breadth of the project and implementation plan.

### 1.4 Identification of the recourses required:

Students under the guidance of teacher should try to identify all the resources required for the completion of the project like equipment, devices, experimental test rig, software, computer, persons to be contacted, suppliers, funds, availability of internal/external lab. The sample size has to be delimited and decided as per the time limit allotted, feasibility and many other considerations.

### 1.5 Preparation of Synopsis:

The students at the end of the semester are expected to submit 'Project Synopsis' after interaction with guide, as per the guidelines and format provided.

### 1.6 Presentation of Synopsis:

After developing the synopsis, student(s) should prepare a Power Point Presentation and present the same in front of examiner, guide and audience. Quality of presentation of data need to be ensured using the following criteria through Rubric-

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

## 2.0 Guidelines to Teachers for Implementation of the Minor Project:

The teacher along with the students should identify the different types of project title(s) as per need of the client as mentioned below:

- Prototype Development
- Experimentation Type
- Software Development Type
- Solving Industrial Problem Type
- Market Survey Type
- Feasibility Study Type
- Simulation Based
- Application Type
- Product Type
- Research Type
- Review Type

The project must be feasible. The guide allocated for each project are responsible for the quality of student's work, on different criteria including the synopsis writing which can be monitored on continual basis.

The guide must ensure that the feasibility of the project, the availability of resources/ software technology, sufficiency of time, finance and requirements during each and every step or activity of project work in advance.

## J) Assessment of the Minor Project:

Continual Monitoring and feedback mechanism should be developed by the guide. An assessment plan on weekly progress/updates, action taken on different criteria and sub-criteria of the project work is suggested below. Path-breaking teachers who think out of the box are required to guide, monitor and evaluate the project work.

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 below mentioned assessment criteria at project planning stage. The Project guide must prepare detailed rubric(s) for each criteria to have valid and reliable assessment.

**Assessment Scheme for Minor Project**

| S. No. | Suggested Assessment Criteria | Suggested Weightage (%) |
|---|---|---|
| 1. | Identification of Area/Problem Statement | 10 |
| 2. | Literature Survey | 20 |
| 3. | Formulation of Project Title | 10 |
| 4. | Clarity in Formulation of Outcomes of The Project | 10 |
| 5. | Preparation of Synopsis | 30 |
| 6. | Presentation of Synopsis | 20 |
| | **Total** | **100** |

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