GOVERNMENT POLYTECHNIC, PUNE

'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN E & TC**
PROGRAMME CODE	**03**
COURSE TITLE	**DRONE TECHNOLOGY**
COURSE CODE	**ET51206**
PREREQUISITE COURSE CODE & TITLE	**NA**
CLASS DECLARATION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TSL				Based on SL		Total Marks
														Practical						
			CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
										Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
ET51206	DRONE TECHNOLOGY	DSE	3	1	2		6	3	3	30	70	100	40	25	10	25#	10			150

Total IKS Hrs for Term: 0 Hrs

Abbreviations: CL-Classroom Learning, **TL**-Tutorial Learning, **LL**-Laboratory Learning, **SLH**-Self Learning Hours, **NLH**- Notional Learning Hours, **FA** - Formative Assessment**, SA** -Summative assessment, **IKS** – Indian Knowledge System, **SLA**- Self Learning Assessment

Legends: @-Internal Assessment, **#** - External Assessment, ***#** - Online Examination, **@$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as **'Detained'** in that course.
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as **'fail'** and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. * Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

An unmanned aerial vehicle (UAV) or uncrewed aerial vehicle commonly known as a drone, is an aircraft without any human pilot, crew or passengers on board. UAVs are a component of an unmanned aircraft system (UAS), which include additionally a ground-based controller and a system of communications with the UAV. The flight of UAVs may operate under remote control by a human operator, as remotely piloted aircraft (RPA), or with various degrees of autonomy, such as autopilot assistance, up to fully autonomous aircraft that have no provision for human intervention. UAVs were originally developed through the twentieth century for military missions. As control technologies improved and costs fall, their use in the twenty-first century is rapidly finding many more applications including aerial photography, product deliveries, agriculture, policing and surveillance, infrastructure inspections. The goal of the Drone Technology course is to familiarize the students with the concepts and techniques used in design of a small drones and its applications.

III. COURSE-LEVEL LEARNING OUTCOMES (CO'S)

Students will be able to achieve & demonstrate the following COs on completion of course-based learning

CO1: Know about a various type of drone and its technology.
CO2: Select appropriate sensors and actuators for drones.
CO3: Interpret the role and working of drone motors and ESC.
CO4: Analyze the stability and control system used in drone.
CO5: Execute the suitable operating procedures for functioning a drone.
CO6: Develop a drone mechanism for specific applications.

THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
SECTION I				
UNIT-I INTRODUCTION TO DRONE TECHNOLOGY (CL Hrs-08, Marks-08)				
1.	**TLO 1.1:** Describe history of Flight and Ancient Concepts related to it. **TLO 1.2:** Describe evolution of UAV Technology. **TLO 1.3:** Explain drones types and its applications. **TLO1.4:** Classify drones by their weight category. **TLO 1.5:** Explain terminologies related to drones.	1.1 History of drone. 1.2 Evolution of drone . 1.3 Introduction of drones: types (fixed, rotary, hybrid) 1.4 Applications of drone. 1.5 Classification of drone by weight categories. 1.6 Terminology Related to Drone -UAV (Unmanned Aerial Vehicle), Remote Pilot, UAS (Unmanned Aircraft System),RPAS (Remotely Piloted Aircraft System),GCS(Ground control station),VLOS(Visual Line of Sight) BVLOS(Beyond Visual Line of Sight),UIN(UAV Identification Number),UAOP(UAV Operations Permit)	Classroom Learning, Reference books, NPTEL	**CO1**
UNIT-II DRONE COMPONENTS AND SAFETY (CL Hrs-10, Marks-15)				
2	**TLO 2.1:** Describe basic Building blocks of drone system and subsystem . **TLO 2.2:** Describe drone components and its function. **TLO 2.3:** Explain drone flying rules, regulations and safety precautions.	2.1 Basic Building blocks of Drone system and subsystem. 2.2 Sensors-Accelerometer, Magnetometer, Barometer, Camera. 2.3 Drone components: Motors, Batteries Propellers, ESC (Electronic Speed Controller) Drone transmitter and receiver, Drone software and firmware. 2.4 Selecting and assembling drone components such as motors, batteries, flight controllers, and cameras. 2.5 Regulation and Safety: Drone flying rules, regulations and safety precautions (as per Drone Rules 2021) governed by DGCA .	Classroom Learning, Reference books, NPTEL	**CO2**

UNIT-III DRONE MOTORS AND ESC (CL Hrs-06, Marks-12)				
3	**TLO 3.1** Explain types and working of drone motors**.** **TLO 3.2:** Describe propellers and its type. **TLO 3.3:** Describe working of frames and its types. **TLO 3.4:** Describe the working of components associated with drone.	3.1 Motor: Types of motor, Brush and Brushless Motors, motor sizing and identification, mounting patterns and thread size, Thrust to Weight ratio, KV ratings, advanced motor selection. 3.2 Electronic Speed Controllers (ESC)-Working principle and specifications. 3.3 Propellers and its type 3.4 Frame and its type.	Classroom Learning, Reference books, NPTEL	**CO3**
SECTION II				
UNIT- IV FLIGHT DYNAMICS (CL Hrs-6, Marks-08)				
4	**TLO 4.1:** Explain principles of flight. **TLO 4.2** Explain Working of flight controller. **TLO 4.3:** Describe power management used in drone.	4.1 Principle of Flight: Lift thrust, drag, weight, axis of drone motion (pitch, roll and yaw), aerodynamic principle. 4.2 Flight Controller- working principle 4.3 Power Management -Batteries, calculations of flying time based on battery capacity, power distribution board.	Classroom Learning, Reference books, NPTEL	**CO4**
UNIT- V DRONE DESIGN ASSEMBLY, OPERATION AND MAINTENANCE (CL Hrs-08, Marks-15)				
4	**TLO 5.1** Explain drone design principle. **TLO 5.2:** Describe selection criteria for different components used in drone. **TLO 5.3:** Explain assembly and integration system of drone. **TLO 5.4:** Describe procedure for drone operation. **TLO 5.5:** Explain the maintenance process of drone.	5.1 Design considerations for drone airframe and propulsion systems: aterial selection, frame structure and shape 5.2 Component Selection: Motor, Frame, Propeller ,power distribution board, Battery, Flight controller, Transmitter and Receiver, Cameras and Sensors 5.3 Assembly and Integration : Basic wiring and soldering ,assembling components into functional drone. 5.4 Procedure for drone operation.. 5.5 Troubleshooting And Maintenance: Diagnosing and fixing common issues (Power Issue, Connectivity problems , GPS issues, Motor and ESC malfunctions, propeller problems, Battery problems, Camera and Gimbal Issue, Firmware or Software Errors), maintenance (pre-fight maintenance, Post-flight Maintenance, Battery Maintenance, Motor and Propeller maintenance, Regular Inspections) and calibration.	Classroom Learning, Reference books, NPTEL	**CO5**

UNIT –VI DRONE APPLICATIONS AND FUTURE TRENDS Hrs-07, Marks-12)				
5	**TLO 6.1** Explain applications of drone in various field . **TLO 6.2** Explain Autonomy and AI concepts used in drone **TLO 6.3** Explain role of drone technology in future	6.1 Applications: Drones in agriculture, construction, logistics, military and cinematography. 6.2 Autonomy and AI: Basics of autonomous flight, waypoint navigation, sensor fusion and machine learning for object selection. 6.3 Emerging trends: Drone swarming, AI-Powered Drone for Data Analytics ,Solar powered drone, Advanced sensors used in Drones for Imaging Technology	Classroom Learning, Reference books, NPTEL	**CO6**

LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL/ TUTORIAL EXPERIENCES.

Sr. No	**Practical/Tutorial/Laboratory Learning Outcome (LLO)**	**Laboratory Experiment / Practical Titles /Tutorial Titles**	**Number of hrs.**	**Relevant COs**
1*	LLO 1. Know history of flight and ancient concepts of aerodynamics. LLO 1 Understand overview of drones, including their history, types, and applications.	Preparation of a report/chart on the history of flight and illustrate the evolution timeline of UAV technology for various module till date.	2	**CO1**
2	LLO 2.1 Explore Digital sky platform	Exploration of Digital sky platform	2	**CO1**
3*	LLO 3.1 Identify the zones (Red, Yellow, Green) by using Airspace map for any district and area near the airport.	Identification of zones (Red, Yellow, Green) by using Airspace map for any district and area near the airport.	2	**CO1**
4*	LLO 4.1 Classify of drones by weight categories and define the related terminologies as per Drone Rules 2021	Preparation of a report/chart on the classification of drones by weight categories and define the related terminologies as per Drone Rules 2021	2	**CO1**
5*	LLO 5.1 Identify the mechanical components in drones, and describe their specifications and functions.	Identification of mechanical components in drones, and describe their specifications and functions.	2	**CO2**
6*	Identify the electrical components in drones, describing their specifications and functions.	Identification of electrical components in drones, describing their specifications and functions.	2	**CO2**
7	Identify the electronics components in ones, describing their specifications and functions.	Identification of electronics components in ones, describing their specifications and functions.	2	**CO2**
8*	LLO 8.1 Memorize the DGCA regulations & safety Protocols for	Preparation of a report/chart on DGCA regulations & safety Protocols for Drone	2	**CO2**

	Drone operation.	operation.		
9*	LLO 9.1 . Plot the Speed-Torque characteristics of a BLDC Motor used in drone.	Plot the speed-torque characteristics of Drone's BLDC motor	2	**CO3**
10*	LLO 10.1 Observe battery pack for bulges and leakage.	Inspection of a battery pack for bulges and leakage.	2	**CO4**
11*	LLO 11.1 Calculate the flying time based on battery capacity.	Calculation of flying time based on battery capacity.	2	**CO4**
12*	LLO 12. I Assembling of the quadcopter Drone	Assemble the quadcopter Drone using the given components	2	**CO5**
13*	LLO 13.1 Configure and operate the Drone transmitter and receiver	Configuration and operation of Drone transmitter and receiver	2	**CO5**
14	LLO 14.1 Test the assembled drone LLO 14.2 Troubleshoot the assembled drone	Test the assembled drone.	2	**CO5**
15	LLO 15 Search different application of drone technology in Agriculture.	Preparation of a report/chart on application of Drone technology in Agriculture.	2	**CO6**
16*	LLO 16.1Search different application of Drone technology in cinematography.	Preparation of a report/chart on application of Drone technology in cinematography	2	**CO6**

Note: A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of a minimum of 12 or more practical needs to be performed. Out of which, the practical marked as '*' are compulsory.

IV. SUGGESTED MICRO PROJECT /ASSIGNMENT/ACTIVITIES FOR SPECIFIC LEARNING/ SKILLS DEVELOPMENT (SELF-LEARNING)

Micro project

- .
- Write a report describing the power systems in drones. Include types of batteries, voltage regulators, and power distribution methods used.
- Create a chart to explain the different types of power systems used in drones, including batteries, voltage regulators, and power distribution boards.
- Explain how drones maintain stability in flight (control surfaces, sensors, etc.). Provide a basic explanation of how drones stay balanced during flight.
- Prepare a report on how Drones communicate with remote controllers and base stations. Provide a brief explanation of wireless communication protocols like RF, Wi-Fi, and telemetry.
- Write a report on the future of drones, including trends like Al integration, drone swarming, and new applications. Discuss how these trends could impact various industries
- Explore and make ppt on current drone regulation (DGCA.) and summarize the key safety and operational rules.
- Make chart explaining the Drone policy implemented in India for various application.
- Draw a diagram illustrating the principles of drone flight (It, thrust. d weight). Label the forces and explain how they work together in stable flight
- Create an info-graphic or chart that shows the key components of a drone (motors, ESCs, flight controller, GPS sensors). Briefly describe each part's role in the flight system

- Create a comparison table of popular drone software like ArduPilot, PX4, and ROS. Highlight their features, advantages, and differences in functionality
- Create a chart that compares different types of drones (fixed-wing rotary-wing, hybrid). Include details such as their flight mechanism, uses, and advantages/disadvantages.
- Explore Indian Government schemes related to Drone used various sector and tabulate it

V. LABORATORY EQUIPMENT/ INSTRUMENTS/ TOOLS/ SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Computer system with internet connectivity	1 23 4 8 15,16
2	Any office software and browser	1 2 3 4 8 15,16
3	Quadcopter Drone K 11	5,6,7,9,10,11,12,13,14
4	Tinker cad Circuit Software	7
5	Tachometer	9
6	Digital Multimeter	9,10,12,13,14

VIII.SUGGESTED FOR WEIGHTAGE TO LEARNING EFFORTS &ASSESSMENT PURPOSE (Specification Table)

Sr. No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
SECTION I								
1	I	**INTRODUCTION TO DRONE TECHNOLOGY**	CO1	08	4	2	2	8
2	II	**DRONE COMPONENTS AND SAFETY**	CO2	10	5	6	4	15
3	III	**DRONE MOTORS AND ESC**	CO3	06	4	4	4	12
								35
SECTION II								
4	IV	**FLIGHT DYNAMICS**	CO4	06	2	2	4	8
5	V	**DRONE DESIGN ASSEMBLY, OPERATION AND MAINTENANCE**	CO5	08	3	6	6	15
6	VI	**DRONE APPLICATIONS AND FUTURE TRENDS**	CO6	07	2	4	6	12
								35
		Grand Total		**45**	**20**	**24**	**26**	**70**

VI. ASSESSMENT METHODOLOGIES / TOOLS

Formative assessment (Assessment for Learning)		Summative Assessment (Assessment of Learning)
1. Tests	4. Self-Learning	1. End Term Exam
2. Assignment	5. Term Work	2. Micro-project
3. Midterm Exam	6. Seminar/Presentation	

VII. SUGGESTED COS- POS MATRIX FORM

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	PSO-3
CO1	2	1	1	1	3	2	2	2	1	1
CO2	2	2	3	2	3	2	3	3	2	2
CO3	3	2	3	2	3	2	3	3	2	2
CO4	3	3	3	3	3	2	3	3	3	3
CO5	3	3	3	3	2	2	3	3	3	3
CO6	3	3	3	3	3	3	3	3	3	3

Legends:- High:03, **Medium:**02, **Low:**01, **No Mapping:** -
*PSOs are to be formulated at the institute level

SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher
1	Dr. B. S. sahay	Introduction to UAVs and Drone Technologies	Wiley India, ISBN: 978-8126566430
2	Dr. N. K. soni, S. K. Gupta	Fundamentals of UAVs and Drone Systems	Cambridge University Press, ISBN: 978-9386768365
3	Dr. P. S. Bhatia, Dr. R. K. Gupta	Unmanned Aerial Vehicles: Design and Applications	Narosa Publishing House, ISBN: 9788173195961
4	Dr. S. R. Das, Dr. D. K. Jha	Introduction to Drones: Design and Development	CRC Press, ISBN: 978-0367338372
5	Dr. Vijay R. lyer, Dr. S. P. Verma	Drones: A New Horizon in Aerial Robotics	Tata McGraw Hill, ISBN: 9781259008484

VIII. LEARNING WEBSITES & PORTALS

Sr.No	Link/Portal	Description
1.	https://digitalsky.dgca.gov.in/airspace-map/#/app	A digital sky airspace map is an interactive, real-time representation of airspace boundaries, flight paths, and aviation regulations, often used for flight planning and navigation
2.	https://playhop.com/app/154828	Drone flight simulator
3.	https://www.dgca.gov.in/digigovportal/jsp/dgca/homePage	The Drone Rules, 2021, Unmanned Aircraft System Rules, Government of India in the Ministry of Civil Aviation
4.	https://digitalsky.dgca.gov.in/home	Digital Sky Platform is an online portal by the Indian government for managing and regulating the operations of drones in Indian airspace.

Name & Signature:

Smt. M.V.Saraf
Lecturer in E&TC
(Course Experts)

Smt. A.P.Ghode
Lecturer in E&TC
(Course Experts)

Name & Signature:

Dr.Y.V.Chavan
(Programme Head)

Name & Signature:

Shri. S.B. Kulkarni
(CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE
'120-NEP' SCHEME

PROGRAMME	**DIPLOMA IN E & TC**
PROGRAMME CODE	**03**
COURSE TITLE	**ELECTRICAL VEHICLES**
COURSE CODE	**ET51207**
PREREQUISITE COURSE CODE & TITLE	**NA**
CLASS DECLARATION COURSE	**YES**

I. LEARNING AND ASSESSMENT SCHEME:

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week						Paper Duration(hrs.)	Theory				Based on LL & TL				Based on Self Learning		Total Marks
														Practical						
			CL	TL	LL	SLH	NLH			FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
										Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
ET51207	ELECTRICAL VEHICLES	DSE	03	01	02	-	06	03	03	30	70	100	40	25	10	25#	10	-	-	150

Total IKS Hrs. for Semester: 0 Hrs.
Abbreviations: CL- Class Room Learning, TL- Tutorial Learning, LL- Laboratory Learning, SLH- Self Learning Hours, NLH- Notional Learning Hours, FA - Formative Assessment, SA-Summative assessment, IKS – Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# Online Examination, @$- Internal Online Examination.
Note:

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If the candidate is not securing minimum passing marks in the FA-PR of any course, then the candidate shall be declared as "Detained" in that course.
3. If candidate is not securing minimum passing marks in SLA of any course, then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL) hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self-learning hours shall not be reflected in the Timetable.
7. * Self-learning includes micro project/assignments / other activities.

II. RATIONALE:

The present movement for sustainable energy has positioned electric vehicle (EV) technology as a crucial field for electrical engineers. This course is designed to provide students with the essential knowledge and skills to understand, test, and work with EV systems. Through a blend of theoretical instruction and hands-on laboratory experiments, students will develop a skill and knowledge of EV technology, equipping them for careers in the rapidly expanding electric vehicle industry.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course-based learning
CO1 - Identify components and subsystems used in electric vehicles.
CO2 - Select electrical drives for EV applications.
CO3 - Check the performance of batteries and energy storage systems used for EV applications.
CO4 - Interpret Battery Management Systems and Fuel Cell used for EV applications
CO5 - Apply the concept of converters and charging systems in EVs.
CO6 - Implement Indian and state EV policies for EV applications.

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No.	Theory Learning Outcomes(TLO's) aligned to CO's.	Learning content mappedwith TLO's	Suggested Learning Pedagogies	Relevant Cos
SECTION - I				
UNIT 1: INTRODUCTION OF ELECTRIC VEHICLES (CL Hrs.- 08 , Marks – 12)				
1	TLO 1.1 Compare electric vehicles and internal combustion engine vehicles on the given points. TLO 1.2 Describe the configuration of the given types of EV systems. TLO 1.3 Compare given EVs based on given points. TLO 1.4 Describe the function of a given EV subsystem.	1.1 History of electric vehicles (EV), need of EV, Electric vehicles and internal combustion engine vehicles: Comparison based on environmental impact, power source, maintenance, gear change, noise level, vibration level, capital cost, and running cost. 1.2 Electric vehicle architecture, Classification of EV: Battery Electric Vehicle (BEV), Hybrid Electric Vehicle (HEV), Plug-in Hybrid Electric Vehicle (PHEV), Fuel Cell Electric Vehicle (FCEV). 1.3 Comparison of different electric vehicle types based on Driving Components, Energy Source used, Features, Problems, and models available in the market. 1.4 EV Block diagram subsystems: energy source, propulsion, and auxiliary subsystem.	Lecture Using Chalkboard, Presentations, Visit, Hands-on, Video Demonstrations	**CO1**
UNIT 2: ELECTRIC VEHICLES DRIVES (CL Hrs. – 09, Marks--15)				
2	TLO 2.1 Classify Electric Vehicles. TLO 2.2 Interpret the characteristics of the electric motor(s) used in EV. TLO 2.3 Distinguish between the given EV motors based on the given points. TLO 2.4 Select given electrical drives for EV applications.	2.1 Types of electric drives used in EV: DC Motor drives, AC Motor drives. 2.2 Brushed DC Motor, Brushless DC Motor (BLDC), Permanent Magnet Synchronous Motor (PMSM), Induction Motor (IM), Synchronous Reluctance Motor (SynRM), PM Assisted Synchronous Reluctance Motor, Axial Flux Ironless Permanent Magnet Motor: Salient features, characteristics, advantages, limitations, and usage of different motor types in EV models. 2.3 Comparison of EV motors based on power-weight ratio, torque-speed characteristic, cost of controllers required, and cost of motors. 2.4 Position of motor in EV, Rating of motors, Connections (Mechanical and Electrical), and Selection criteria of various types of EV motors.	Lecture Using Chalkboard, Presentations, Visit, Hands-on, Video Demonstrations	**CO 2**

UNIT-3 ENERGY STORAGE SYSTEM AND BATTERIES (CL Hrs.- 06 , Marks- 08)				
3	TLO 3.1 Describe the given terms related to battery parameters. TLO 3.2 Describe the procedure for selecting of battery for the given EV. TLO 3.3 Calculate EV battery capacity based on mileage and load.	3.1 Energy storage technology: EV Batteries, Supercapacitors, flywheel energy storage. Battery Parameters: Cell and Battery Voltages, Charge (or Amphour) Capacity, Energy Stored, Specific Energy, Energy Density, Specific Power, Amphour (or Charge) Efficiency, Energy Efficiency, Charging -discharge Rates, Battery Structure, Battery Temperature, Heating and Cooling Needs, Battery Life and Number of Deep Cycles. 3.2 Batteries: Lead-acid, NiMH (Nickel-Metal Hydride), Li-Ion (Lithium-Ion), Ni-Zn (Nickel-Zinc), Ni-Cd (Nickel-Cadmium), Aluminum–Ion batteries (Al–Ion batteries), Aluminum–air batteries (Al–air batteries)- their basic construction components, lifetime (cycles), efficiency, advantages, and disadvantages. Comparison of various batteries. Factors affecting the operation of the battery and the selection of the battery. Series and Parallel connection of Batteries, Calculation of battery capacity.	Lecture Using Chalkboard, Presentations, Visit, Hands-on, Video Demonstrations	**CO3**
SECTION - II				
UNIT-4 BATTERY MANAGEMENT SYSTEMS AND FUEL CELL (CL Hrs.- 06 , Marks- 08)				
4	TLO 4.1 Describe the process of the given Battery Management System (BMS). TLO 4.2 Compare the given types of fuel cells based on given points.	4.1:Battery Management Systems (BMS): Need of BMS, Block diagram of BMS, the Function of each block, Battery Condition Monitoring, "3R" (Reduce, Reuse, Recycle) process for the battery. 4.2 Fuel Cell: Difference between fuel cell and batteries, Fuel Cell Terminology: Anode, Cathode, Electrolyte, Catalyst, Reformer, Direct Fuel Cell, Working principle of fuel cell. Types of Fuel Cells used in EVs: Alkaline Fuel Cell (AFC), Polymer Electrolyte Membrane Fuel Cell (PEMFC), Phosphoric Acid Fuel Cell (PAFC), Molten Carbonate Fuel Cell (MCFC), Solid Oxide Fuel cell (SOFC), Their comparison based on Electrolyte type, Cell voltage, Operating temperature, System output (kW), Efficiency (%) and Applications.	Lecture Using Chalkboard, Presentations, Visit, Hands-on, Video Demonstrations	**CO 4**
UNIT-5 CONVERTERS AND EV CHARGERS (CL Hrs. - 08, Marks- 15)				
5	TLO 5.1 Describe the configuration and functions of the given type of converter. TLO 5.2 Describe given	5.1 Introduction to power electronics components used in EV, Block diagram of typical EV: Functions of DC-to-DC Converter, DC to AC Converter, AC to DC Converter (Rectifier), and filters.	Lecture Using Chalkboard, Presentations, Visit,	**CO 5**

	type of EV charging method(s). TLO 5.3 Distinguish between given charging systems. TLO 5.4 Describe the given type of charging station. TLO 5.5 Calculate charging time based on given data.	5.2 Battery Charging Methods: Home charging, Trickle charging, Household AC charging, public charging (DC Fast charging). 5.3Battery Charging System: Classification-Wireless, Onboard and Off-board charging, V1G (Uni-directional smart charging), V2B/V2H (Vehicle-to-Building/ Vehicle-to-Home), V2X (Vehicle-to-Everything), V2G (Vehicle-to-Grid, Bi-directional smart charging). 5.4 Charging Stations: Types of charging station, Public charging station: Selection and sizing, components and, single line diagram. Calculation of charging time and concept of battery swapping. Precautions were observed while charging.	Hands-on, Video Demonstrations	
UNIT-6 ELECTRIC VEHICLE (EV) POLICIES (CL Hrs- 8, Marks- 12)				
6	TLO 6.1 State the given points related to NEMMP. TLO 6.2 Compare incentive policies for the given types of electric vehicle.	6.1 Goal of EV30@30 campaign. Goals of the electric vehicles initiative in India. National Electric Mobility Mission Plan 2020 (NEMMP): Objectives, Steps taken by the Indian Government for faster adoption of electric vehicles, Barriers to adoption of electric mobility, E-mobility strategy, NEMMP 2020 Implementation structure. 6.2 Maharashtra Electric Vehicle Policy, 2021: Objectives, Basic demand incentives for electric vehicles, Vehicle segment-wise scrappage incentives, Incentives for charging infrastructure.	Lecture Using Chalkboard, Presentations, Visit, Hands-on,Video Demonstrations	**CO 6**

V. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL / EXPERIEMENT

.Sr. No.	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment/Practical Titles/Tutorial Titles	No. of Hrs.	RelevantCOs
1	LLO 1.1 Identify components of various types of electric vehicles.	*Identification of electric vehicle components.	2	CO1
2	LLO 2.1 Identify various subsystems of electric vehicles.	*Identification of subsystems of electric vehicles.	2	CO1
3	LLO 3.1 Identify the terminals of the Permanent Magnet Synchronous Motor. LLO 3.2 Identify the terminals of the Three-phase Squirrel cage Induction Motor. LLO 3.3 Identify the terminals of the Synchronous Reluctance Motor. LLO 3.4 Identify the terminals of the Brushless DC motor.	*Identification of terminals of motors used in EVs.	2	CO2

4	LLO 4.1 Determine and compare the characteristics of given EV motors.	Comparison of characteristics of EV motors.	2	CO2
5	LLO 5.1 Measure the open circuit voltage of a given battery using multimeter. LLO 5.2 Identify the charged, discharged and dead battery conditions. LLO 5.3 Determine Amp-hour (Ah) capacity of the battery.	*Testing of EV batteries.	2	CO3
6	LLO 6.1 Perform Active Lithium-Ion Cell balancing using a Plastic Platform Scale.	Battery Cell balancing.	2	CO3
7	LLO 7.1 Estimate capacity of battery pack for specified capacity of EV.	*Estimation of battery for EV.	2	CO4
8	LLO 8.1 Charge an EV battery using various methods, and record charging times and efficiency.	*Charging of EV battery.	2	CO5
9	LLO 9.1 Develop a charging station layout. LLO 9.2 Select the appropriate components of the charging station. LLO 9.3 Draw a single-line diagram of a charging station. LLO 9.4 Simulate the charging process of a charging station using any open-source software.	Development of a public charging station.	2	CO5
10	LLO 10.1 Calculate the charging time for different battery capacities using given formulas.	*Calculation of charging time of battery.	2	CO5
11	LLO 11.1 Prepare a report on Indian EV policy.	Report on Indian EV policy.	2	CO6
12	LLO 12.1 Prepare a report on Maharashtra EV Policy, 2021.	*Report on Maharashtra EV Policy, 2021.	2	CO6

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) are mandatory.
- Minimum 80% of above list of lab experiment are to be performed. Judicial mix of LLOs are to be performed to achieve desired outcomes.

Perform Any 10 Practical. All COs should be covered in the Perform practical.

VI. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING/SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

Prepare a report on the performance analysis of DC-DC converters and inverters in an EV setup.
Build and test simple DC-DC converters and inverters.
Develop an EV system model and simulate using any open-source software. Test sensors and systems for autonomous EVs and submit a report on it.
Perform sub-system simulations of an electric vehicle using any open-source software.

Assignment

Prepare a report on the comparative study of various two-wheeler EVs available in the market. Prepare a report on the setting of the Fast DC charging station.
Prepare a report on EV battery swapping technology.
Prepare a report on the comparative study of various four-wheeler EVs available in the market.
Prepare a report on the Internet of Things (IoT)/ Virtual Reality (VR)/ Augmented Reality (AR) related to EV.
Prepare a report on driverless EV cars available in the market.

Note : Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.

The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
If a microproject is assigned, it is expected to be completed as a group activity.
SLA marks shall be awarded as per the continuous assessment record.
For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional . Faculty may encourage students to perform these tasks for enhanced learning experiences.
If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Electric Vehicle two-wheeler: Top Speed-23 KM/H, Minimum Range-80 KM/C, Full Charge-4 to 5 HRS, Minimum Motor Power-250 Watts, Wheel Size-12 Inch, Minimum Battery Capacity/Rating-50V / 30Ah.	1,2,3,4
2	3½ Digit Digital Multimeter.	1,2,3,4
3	Brushless DC motor: 1 kW, 3000 rpm, at 3 Nm load torque/ whichever is available.	2
4	Three-phase AC Induction Motor: Max Motor Power: 41hp at 4500rpm, Max Motor Torque: 91Nm at 3000rpm/ whichever is available.	2
5	Permanent Magnet Synchronous Motor: Minimum power and torque/ whichever is available.	2
6	Synchronous Reluctance Motor: Minimum power and torque/ whichever is available.	2
7	Plastic Platform Scale Active Lithium Cell Balancing, Size: A3, Capacity: 80Ah.	3
8	Lithium-Ion E-Bike Battery, 20 Ah, Capacity (Ah).	3,4
9	Nickel-Metal Hydride E-Bike Battery, 20 Ah, Capacity (Ah).	3,4

VIII. SUGGESTED FOR WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
SECTION - I								
1	**I**	**Introduction Of Electric Vehicles**	CO1	8	2	6	4	12
2	**II**	**Electric Vehicles Drives**	CO2	9	5	6	4	15
3	**III**	**Energy Storage System and Batteries**	CO3	6	2	4	2	08
								35

SECTION - II								
4	**IV**	**Battery Management Systems And Fuel Cell**	CO4	6	2	4	2	08
5	**V**	**Converters and EV Chargers**	CO5	8	5	6	4	15
6	**VI**	**Electric Vehicle (EV) Policies**	CO6	8	4	4	4	12
								35
Grand Total				**45**	**20**	**30**	**20**	**70**

IX. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment of learning)	**Summative Assessment (Assessment of learning)**
Two unit tests of 30 marks will be conducted and an average of two unit tests considered. For formative assessment of laboratory learning 25 marks. Each practical will be assessed considering the appropriate % weightage to process and product and other instructions of assessment.	End semester assessment of 70 marks through offline mode of examination.

X. SUGGESTED COS- Pos –PSOs MATRIX FORM

Course Outcomes (Cos)	**Programme Outcomes(Pos)**									
	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 Lifelong Learning**	**PSO-1**	**PSO-2**	**PSO-3**
CO1	3	2	3	2	3	2	2	2	2	2
CO2	3	2	3	2	3	1	2	2	2	3
CO3	3	2	2	2	2	2	2	2	1	2
CO4	3	2	1	2	2	2	2	1	2	2
CO5	3	1	2	2	2	1	2	1	1	2
CO6	3	1	2	2	2	1	2	1	1	2

XI. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	**Author**	**Title**	**Publisher with ISBN Number**
1	Mehrdad Ehsani, Yimin Gao, Stefano Longo, and Kambiz Ebrahimi.	Modern Electric, Hybrid Electric, and Fuel Cell Vehicles.	CRC Press, 2019, ISBN 13: 978-0367137465.
2	James Larminie, John Lowry.	Electric Vehicle Technology Explained.	Wiley-Blackwell, 2012, ISBN 13: 978-1119942733
3	Dr. Nitesh Tiwari, Dr. Shekhar Yadav.	Electric Vehicle (Green and Sustainable Transportation).	S.K. Kataria & Sons, 2023, ISBN 13: 987-81-963589-0-7.
4	Ali Emadi, Mehrdad Ehsani, John M. Miller.	Vehicular Electric Power Systems: Land, Sea, Air, and Space Vehicles.	CRC Press, 2003, ISBN 13: 978-0824747510.
5	Sunil R. Pawar.	Electrical Vehicle Technology: The Future Towards Eco-Friendly Technology.	Notion Press Publication, 2021, ISBN 10:1685545610.

XII. LEARNING WEBSITES & PORTALS

Sr. No	Link / Portal	Description
1	https://youtu.be/2IgZSDDFW-Y?si=Z1tfZO24ljBppzVA	Identification of terminals of BLDC motor.
2	https://www.niti.gov.in/sites/default/files/2023-02/EV_Handbook_Final_14Oct.pdf	Handbook of electric vehicle charging infrastructure implementation.
3	https://heavyindustries.gov.in/sites/default/files/2023-07/N EMMP-2020.pdf	National Electric Mobility Mission Plan 2020.
4	https://www.cleanenergyministerial.org/initiatives-campaigns/electric-vehicles-initiative/	Goal of EV30@30 campaign.
5	https://maitri.mahaonline.gov.in/PDF/EV%20Policy%20GR%202021.pdf	Maharashtra Electric Vehicle Policy, 2021.
6	https://www.mdpi.com/1996-1073/10/8/1217	Electric vehicle review paper.
7	https://archive.nptel.ac.in/courses/108/103/108103009/	NPTEL electric vehicle course literature.
8	https://onlinecourses.nptel.ac.in/noc22_ee53/preview	NPTEL electric vehicle course videos.
9	https://www.mdpi.com/1996-1073/15/3/1241	DC-AC converters for electric vehicle review paper.
10	https://www.niti.gov.in/sites/default/files/2022-05/Battery_swapping_report_09052022.pdf	Battery swapping.

Note :

- Teachers are requested to check the Creative Commons license status/financial implications of the suggested online educational resources before use by the students

Name & Signature: **Mrs R.S.Deulkar** Lecturer in E & TC	**Mrs M.V.Saraf** Lecturer in E& TC
(Course Experts)	
Name & Signature **Dr. Yashvant V.Chavan** (Program Head)	Name & Signature: **Shri. S.B. Kulkarni** (CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE

'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN E & TC**
PROGRAMME CODE	**03**
COURSE TITLE	**EMBEDDED SYSTEM**
COURSE CODE	**ET 51202**
PREREQUISITE COURSE CODE & TITLE	**ET31207**
CLASS DECLARATION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme										
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TSL				Based on SLA		Total Marks
														Practical						
			CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
										Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
ET51202	EMBEDDED SYSTEM	DSC	4	--	2	2	8	4	3	30	70	100	40	25	10	25#	10	25	10	175

Abbreviations: CL-Classroom Learning, **TL**-Tutorial Learning, **LL**-Laboratory Learning, **SLH**-Self Learning Hours, **NLH**-Notional Learning Hours, **FA** - Formative Assessment**, SA** -Summative assessment, **IKS** – Indian Knowledge System, **SLA**- Self Learning Assessment

Legends: @-Internal Assessment, **#** - External Assessment, ***#** - Online Examination, **@$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as '**Detained**' in that course
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as '**fail**' and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. * Self-learning includes micro-projects/assignments/other activities.

RATIONALE:

Embedded systems are designed for specific tasks to excel in real-time performance, resource utilization and reliability. These systems are playing a vital role in modern technology, enabling sophisticated functionalities in a wide array of devices and applications. Embedded systems are integral to the advancement of technology across multiple sectors. By learning this course, students will develop skills to use embedded systems for simple applications. It will also enable them to use open-source embedded system for solving real time problems

COURSE-LEVEL LEARNING OUTCOMES (CO's)

Students will be able to achieve & demonstrate the following COs on completion of course-based learning.

CO1 - Select the relevant microcontrollers for various industrial applications.
CO2 - Interpret the architecture of ATMEGA 328.
CO3 - Develop basic programs of ATMEGA 328.
CO4 - Interpret the communication standards of embedded systems.
CO5- Analyse the features of Real Time Operating System.
CO6 - Develop the applications using Arduino board.

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
	SECTION I			
	UNIT 1. OVERVIEW OF EMBEDDED SYSTEMS (CL Hrs-08, Marks-11)			
1	TLO 1.1 Identify the components of the embedded system and their functions. TLO 1.2 Describe the given characteristic of the specified embedded system. TLO 1.3 Classify the embedded system. TLO 1.4 List the selection factors of the embedded systems.	1.1Embedded system, block diagram description, layered model 1.2Characteristics of embedded system: CPU type, maximum CPU speed, processing power, memory, performance 1.3Classification of embedded system: small scale, medium scale, sophisticated, stand-alone, reactive/real time (soft and hard real time) 1.4Selection criteria of embedded system: operating system, reliability, NRE cost, unit cost, size, flexibility, time to prototype, time to market, maintainability, correctness and safety	Classroom Learning, Reference books, NPTEL	**CO1**
	UNIT-II MICROCONTROLLER ARCHITECTURE (CL Hrs-10, Marks-12)			
2	TLO 2.1 Compare different types of microcontrollers used for embedded system designing. TLO 2.2 Describe AVR microcontroller with the help of block diagram. TLO 2.3 Sketch the block diagram of ATMEGA328 and describe the functions of each block.	2.1 Microcontroller Types: PIC, AVR, ARM, features and applications. 2.2AVR Microcontroller: types ,and features 2.3ATMEGA328: internal architecture, Pin diagram and pin function, AVR CPU Core, Power management, System Controls, Registers in ATMEGA328. Configurations of ATMEGA328: I/O port, peripherals, counter, timer	Classroom Learning, Reference books, NPTEL	**CO2**

UNIT-III ARDUINO PROGRAMMING(CL Hrs-12, Marks-12)				
3	TLO 3.1 Write a C program for connecting LEDs & Switches. TLO 3.2 Write a C program for connecting Analog input and output	3.1 Arduino programming environments: Arduino IDE, Arduino program structure, data types, operators, control statement, loops, functions, array, basic programs using ATMEGA 328. 3.2 Programming of Digital I/O, connecting LEDs, Switches. 3.3 Programming Analog I/O : reading Potentiometer through analog input, Fading LEDs through analog output .	Classroom Learning, Reference books, NPTEL	**CO3**
SECTION II				
UNIT-IV COMMUNICATION STANDARD PROTOCOL (CL Hrs-8, Marks10)				
4	TLO 4.1 Describe the given type of modes for communication. TLO 4.2 Describe the given communication protocol(s) with relevant sketches. TLO 4.3 Describe the given wireless serial communication interface. TLO 4.4 Differentiate between given protocols for given parameters	4.1 Modes of communication: serial, parallel, synchronous and asynchronous 4.2Communication Protocols its types: Serial: I2C, CAN, USB 4.3Serial peripheral interface (SPI), IEC 61850 GOOSE (Protocol for Electric power system applications) 4.4Wireless protocol: IrDA, Bluetooth, Zigbee, WiFi, LORA, LoWPAN	Classroom Learning, Reference books, NPTEL	**CO4**
UNIT –V REAL TIME OPERATING SYSTEM(CL Hrs-8, Marks-10)				
5	TLO 5.1 Describe the functions of the given operating system. TLO 5.2 Compare RTOS and general OS for the given parameters. TLO 5.3 Describe features of RTOS with neat sketch. TLO 5.4 Explain deadlock condition in RTOS with suitable sketch.	5.1Operating system: general and real time operating system 5.2Characteristics of real time operating system: consistency, reliability, scalability, performance, predictability 5.3Functions of RTOS, Task management: inter task communication and multitasking, threads, task Scheduling: scheduling algorithms Preemptive Priority Scheduling, Round robin, resource allocation and interrupt handling 5.4Features of RTOS: watchdog timer, semaphore Deadlock: reasons of occurrence, handling of deadlock	Classroom Learning, Reference books, NPTEL	**CO5**
UNIT –VI INTERFACING APPLICATIONS (CL Hrs-14, Marks-15)				
6	TLO 6.1 Enlist the different types of	Programming and Interfacing sensors & actuators and displaying on	Classroom Learning,	**CO6**

	Arduino boards and their major features. TLO 6.2 Describe the working of development board using block diagram. TLO 6.3 Describe the given Arduino functions. TLO 6.4 Write steps to interface the given peripheral with Arduino. TLO 6.5 Interface the given sensor with Arduino.	LED/LCD with ATMEGA328. 1. Peripheral interfacing with Arduino: keyboard, LCD, I2C LCD , seven segment Display, relay, stepper motor, DC motor. 2. Sensor interfacing with Arduino: Temperature sensor - LM35, DHT11, LDR, IR sensor, ultrasonic sensor. 3. Home Automation	Reference books, NPTEL	

V.LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL/ TUTORIAL EXPERIENCES.

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles/Tutorial Titles	Number of hrs.	Relevant COs
1*	LLO1 Identify Components of Embedded System	* Identification of different components of Embedded system and their functions	02	CO1
2*	LLO2 Identify pins and functions of ATMEGA328 microcontroller.	*Identification of pins of ATMEGA 328C Microcontroller. Hardware of Embedded system	02	CO2
3*	LLO3 Use an Integrated Development Environment (IDE) tool for developing C Programs of ATmega 328.	*Use an IDE for ATmega 328 programming.	02	CO2
4	LLO4 Develop AVR C program to perform addition, subtraction, and multiplication operations on two constant data and output the result to port with some delay between each output.	Write C program to perform various arithmetic operations	02	CO3
5*	LLO5 Interfacing LED, Buzzer & Relay with Arduino/Node/Raspberry Pi to turn it ON/OFF	*Interface LED with Arduino to turn it ON/OFF	02	CO3
6	LLO6 Interfacing Buzzer & Relay with Arduino to turn it ON/OFF	Interface Buzzer & Relay with Arduino and turn it ON/OFF	02	CO3
7*	LLO 7.1 Interface 4 x 4 LED matrix with ATmega328	*Interface LED matrix with ATmega328	02	CO3

	LLO 7.2 Develop C program to display various patterns.	microcontroller		
8*	LLO 8 Configure USB protocol on PC .	*Serial Communication using USB	02	CO4
9*	LLO9 Demonstrate Round Robin scheduling algorithm.	*Round Robin scheduling algorithm.	02	CO5
10*	LLO10 Install Arduino IDE and its development tool for Windows/MacOS/Linux operating systems	*Installation of Arduino IDE for Windows/MacOS/Linux operating Systems	02	CO6
11*	LLO 11.1Build the circuit using 4 switches and 4 LEDs to Arduino Board. LLO11.2 Test the LED on/off as per switch positions.	*Building and Testing switch and LED interface using Arduino	02	CO6
12	LLO 12 Interfacing Switch with Arduino/ NodeMCU /Raspberry Pi	Interface Switch with Arduino/ NodeMCU /Raspberry Pi	02	CO6
13*	LLO 13 Develop programs to perform arithmetic operation using math functions: constrain (), max (), min (), Pow(), sq(), sqrt() using Arduino.	*Programs to perform arithmetic operations on Arduino	02	CO6
14*	LLO 14.1 Interface two 16 x 2 LCD modules with Arduino using I2C serial communication protocol. LLO 14.2 Interface seven segment display with Arduino.	*LCD Interfacing to Arduino board. *Seven segment display Interfacing to Arduino board	02	CO6
15*	LLO 15 Develop program to read the data from the temperature sensor through Arduino and display on LCD.	*Temperature sensor interfacing to Arduino board	02	CO6
*16	Microproject	*Complete a Micro-project based on guidelines provided in sr.no.VI	-	ALL

Note: A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of a minimum of 10 or more practical needs to be performed. Out of which, the practical marked as ' *' are compulsory.

VI.SUGGESTED MICRO PROJECT /ASSIGNMENT/ACTIVITIES FOR SPECIFIC LEARNING/ SKILLS DEVELOPMENT (SELF-LEARNING)

Assignment

List different types of sensors and actuators used with embedded system and also write application of each sensor

Create a program to control a DC motor using PWM (Pulse Width Modulation).

Interface a temperature sensor with Arduino and display the readings on the serial monitor

Develop a simple program to blink an LED using assembly language.

Implement SPI communication to control an LED matrix display.

Conduct a market survey for various types of Arduino boards available

Micro project

Control the position of a servo motor using Arduino
Control home appliances using Arduino and relays
Design digital soil moisture meter using Arduino
Implement a digital clock using an RTC (Real-Time Clock) module
Create a digital thermometer using Arduino and a temperature sensor
Implement an RFID-based door lock system using Arduino
Create a simple home automation system to control appliances using an AVR/PIC microcontroller
Measure distances using an ultrasonic sensor and display the results on an LCD
Interface any I/O deice to Raspberry pi development board

VII.LABORATORY EQUIPMENT/INSTRUMENTS/ TOOLS/ SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Components: AVR, PIC Microcontroller	1
2	Temperature sensors; range -55 to 125°C	10
3	Simulation softwares: Arduino IDE, Atmel studio, Microchip studio.	3,4,7,8,9,10
4	Microcontroller kit (AVR ,AT mega 328 board and PIC): single board systems with minimum 8K RAM, ROM memory with battery backup, 16 x 4 LCD display, seven segment display, PC keyboard interfacing facility, cross 'C' compiler, USB, interfacing facility with built in power supply.	4
5	Arduino board UNO/ Nano or available microcontroller: ATmega328P, operating voltage: 5V input voltage (recommended): 7-12V input voltage (limit): 6-20V digital I/O pins: 14 (of which 6 provide PWM output) analog input pins: 6 DC current per I/O Pin: 20 mA DC current for 3.3V pin: 50 mA flash memory: 32 KB (ATmega328P) of which 0.5 KB used by bootloader SRAM: 2 KB (ATmega328P) EEPROM: 1 KB (ATmega328P) clock speed: 16 MHz LED bulit in: 13 dimensions: 68.6 mm x 53.4 mm weight: 25 g	6,7,8,9
6	LCD 16x2 Modules	9
7	Desktop PC with minimum RAM 4GB, Windows OS	All

VIII.ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two off line unit test of 30 marks and average of two-unit test will considered for out of 30 marks.
- For formative assessment of laboratory learning 25 marks.
- Each practical will be assessed considering 60% weightage to process, 40% weightage to product.

Summative Assessment (Assessment of Learning)

- End semester assessment of 70 marks.
- End semester summative assessment of 25 marks for laboratory learning.

IX.SUGGESTED FOR WEIGHTAGE TO LEARNING EFFORTS &ASSESSMENT PURPOSE

(Specification Table)

Sr. No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
SECTION I								
1	I	Overview of Embedded Systems	CO1	08	3	4	4	11
2	II	Microcontroller Architecture	CO2	10	2	4	6	12
3	III	Instruction set and programming	CO3	12	2	4	6	12
								35
SECTION II								
4	IV	Communication Standards and Protocols	CO4	8	2	4	4	10
5	V	Real Time Operating System	CO5	8	4	4	2	10
6	VI	I/O Interfacing with Arduino	CO6	14	3	6	6	15
								35
Grand Total				**60**	**16**	**26**	**28**	**70**

X.ASSESSMENT METHODOLOGIES / TOOLS

Formative assessment (Assessment for Learning)			Summative Assessment (Assessment of Learning)
1. Tests	4.	Self-Learning	1. End Term Exam
2. Assignment	5.	Term Work	2. Micro-project
3. Midterm Exam	6.	Seminar/Presentation	

XI.SUGGESTED COS- POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes(POs)							Programme Specific Outcomes*(PSO)		
	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	PSO-3
CO1	2	2	2	1	1	-	2	3	1	1
CO2	3	3	2	1	1	1	2	3	1	1
CO3	2	2	2	2	1	-	2	3	3	3
CO4	2	3	3	3	1	1	2	3	2	2
CO5	2	3	3	2	1	1	2	1	1	1
CO6	3	3	2	3	1	1	2	3	3	3

Legends:- High:03, **Medium:**02, **Low:**01, **No Mapping:** -
*PSOs are to be formulated at the institute level

XII.SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Raj Kamal	Microcontroller Architecture Programming, Interfacing and System Design	Pearson Education India, Delhi, 2012 ISBN: 978-8131759905
2	Muhamed Ali Mazidi, Sarmad Naimi, Sepehr Naimi	AVR Microcontroller and Embedded Systems: Using Assembly and C	Pearson Education India, Delhi, 2013 ISBN: 978-9332518407
3	Dawoud Shenouda Dawoud, Peter Dawoud	Serial Communication Protocols and Standards	River Publishers, Denmark, 2020 ISBN: 978-8770221542
4	David E. Simon	An Embedded Software Primer	Addison-Wesley, Delhi, 2002 ISBN: 978-9332518407
5	J.M.Hughes	Arduino: A Technical Reference	O'REILLY, 2016 ISBN: 978-1491921760
6	Jeremy Blum	Exploring Arduino Tools and Techniques for Engineering Wizardry	John Wiley & Sons, 2019 ISBN: 978-1118549360
7	Michael McRoberts	Beginning Arduino	APRESS, 2011 ISBN: 978-1430232414

XIII.LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.microchip.com/en-us/tools-resources/develop/microchip-studio	Microchip Studio for AVR® and SAM Devices is an integrated development platform from Microchip
2	http://arduino.cc/	Link for Arduino Related Hardware and Software Download and installation
3	https://learn.sparkfun.com/tutorials/what-is-an-arduino	Arduino Basics
4	https://onlinecourses.swayam2.ac.in/aic20_sp04/preview	Introduction and Concepts of Arduino
5	https://support.arduino.cc/	Tutorials, data sheets, guides and other technical documentation
6	http://vlabs.iitkgp.ac.in/rtes/	Virtual lab link for Microcontrollers
7	https://semiconductors.es/datasheet-pdf/219613/ATMEGA32.html	Datasheet for ATmega Microcontrollers
8	https://www.alldatasheet.com/datasheet-pdf/pdf/82338/MICROCH IP/PIC16F877A.html	Datasheet for PIC Microcontroller

Name & Signature:

Smt.C.D.Pophale
Lecturer in E&TC

Smt. V.G.Mahendra
Lecturer in E&TC

(Course Experts)

Name & Signature:	Name & Signature:
Dr.Y.V.Chavan (Programme Head)	**Shri. S.B. Kulkarni** (CDC In-charge)

GOVERNMENTPOLYTECHNIC, PUNE

'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN E & TC**
PROGRAMME CODE	**03**
COURSE TITLE	**CAPSTONE PROJECT**
COURSE CODE	**ET41207**
PREREQUISITE COURSE CODE & TITLE	**ACQUIRED MINIMUM OF 60 CREDITS**
CLASS DECLARATION COURSE	YES

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TSL				Based on SL		Total Marks
														Practical						
			CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
										Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
ET41207	CAPSTONE PROJECT	INP	--	--	--	4	--	2	--	--	--	--	--	--	50	20	50#	20	--	100

Total IKS Hrs for Term: 0 Hrs

Abbreviations: CL-Classroom Learning, **TL**-Tutorial Learning, **LL**-Laboratory Learning, **SLH**-Self Learning Hours, **NLH**-Notional Learning Hours, **FA** - Formative Assessment**, SA** -Summative Assessment, **IKS** – Indian Knowledge System, **SLA**- Self Learning Assessment

Legends: @-Internal Assessment, # - External Assessment, ***#** - Online Examination, **@$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If a candidate is not securing the minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as **'Detained'** in that Course.
2. If a candidate does not secure the minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as **'fail'** and will have to repeat and resubmit the SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. * Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

Project work at the institute level serves as a vital bridge between theoretical learning and practical application. It offers students a valuable platform to apply the concepts, knowledge, and technical skills acquired in classrooms and laboratories to address real-world problems—ranging from well-defined tasks to complex, open-ended challenges. This experiential learning approach fosters a deeper understanding of engineering and technological principles by encouraging students to design, develop, and implement solutions in realistic contexts.

The course is strategically designed to integrate interdisciplinary knowledge gained throughout the diploma program, thereby enhancing students' ability to approach problems holistically. Furthermore, it plays a crucial role in nurturing essential professional competencies such as critical thinking, problem-solving, creativity, teamwork, project planning, and innovation.

In alignment with industry and societal expectations, students are encouraged to undertake projects that go beyond conventional solutions and aim to provide impactful, sustainable outcomes. By engaging in such projects, students not only reinforce their technical capabilities but also improve their employability by developing a mindset geared towards innovation, collaboration, and continuous improvement.

III. INDUSTRY EXPECTED OUTCOME

This course is designed to enable students to develop the industry-relevant competency of:

Effectively executing innovative solutions to real-world problems through collaborative teamwork, adhering to defined timelines, and delivering a well-documented project report.

IV. COURSE-LEVEL LEARNING OUTCOMES (CO'S)

Students will be able to achieve & demonstrate the following CO's on completion of course-based learning

CO1: Identify real-world field problems relevant to the project work conducted at the institute.
CO2: Analyse the feasibility and viability of the project by conducting data collection and experiments, as well as evaluating required resources, costs, and support.
CO3: Apply technical knowledge and engineering skills to develop effective solutions for real-life or industrial problems.
CO4: Evaluate the proposed project work's ethical considerations and societal impacts.
CO5: Create a comprehensive project report and present the methodology and results within the institute.
CO6: Demonstrate the project outcomes, findings, and achievements effectively through presentations and exhibits.

V. GENERAL GUIDELINES FOR PROJECT WORK

a) Project Selection and Scope

- The project must align with the field of engineering or technology. Interdisciplinary projects are permitted if expected to deliver outcomes aligned with industry relevance or societal needs.

Indicative Project Focus Areas:

i) Automation and PLC
ii) Manufacturing and Production Engineering
iii) Medical Electronics
iv) VLSI Based
v) Robotics applications
vi) Drone technology
vii) Renewable Energy Technologies
viii) IOT and Smart city
ix) Environmental and Sustainable Engineering
x) Interdisciplinary and Smart Systems
xi) Agricultural and Rural Engineering Solutions
xii) Embedded System based
xiii) Communication/Bluetooth/Mobile
xiv) Radar Technology
xv) Signal processing
xvi) Cyber security
xvii) AI Based

- Students should select projects that match their skills, knowledge and interests. Faculty should support students in identifying suitable topics.
- Study-based (theoretical-only) projects are **not encouraged**. Projects should involve practical implementation.
    - Project diary
    - Final demonstration
    - Assessment based on institutional RUBRICs

i) Team Structure and Mentorship

- Each project must be executed by a group of 3–4 students under the guidance of an assigned faculty mentor.
- Faculty may organize teams based on:

    - Students' individual strengths and interests
    - Industry-relevant functional roles
    - Project requirements and scope
    - Balanced skill distribution among team members
    - Academic performance and specialization

ii) Nature and Type of Projects

Projects may involve:

- Hardware development
- Software development
- Combination of both

All projects must demonstrate logic building, problem-solving, and application of technologies learned during the diploma program.

Acceptable project formats include:

- Prototype design (design, build, test, and evaluate)
- Application/software development

iii) Project Execution and Documentation

- Students must develop a working model/prototype/software and simultaneously prepare a comprehensive project report.
- Submissions must include:
- One hard copy and one soft copy of the project report
- A soft copy of the source code or a demonstration video/file of the working model
- The project report should include (as applicable):
- Problem Definition
- Platform/Hardware Specifications
- Feasibility Study (Cost & Time Estimates)
- Design Diagrams (UML, Use Case, Activity, DFD, CFD, ERD, etc.)
- Key Code Snippets
- Testing Methodology and Results
- Limitations and Future Scope
- References (Books, Journals, Websites)

iv) Project Diary and Supervision

A project diary must be maintained by each group to log:

- Weekly progress and milestones
- Design decisions and challenges
- Faculty feedback and updates
- Faculty mentors should review the diary weekly and provide constructive feedback. The diary should be concise (5–10 pages) and follow the format outlined in Annexure IV.

v) Learning Outcomes Expected (As Applicable)

- Faculty should ensure students gain the following competencies through project execution:
- Identify and define real-world problems within their domain
- Investigate root causes and possible solutions
- Evaluate solution feasibility, including financial implications
- Gather and analyze data from reliable sources (e.g., books, web, experts, market)
- Develop required designs and execution plans
- Prepare and deliver effective seminar presentations.

vi) Industry-Sponsored Projects

- For industry-guided projects, implementation steps may vary per industry standards.
- However, students must still meet institutional submission criteria:
- Project report format
- Project diary
- Final demonstration
- Assessment based on institutional RUBRICs

a) National Relevance

Projects should ideally address national thrust areas such as:

- Environmental Sustainability
- Digitization
- Automation
- Renewable Energy
- Other relevant socio-technical development domains.

VI. COURSE IMPLEMENTATION STAGES

1. Orientation Session

A Project Orientation Session shall be conducted during the last week of the fourth term by the Portfolio In-charge faculty. This session will brief students on:

- Project objectives.
- Scope and expected deliverables
- Guidelines for execution and assessment
- Faculty and institutional support

2. Mapping of Students and Faculty Mentors

Students will be organized into teams and assigned faculty mentors based on the following criteria:

- Alignment of student interests
- Faculty expertise
- Team size and project scope.

3. Problem Identification and Finalisation

Students are required to:

- Conduct a field survey or exploratory study under faculty supervision
- Identify a real-world, relevant, and feasible problem
- present the idea to a group of faculty members for approval
- This activity should commence in the final week of the 4th semester and be completed by the first week of the 5th semester.

4. Requirement Gathering

A dedicated week is allotted for collecting detailed project requirements, including:

- Estimation of human resources
- Identification of technical (hardware/software) needs
- Feasibility study and cost analysis

Outcome: Students must present their findings to the faculty mentor for approval.

5. Project Planning

Students must prepare a comprehensive project plan covering:

- Task allocation and resource planning
- Time frame and cost estimation
- Team member responsibilities
- Selection of an appropriate development model (e.g., Waterfall, Agile, Spiral)

Deliverables: A clear roadmap including timelines, milestones, and expected outcomes.

6. Project Proposal Submission

The finalized project proposal must be submitted in **soft copy format** and should include:

- Project title and objectives
- Detailed requirement analysis
- Project plan and execution strategy
- Expected deliverables and outcomes
- Development model and tools to be used

7. Project Development, Testing & Report Preparation

Under the continuous guidance of faculty mentors, students shall:

- Develop the project according to the approved plan
- Maintain project documentation throughout the development lifecycle
- Prepare a detailed final report that includes:
  - System design and architecture
  - Implementation details
  - Testing procedures and results
  - Challenges encountered and solutions adopted
  - Final outcomes and evaluation metrics.

8. Project Demonstration

Students must present their project in two stages:

- **Preliminary Demonstration:** A progress review shown to the faculty guide during the development phase.

- **Final Demonstration:** A complete presentation of the working model or application during the End Semester Examination (ESE).

VII. DETAILED WEEKWISE TIMELINE FOR THE COURSE IMPLEMENTATION STAGES:

Week	Activity	Responsibilities
Week 1	**Orientation Session** (Last week of 4th Term)	Portfolio In-charge Faculty: Brief students on project objectives, scope, deliverables, guidelines, execution, and assessment.
Week 2	**Mapping of Students and Faculty Mentors**	Portfolio In-charge Faculty: Organize students into teams based on interests, faculty expertise, team size, and project scope.
Week 3-4	**Problem Identification and Finalisation**	Students: Carry out a field survey or exploratory study under faculty supervision, identify a relevant real-world problem, finalise the issue, and submit a synopsis for faculty approval.
Week 5	**Requirement Gathering**	Students: Collect detailed project requirements (human resources, technical needs, feasibility study, and cost analysis).
Week 6	**Requirements Gathering Presentation**	Students: Present findings to the faculty mentor for approval.
Week 7	**Project Planning**	Students: Prepare a project plan including task allocation, resource planning, timeline, budget, development model, and deliverables. Faculty Mentor: Review plan.
Week 8	**Project Proposal Submission**	Students: Submit final project proposal (title, objectives, requirements, plan, tools, outcomes). Faculty Mentor: Review and approve.
Week 9-12	**Project Development, Testing & Report Preparation**	Students: Begin project development according to the plan. Maintain documentation. Test and iterate. Prepare final report (design, implementation, testing results).
Week 13	**Preliminary Demonstration**	Students: Present a progress review to the faculty mentor.
Week 14	**Project Finalisation & Report Completion**	Students: Finalise development. Prepare a detailed project report with system design, testing results, challenges, and outcomes.
According to the Examination Schedule	**Final Demonstration (End Semester Examination)**	Students: Conduct final demonstration of the working model/application during the ESE. Faculty: Evaluate the project based on the demonstration and report.

VIII. CRITERIA FOR ASSESSMENT/EVALUATION OF PROJECT WORK

A. Formative Assessment (FA) Criteria

The evaluation of students during the fifth semester for Progressive Assessment (PA), totalling **50 marks**, will be carried out based on the following criteria:

Category	Week(s)	Assessment Criteria	Max Marks	Performance Description (Rubric Scale: 1 to 5)	Group Enrollment Nos.	Group Marks
i) Team Assessment (30 Marks)	Week 3-4	Project Selection & Problem Definition	5	2 – Lacks clarity and relevance 3 – Relevant and defined 4 - Clearly defined and suitable 5 – Innovative and impactful		
	Week 5	Literature Review & Data Collection	5	1 – Insufficient or irrelevant sources 2 – Limited data with unclear relevance 3 – Adequate review with relevant data 4 – Structured, relevant data 5 – Comprehensive and critically evaluated sources		
	Week 6	Project Design / Concept & Execution	10	1–2 Design is poorly structured; minimal or no execution 3–4 Weak concept, unclear goals, and limited execution 5–6 Basic concept with moderate execution; design may lack innovation or clarity 7–8 Solid, functional design with good planning and consistent execution 9–10 Creative, technically sound design with excellent		

				planning and thorough execution		
	Week 7	Progress as per Action Plan / Milestones	5	1 – No measurable progress 2 – Progress is significantly behind schedule 3 – Moderate progress; some tasks completed 4 – Mostly on schedule with minor delays 5 – Fully on schedule and meeting milestones		
	Week 8	Quality & Presentation of Project Report	5	1 – Poorly organized and unclear 2 – Disorganized with formatting issues 3 – Fair structure and readability 4 – Well-organized and readable 5 – Professionally formatted and well-written report		

Category	Week(s)	Assessment Criteria	Max Marks	Performance Description (Rubric Scale: 1 to 5)	Individual Enrollment Nos.	Individual Marks
ii) Individual Assessment (20 Marks)	Week 2–13 (Ongoing)	Individual Contribution to the Team	10	1 -2 Rarely involved or shows minimal effort 3 -4 Occasionally contributes with limited involvement 4 –5 Participates adequately 6 – 7 Active and dependable team member 8 –10 Consistently proactive, often leads initiatives		
	Week 2–13 (Ongoing)	Subject Knowledge & Understanding	10	1–2 Very limited understanding of subject concepts; unable to answer questions 3–4 Basic awareness but with significant gaps in understanding 5–6 Fair knowledge of concepts; can answer general questions correctly 7–8 Good understanding of a subject; explains concepts clearly and applies them logically 9–10 Excellent grasp; demonstrates deep insight, applies concepts to real-world/project scenarios		
Total			**50**			

i) Total Formative Assessment (FA) Marks

Sr. No.	Assessment Criteria	Marks
1	Team Assessment	30
2	Individual Assessment	20
Total		**50**

Note: The Total **Formative Assessment (FA) Marks** for the individual student.

B. Summative Assessment Criteria

*The summative assessment for students in the Fifth Semester **SA-PR** will carry a total of **50 marks** and shall be conducted by the faculty. Appropriate rubrics may be developed by the faculty for evaluation.*

Course Name :		**Course Code :**	
Student Name :		**Enrollment Number :**	
Project Batch Number:		**Division :**	
Faculty Guide Name:		**Term :**	

Sr. No.	Week	Assessment Criteria	Max Marks	Performance Description (Score Range)	Marks
1	According to the Examination Schedule	**Knowledge and Skill Set Developed**	10	**1–2**: Minimal knowledge gained	
				3–4: Basic understanding with limited skills	
				5–6: Moderate knowledge and practical exposure	
				7–8: Sound knowledge and good skill application	
				9–10: Excellent grasp and skill mastery with advanced application	
2	According to the Examination Schedule	**Quality and Potential of the Project**	10	**1–2**: Poor quality, unclear purpose	
				3–4: Basic functionality with low impact	
				5–6: Adequate quality with moderate potential	
				7–8: High-quality, practical utility	
				9–10: Exceptional quality and strong potential for real-world implementation	

3	According to the Examination Schedule	**Creativity, Innovation, and Teamwork**	10	**1–2**: Lacks originality, poor collaboration	
				3–4: Limited creativity and uneven teamwork	
				5–6: Shows creativity and fair teamwork	
				7–8: Innovative and well-coordinated efforts	
				9–10: Highly original ideas with exemplary team synergy	
4	According to the Examination Schedule	**Project Design, Development, Execution**	10	**1–2**: Poor design and implementation	
				3–4: Basic structure with several gaps	
				5–6: Functional design and moderate execution	
				7–8: Well-planned and executed efficiently	
				9–10: Robust, optimized design with flawless execution	
5	According to the Examination Schedule	**Project Presentation**	10	**1–2**: Disorganized and unclear	
				3–4: Lacks confidence and structure	
				5–6: Acceptable delivery with room for improvement	
				7–8: Clear, engaging, and well-structured	
				9–10: Highly professional, confident, and impactful presentation	

Note: The above rubric will be used as the summative assessment framework for evaluating individual student performance.

IX. SUGGESTED COS- POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes(POs)							Programme Specific Outcomes (PSOs)	
	PO1 -Basic and Discipline-Specific Knowledge	PO2- Problem analysis	PO3- Design/ Development of Solutions	PO-4 Engineering Tools, Experimentation and Testing	PO-5 Engineering Practices for Society, Sustainability, and Environment	PO-6 Project Management	PO-7 Lifelong Learning	PSO-1	PSO-2
CO1	2	2	--	--	2	2	2	--	--
CO2	2	3	2	2	--	3	2	2	2
CO3	3	3	3	3	2	2	2	3	3
CO4	--	--	--	--	3	2	2	--	--
CO5	2	2	2	2	--	3	2	--	--
CO6	2	2	2	2	2	3	3	--	--

X. TYPOGRAPHICAL GUIDELINES FOR PROJECT REPORT WRITING:

After the completion of the project work, each student is required to submit a project report. The report should adhere to the following structure and formatting guidelines:

A. STRUCTURE OF THE REPORT

The project report must include the following sections in the given order:

1. **Cover Page** – As per *Annexure I*.
2. **Title Page** – As per *Annexure I*.
3. **Certificate** – As per *Annexure II*.
4. **Acknowledgment** – A brief section in which the student may express gratitude to individuals and organizations who supported the project. As per *Annexure III*.
5. **Abstract** – A one-page summary outlining the objective of the project and the methodology adopted. As per *Annexure IV*.
6. **Table of Contents** – Prepared as per general guidelines. As per *Annexure V*.
7. **List of Figures-**The **purpose of the List of Figures** in a project report is to provide a clear and organized index of all visual representations used throughout the document. As per *Annexure VI*
8. **List of Tables -**The **purpose of the List of Tables** in a project report is to provide a structured overview of all tabular data included in the document. As per *Annexure VI*
9. **Project Description** –
   - Divided into chapters or sections.
   - Each chapter should comprehensively describe a specific phase or component of the project.
   - Include properly labelled diagrams, tables, and flowcharts wherever applicable.
10. **Conclusion** – Summarizes findings and outcomes of the project work.
11. **References** –
    - Begin two spaces below the heading "**REFERENCES**", aligned to the left.
    - Use **single spacing** within entries and list in **alphabetical order**.

- References must be cited in the text using **square brackets [ ]**, numbered according to their first appearance.
- Include author name(s), publication year, and other relevant details.

B. REPORT SPECIFICATIONS

1. **Binding**: Hard-bound only
2. **Cover Color**: Black with gold-embossed text (as per *Annexure 1*)
3. **Number of Copies**: Five – One per student and one departmental copy

Paper Size: A4 (portrait orientation)

4. **Margins**:
   - Top: 1 inch
   - Bottom: 1 inch
   - Right: 1 inch
   - Left: 1.5 inches
5. **Font Style**: Times New Roman
6. **Font Sizes**:
   - **Chapter Titles:** 16-point**, Bold, Uppercase**
   - **Headings:** 14-point, **Bold**
   - **Body Text:** 12-point, **Regular**
7. **Line Spacing**: 1.5 throughout the report
8. **Page Numbering**: Bottom center in the format “Page X of N”

Annexure-I

GOVERNMENT POLYTECHNIC, PUNE

(An Autonomous Institute of the Government of Maharashtra)

DEPARTMENT OF ELECTRONICS AND TELECOMMUNICATION ENGINEERING

PROJECT REPORT

ON

"[TITLE OF THE PROJECT IN CAPITAL LETTERS]"

Submitted By

Student name 1 (enrollment no.)
Student name 2 (enrollment no.)
Student name 3 (enrollment no.)
Student name 4 (enrollment no.)

UNDER THE GUIDANCE OF

[Guide's Full Name]
(Designation, e.g., Lecturer, Department of Electronics And Telecommunication Engineering)

Submitted in Partial Fulfilment

of

The Requirements for the Award of the Diploma in

ELECTRONICS AND TELECOMMUNICATION ENGINEERING

ACADEMIC YEAR: 20__–20__

GOVERNMENT POLYTECHNIC, PUNE, Ganeshkhind Road, Shivajinagar, Pune – 411016

Annexure-II

GOVERNMENT POLYTECHNIC, PUNE

(An Autonomous Institute of the Government of Maharashtra)

DEPARTMENT OF ELECTRONICS AND TELECOMMUNICATION ENGINEERING

CERTIFICATE

This is to certify that

1)Name of Student	Enrollment Number
2)Name of Student	Enrollment Number
3)Name of Student	Enrollment Number
4)Name of Student	Enrollment Number

has completed the necessary project work and prepared the bonafide report on

"PROJECT TITLE"

in a satisfactory manner as a partial fulfillment of the requirements for the

DIPLOMA IN

ELECTRONICS AND TELECOMMUNICATION ENGINEERING

FOR THE ACADEMIC YEAR

20__- 20__

(Internal Guide) **(External Examiner)**

(H.O.D) **(Principal)**

Annexure-III

Acknowledgment

(Sample Format)

We would like to express our sincere gratitude to all those who supported and guided us throughout the successful completion of this project.

We are especially thankful to **[Guide's Name]**, our project guide, for their constant encouragement, valuable suggestions, and constructive feedback during the entire duration of this project work.

We would also like to thank **[Head of Department's Name]**, Head of the Department of **[Branch Name]**, Government Polytechnic, Pune, for providing us with the necessary infrastructure and support.

We are deeply grateful to **[Principal's Name]**, Principal, Government Polytechnic, Pune, for providing us with this valuable opportunity and for fostering an academic environment conducive to learning and innovation.

Our heartfelt thanks go to all the faculty members and technical staff of the **[Department Name]** for their help in various ways during this project.

We also wish to acknowledge the support of our classmates, friends, and family members who encouraged and motivated us throughout the journey.

Lastly, we are thankful to the **Government Polytechnic, Pune**, for allowing us to work on this project as a part of our academic curriculum.

Student name 1 (enrollment no.)
Student name 2 (enrollment no.)
Student name 3 (enrollment no.)
Student name 4 (enrollment no.)

Annexure-IV

Abstract

The abstract serves as a one-page comprehensive summary that encapsulates the core aspects of the project. It begins by clearly stating the primary objective or goal of the work, providing the reader with an understanding of the problem being addressed or the purpose behind the study. Following this, the abstract outlines the methodology employed, detailing the approach, techniques, tools, and processes used to achieve the project's objectives. This section may also briefly touch on the scope of the work, key findings, and any conclusions or implications derived from the results. The abstract offers a concise yet informative overview, enabling readers to quickly grasp the essence and significance of the project without delving into the full report.

Annexure-V

Table of Contents

Annexure-VI

List of Figures

List of Tables

Annexure-VII
PROJECT DAIRY

Course code :		**Course Name :**	
Student Name :		**Enrollment Number :**	
Project Batch Number:		**Division :**	
Faculty Guide Name:		**Term :**	

Date	Enrollment Numbers of Present Students	Work Assigned/Corrections Suggested	Faculty Remarks	Faculty Signature

Signature of Faculty **Signature of HOD**

Name & Signature:

Smt.C.D.Pophale
Lecturer in E&TC

Shri. S.B. Kulkarni
Lecturer in Mechanical Engineering

Dr. N. G. Kulkarni
HoD in Mechanical Engineering

(Course Expert)

Name & Signature:

Dr.Y.V.Chavan
(Programme Head)

Name & Signature:

Shri. S.B. Kulkarni
(CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE

'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN E&TC**
PROGRAMME CODE	**03**
COURSE TITLE	**INDUSTRIAL AUTOMATION**
COURSE CODE	**ET41205**
PREREQUISITE COURSE CODE & TITLE	**NA**
CLASS DECLARATION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TSL				Based on SL		Total Marks
														Practical						
			CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
										Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
ET41205	INDUSTRIAL AUTOMATION	DSE	3	1	2		6	3	3	30	70	100	40	25	10	25#	10	-	-	150

Total IKS Hrs for Term: 0

Abbreviations: CL-Classroom Learning, **TL**-Tutorial Learning, **LL**-Laboratory Learning, **SLH**-Self Learning Hours, **NLH**-Notional Learning Hours, **FA** - Formative Assessment**, SA** -Summative assessment, **IKS** – Indian Knowledge System, **SLA**- Self Learning Assessment

Legends: @-Internal Assessment, **#** - External Assessment, ***#** - Online Examination, **@$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as '**Detained**' in that course
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as '**fail**' and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. * Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

In the present global scenario of manufacturing, industries are moving towards complete automation .small and medium scale industries are in the phase of switching to PLC and SCADA technology for the data acquisition and control. Therefore it is necessary for electronics/instrumentation engineers to have knowledge of these technologies to develop operational competency. Hence this course is foundation for the engineers who want to further specialize in the industrial automation field.

III. COURSE-LEVEL LEARNING OUTCOMES (CO's)

Students will be able to achieve & demonstrate the following COs on completion of course-based learning

1. Identify different components of an automation system.
2. Interface the given I/O device with appropriate PLC module.
3. Interpret PLC programming instructions and languages.
4. Develop PLC ladder program for various logic gates and Boolean equations
5. Develop PLC ladder program for given application
6. Prepare a simple SCADA application.

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

SECTION I				
Sr.No	**Theory Learning Outcomes (TLO'S) aligned to CO's.**	**Learning content mapped with TLO's.**	**Suggested Learning Pedagogies**	**Relevant COs**
UNIT 1. INTRODUCTION TO INDUSTRIAL AUTOMATION (CL Hrs-4, Marks-8)				
1.	**TLO 1.1** Describe the benefits of the given Industrial automation system. **TLO 1.2** Describe functions of components of automation system **TLO 1.3**. Compare the characteristic of the given type of automation system. **TLO 1.4** Compare the tools of automation system **TLO 1.5** Enlist application of Automation System	1.1 Need and benefits of Industrial Automation 1.2 Automation Hierarchy(Five layer), Basic components of automation system, description of cach component 1.3. Types of automation system:- Fixed, programmable, flexible 1.4 Different systems for Industrial automation: PLC, HMI, SCADA, DCS, Drives 1.5. Application areas of automation system	Classroom Learning using Chalk-Board , Educatioal Videos,PPT, Reference books, NPTEL	**CO1**
UNIT-II PLC FUNDAMENTALS (CL Hrs-10, Marks-16)				
2	**TLO 2.1** Draw block diagram of PLC and explain functions of each block. **TLO 2.2** Describe operating modes of CPU. **TLO 2.3** Explain redundancy concept in PLC with neat diagram. **TLO 2.4** Classify modular PLC. **TLO 2.5** Select the appropriate I/O module for specific application and illustrate the wiring diagram for interfacing field I/O devices with the	2.1 Architecture of PLC: Block diagram,functionof each block . 2.2 CPU : Function, Scanning cycle, speed of execution, operating modes of CPU (Programing, RUN, REM Mode), Memory organization of PLC 2.3 Redundancy in PLC system. 2.4 Types of PLC- Based on connection (fixed, modular) , based on size (small, medium, large) , advantages of PLC system over relay based system. 2.5 I/O Modules: Types(Discrete and Analog),Discrete I/O module: Block diagram, function of each block, Specifications, wiring of I/O devices with PLC . Analog I/O module: Block diagram, function of each block, Specifications, wiring of I/O devices	Classroom Learning using Chalk - Board , Educational Videos,PPT, Reference books, NPTEL	CO2

	PLC. **TLO 2.6** Explain the sinking and sourcing concept of PLC input output module with neat sketches	with PLC Comparison of AC and DC Discrete PLC Module(Voltage level, speed, noise immunity applications, common output type and safety) 2.6 Sinking and sourcing concept of I/O modules, selection criteria of PLC.		
UNIT-III PLC PROGRAMMING INSTRUCTIONS (CL Hrs-7, Marks-11)				
3	**TLO 3.1**: Specify the proper I/O addressing format of the given PLC. **TLO 3.2:** Explain the use of different PLC programming Instructions **TLO 3.3:** . Compare PLC programming Languages	3.1 PLC I/0 addressing 3.2 PLC programming Instructions: Relay type instructions(NO contact,NC contact , output coil,set out coil, Reset output coil), Timer instructions: On delay, off delay, retentive, Counter instructions. Up. Down, High speed, Logical instructions, Comparison Instructions. Data landling Instructions. Arithmetic instructions 3.3 PLC programming languages- Ladder diagram programming,Functional Block Diagram (FBD). Instruction List, Structured text. Sequential Function Chart (SFC), Ladder Programming	Classroom Learning using Chalk-Board , Educational Videos,PPT, Reference books, NPTEL	**CO3**
SECTION II				
UNIT-IV BASIC PLC PROGRAMMING (CL Hrs-8, Marks-12)				
4	**TLO 4.1:** Describe significance of various parts of ladder diagram **TLO 4.2:**Develop ladder program to test logic gates and Boolean equations **TLO 4.3** Develop ladd er logic for given process using relay instruction used in PLC	4.1 Ladder Logic basics :structure of ladder logic- Rungs,Input,Output,address notation and tag names 4.2 Ladder logic programs for various logic Gates and Boolean expessions 4.3 Ladder logic program examples based on bit/relay instruction.(ON/OFF control ,automatic door opening and closing, sequencing operation Latching/unlatching)	Classroom Learning using Chalk-Board , Educational Videos,PPT, Reference books, NPTEL	**CO4**
UNIT –V ADVNCED PLC PROGRAMMING AND APPLICATION (CL Hrs-10, Marks-15)				
	TLO 5.1.Use PLC appropriates instructions to develop ladder program for the given industrial application.	5.1.Ladder logic for industrial application:Automatic Tank level control,bottle filling plant,car parking,traffic light control, Motor sequence contro	Classroom Learning using Chalk -Board , Educational	**CO5**

5	**TLO 5.2** Develop PLC sequential function chart for the given industrial application**.**	5.2 Sequential functionchart(SFC) programming:Introduction, Structure of SFC,Transition representation Types of SFC (Selection branch ,simultaneous branch),Sequential functional chart design for object sorting,pick up and place	Videos,PPT , Reference books, NPTEL	
UNIT –VI SUPERVISORY CONTROL AND DATA ACQUISITION (CL Hrs-6, Marks-8)				
6	**TLO 6.1** Describe the function of the given element of SCADA **TLO 6.2** Describe the steps to develop a simple SCADA screen for the given application. **TLO 6.3** Interface the given PLC with the SCADA system using OPC	6.1 Introduction to SCADA, typical SCADA architecture/block diagram, benefits of SCADA 6.2 Various editors of SCADA 6.3 Interfacing SCADA system with PLC: Typical connection diagram, Object linking and embedding for Process Control(OPC) architecture, Steps in Creating SCADA Screen for simple object, Steps for Linking SCADA object (defining Tags and items) with PLC ladder program using OPC PLC based SCADA system for IIoT	Classroom Learning using Chalk -Board , Educational Videos,PPT ,Reference books, NPTEL	**CO6**

V.LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL/ TUTORIAL EXPERIENCES.

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles/Tutorial Titles	Number of hrs.	Relevant COs
1	Identify the components of automation systems available in in laboratory	*Identify the components of automation systems available in in laboratory	02	CO1
2	Interface input output devices with PLC and test the output for various inputs	*Interface given I/O devices with PLC	02	CO1 CO2
3	Interface input output devices with PLC and test the output for various inputs in virtual lab	Interface given I/O devices with PLC in virtual lab	02	CO1 CO2
4	Test sinking and sourcing concept in discrete I/O module	Test sinking and sourcing concept in discrete I/O module	02	CO2
5	Test functionality of logic gates using ladder diagram.	*Test functionality of various logic. gates using ladder diagram.	02	CO3,CO4
6	Design 4:1 Mux using adder diagram	Develop ladder program for 4:1 Multiplexer.	02	CO3,CO4

7	Test relay type instructions(NO, NC,output coil ete) using ladder 7 diagram	Test the functionality of latching using basic relay type instructions in ladder diagram.	02	CO3,CO4
8	Test ladder program for sequential ON OFF control of lamps/motors.	*Develop ladder program for sequential ON OFF control of lamps/motors.	02	CO3,CO4
9	Test ladder program for automatic traffic control using virtual lab.	*Develop ladder program for traffic light control system using virtual lab simulator	02	CO4,CO5
10	Develop /test ladder program for tank water level control.	*Develop /test ladder program for tank water level control.	02	CO4,CO5

Sr. No	**Practical/Tutorial/Laboratory Learning Outcome (LLO)**	**Laboratory Experiment / Practical Titles/Tutorial Titles**	**Number of hrs.**	**Relevant Cos**
11	Test ladder program for automated car parking system.	Develop ladder program for automated car parking system.	02	CO4,CO5
12	Develop ladder program to control the direction (Clockwise and Anticlockwise) of stepper motor.	Control the direction of stepper motor using ladder diagram.	02	CO4,CO5
13	Test ladder program to identify metallic and non-metallic objects.	Develop ladder program to sort metalic and non-metalic objects.	02	CO4,CO5
14	Test SFC to identify metallic and non-metallic objects.	*Develop Sequencial Function Chart (SFC) to sort metalic and non-metalic objects.	02	CO4,CO5
15	Develop SCADA graphic screen integrate it with PLC to perform the sequential ON-OFF control of Lamps/motors.	*Develop SCADA graphic screen and integrate with PLC to perform the sequential ON-OFF control of Lamps/motors. .	02	CO6
16	Develop a SCADA mimic diagram tank level control.	Simulate tank level control using available SCADA system.	02	CO6

Note: A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of a minimum of 12 or more practical needs to be performed. Out of which, the practicals marked as ' *' are compulsory.

VI. SUGGESTED MICRO PROJECT /ASSIGNMENT/ACTIVITIES FOR SPECIFIC LEARNING/ SKILLS DEVELOPMENT (SELF-LEARNING)

Assignment/Activity

- Do the internet survey and make a list of leading manufactures of the PLC, SCADA, DCS,HMI and other industrial automation tools with their brand names.
- Refer operating manual of the PLC of reputed manufactures and prepare a step by step procedure to use PLC for specified application.
- Prepare a PPT on the troubleshooting technique of PLC.
- Prepare a list of available analog input/output devices available in the market.
- Prepare a report on analog 1/0 module and Digital I/O module.
- Give selection criteria's of I/O modules in automation system.
- Industrial Visit
- Visit nearby PLC/SCADA/DCS based process/packaging industry, observe the industrial automation and prepare a report ished

Micro project

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs.(Affective Domain Outcomes) .Each student will have to maintain activity chart consisting of individual contribution in the project work and give a seminar presentation of it before submission.. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned faculty:

a. Automatic Street light Controller: Prepare a PLC based system to control the street light as per the intensity of natural light.
b. Automatic agriculture irrigation system: Prepare a PLC based system to control drip irrigation.
c. Railway gate automation: Prepare a PLC and SCADA based system to open or close the prototype railway gate automatically.
d. Home Automation: Implement the versatile automation system for home that can automate any three home appliances.
e. Bottle filling station: Prepare a PLC and SCADA based system for proto type bottle filling station.
f. Troubleshoot the faulty equipment available in Automation Laboratory.

VII. LABORATORY EQUIPMENT/ INSTRUMENTS/ TOOLS/ SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Nano PLC, Mini PLC, Micro PLC with analog and Digital I/O, memory, peripheral interfaces, Profinet and Profibus network.	1,2,4,,5,6,7,8,10,12,14,13,15,16
2	Input output devices for PLC:lamp,leds,motors,switches	1,2,4,,5,6,7,8,10,12,14,13,15,16
3	Ladder logic simulator: Such as TIA portal/RS Logix/CODESYS/Pico soft Simulator/ EDA tools.	1,2,4,,5,6,7,8,10,12,14,13,15,16
4	PLC with programming Software and interfacing hardware, user manual, (complete PLC Trainer system)	1,2,4,,5,6,7,8,10,12,14,13,15,16
5	SCADA software: Ellipse/FTVSE/wonder ware	15,16
6	Virtual Lab	3,9

VIII. SUGGESTED FOR WEIGHTAGE TO LEARNING EFFORTS &ASSESSMENT PURPOSE (Specification Table)

Sr. No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
		SECTION I						
1	I	**INTRODUCTION TO INDUSTRIAL AUTOMATION**	CO1	04	4	4	-	08
2	II	**PLC FUNDAMENTALS**	CO2	10	4	6	6	16
3	III	**PLC PROGRAMMING INSTRUCTIONS**	CO3	07	2	5	4	11
								35
		SECTION II						
4	IV	**BASIC PLC PROGRAMMING**	CO4	08	2	4	6	12
5	V	**ADVANCE PLC PROGRAMMING AND APPLICATION**	CO5	10	3	6	6	15
6	VI	**SUPERVISORY CONTROL AND DATA ACQUSITION SYSTEM**	CO6	06	2	4	2	08
								35
Grand Total				**45**	**17**	**29**	**24**	**70**

IX. ASSESSMENT METHODOLOGIES / TOOLS

Formative assessment (Assessment for Learning)		Summative Assessment (Assessment Of Learning)
1. Tests	4. Self-Learning	1. End Term Exam
2. Assignment	5. Term Work	2. Micro-project
3. Midterm Exam	6.Seminar/Presentation	

X.SUGGESTED COS- POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes(POs)							Programme Specific Outcomes*(PSO)		
	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	PSO-3
CO1	3	1	2	1	1	-	2	2	-	-
CO2	3	1	2	1	1	1	2	3	-	-
CO3	3	2	2	2	2	1	2	3	2	1
CO4	3	3	3	2	2	1	2	3	2	1
CO5	2	3	3	2	2	2	2	3	3	2
CO6	2	2	3	2	2	2	2	3	3	2

Legends:- High:03, **Medium:**02, **Low:**01, **No Mapping:** -
*PSOs are to be formulated at the institute level

X. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher
1	Jadhav V. R.	Programmable logic controller	Khanna Publishers, New Delhi 2017 ISBN :9788174092281
2	Petruzella F. D.	Programmable logic controller	Tata –McGraw Hill India,New Delhi, Fourth edition 2010ISBN:9780071067386
3	Boyar S.A.	SCADA	SIA Publication, New Delhi, Fourth editionISBN:978-1936007097
4	Jon Stenerson	Industrial automation and process control	PHI Learning,New DelhiISBN:9780130618900
5	Madhuchhand A Mitra, Samarjit Sen Gupta	Introduction to Programmable Logic Controllers	Penram international publication, New Delhi, 2015, ISBN: 978-8187972174
6	Garry Dunning	Introduction to Programmable Logic Controllers	Edition 3 Delmar Cengage Learning, ISBN-13978-1401884260

XI. LEARNING WEBSITES & PORTALS

Sr.No	Link/Portal	Description
1	PLC tutorial:http://users.ist.ist.utl.pt/-jag/aulas/api13/API_I_C3_3_ST.pdf	Introduction to PLC
2	https://youtu.be/tw-79FiRYKA?feature=shared	Introduction to automation system
3	http://www.youtube.com/watch?v=pPiXEfBO2qo	Introduction to relay
4	https://youtu.be/E2WNPXJF-Kw?feature-shared	Introduction to PLC Basics
5	https://youtu.be/zsajTNtxfAE?feature shared.	PLC ladder programming
6	https://youtu.be/mD146055UN8?feature=shared	PLC ladder programming
7	https://www.youtube.com/watch?app=desktop&v=euFbTdFvAiI	Timer and Counters
8	https://ple-coep.vlabs.ac.in/	Virtual lab for PLC programming

Name & Signature:

Smt. J.J.Pathan
Lecturer in E&TC

Smt. S.S.Chhatwani
Lecturer in E&TC

(Course Experts)

Name & Signature:	Name & Signature:
Shri. Dr.Y.V.Chavan (Programme Heads)	**Shri. S.B. Kulkarni** (CDC In-charge)

GOVERNMENTPOLYTECHNIC, PUNE

'120– NEP'SCHEME

PROGRAMME	**DIPLOMA IN E&TC**
PROGRAMME CODE	**03**
COURSETITLE	**IOT APPLICATIONS**
COURSECODE	**ET41204**
PREREQUISITE COURSE CODE & TITLE	**ET31206**
CLASS DECLARATION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TSL				Based on SL		Total Marks
														Practical						
			CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
										Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
ET41204	IOT APPLICATIONS	DSE	3	1	2	0	6	3	3	30	70	100	40	25	10	25#	10	-	-	150

Total IKS Hrs for Term: 0 Hrs

Abbreviations: CL- Classroom Learning, **TL**-Tutorial Learning, **LL**-Laboratory Learning, **SLH**-Self Learning Hours, **NLH**-Notional Learning Hours, **FA** - Formative Assessment**, SA** -Summative assessment, **IKS** – Indian Knowledge System, **SLA**- Self Learning Assessment

Legends:@-Internal Assessment, **#**-External Assessment, ***#**-Online Examination, **@$**-Internal Online Examination

Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment -Practical)of any course, then the candidate shall be declared as **'Detained'** in that course.
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as **'fail'** and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are**(CL+LL+TL+SL)hrs.*15Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. *Self-learning hours shall not be reflected in the Timetable.
6. *Self-learningincludesmicro-projects/assignments/otheractivities.

II. RATIONALE:

The IoT Applications syllabus is designed to provide students with a practical and theoretical foundation in developing and deploying IoT solutions across various domains. It emphasizes hands-on experience with sensors, microcontrollers, communication protocols, and cloud integration. The course bridges embedded systems, networking, and data analytics to prepare students for real-world IoT challenges.

III. COURSE-LEVEL LEARNING OUTCOMES(CO'S)

Students will be able to achieve & demonstrate the following Cos on completion of course-based learning

CO1: Identify and classify different types of IoT systems based on their application domains and functional characteristics.

CO2: Develop basic IoTpplications using Node MCU ESP8266 .

CO3: Interpret technical specifications and working of various sensors and actuators

CO4: Implement various communication protocols with NodeMCU for IoT applications.

CO5: Demonstrate different applications of IOT.

CO6: Identify and describe the core components of IIoT systems.

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
	SECTION I			
	UNIT - I BASICS OF INTERNET OF THINGS (IOT) (CL Hrs-08,Marks-12)			
1.	**TLO 1.1** Illustrate and explain the basic IoT architecture using a block diagram. **TLO 1.** 2 Classify different types of IoT systems. **TLO 1.3** Explain how embedded systems are used to design smart IoT devices with real-world examples. **TLO 1.4** Elaborate IoT enabling technology for the given application. **TLO 1.5** Explain common security threats to IoT systems	1.1 Basics of IoT: Need, history, definition, characteristics, architecture of IoT with block diagram, deployment level and IoT applications. 1.2 Communication models of IOT 1.3 Types of IoT system 1.4 Enabling technologies for IoT with examples : Big Data Analytics, Cloud computing, Wireless Sensor Networks, Embedded Systems 1.5 IoT system challenges for design and security	Chalk-Board Presentations Video Demonstration	**CO1**
	UNIT- II MICROCONTROLLERS FOR IOT (CL Hrs-08,Marks-12)			
2.	**TLO 2.1** Describe the hardware architecture of the NodeMCU ESP8266 microcontroller. **TLO 2.** Illustrate how NodeMCU supports UART, I2C, and SPI for communication with external devices. **TLO 2.3** Explain the structure and components of the NodeMCU ESP8266 development board. **TLO 2.4** Create, compile, and upload basic programs (sketches) from Arduino IDE to the NodeMCU board. **TLO 2.5** Compare Raspberry pi models	2.1 NodeMCU ESP8266: features, specifications, hardware architecture, GPIO pins. 2.2 NodeMCU communication port: UART, I2C, SPI 2.3 Terms used with NodeMCU: firmware, Wi-Fi, NodeMCU ESP8266 development board and its pin configuration 2.4 Arduino Integrated Development Environment - (IDE), Arduino IDE setup, creating, compiling, and uploading programs from Arduino IDE to NodeMCU 2.5 Applications using NodeMCU ESP8266 and Arduino IDE. (Use of functions, string, array, timer, I/O function, PWM, interface LED & switch) 2.6 Introduction to Raspberry pi, Core Capabilities, Popular Raspberry Pi Models and their Features	Classroom Learning, Reference books, NPTEL	**CO2**

UNIT - III IOT SENSORS AND ACTUATORS (CL Hrs-07,Marks-11)				
3.	**TLO 3.1** Differentiate between linear and digital input sensors with suitable examples. **TLO 3.2** Describe the technical specifications of common actuators. **TLO 3.3** Draw and interpret the pin diagram and circuit connection for interfacing each sensor with NodeMCU **TLO 3.4** Write program to interface sensors and actuators. **TLO 3.5** Describe the process of setting up Raspberry pi for application.	3.1 Linear and Digital input devices, Sensors: LDR, PIR, LM35, DHT11, IR, Gas sensor-MQ 4 3.2 Actuators: Linear and Rotary Actuators, servo motor and servo drive, solenoid valve, motorized actuators relay, stepper motor (only technical specifications, pin diagram and working expected) 3.3 Programming and Interfacing sensors and actuators with Node MCU: Temperature sensor- LM-35, Gas sensor -MQ 4, Humidity sensor- DHT11, Photo sensors- LDR, PIR, IR with NodeMCU 3.4 Installation and configuring Raspberry pi : Setting up Raspberry pi OS.	Classroom Learning, Reference books, NPTEL	**CO3**
SECTION II				
UNIT - IV IOT COMMUNICATION PROTOCOL (CL Hrs-08,Marks-14)				
4.	**TLO 4.1** Explain the features and working methods of given protocols. **TLO 4.2** Write steps to connect NodeMCU to Wi-Fi network. **TLO 4.3** Write step by step procedure to create web Server with NodeMCU. **TLO 4.4** Select IoT platform for the given application with suitable reason. **TLO 4.5** Describe the publish / subscribe architecture of MQTT. **TLO 4.6** Analyze suitable network technologies based on application requirements.	4.1 IoT Protocols: HTTP-REST, MQTT, CoAP (features, methods, communication, applications) 4.2 IEEE802.11: Wi-Fi (features, applications), configure Wi-Fi on NodeMCU, Wi-Fi libraries, code for connecting to Wi-Fi networks 4.3 Procedure to create web server with NodeMCU 4.4 Introduction to IoT cloud platforms: AWS IoT, ThingSpeak, Google Cloud IoT, Microsoft Azure IoT. (Use cases and features) 4.5 Data Communication using MQTT with NodeMCU: connect to a broker, publish and subscribe topics, collect, send and receive data using MQTT 4.6 IoT networking technology : LoRa, NbIoT (Features and applications)	Classroom Learning, Reference books, NPTEL	**CO4**
UNIT - V IOT APLLICATIONS AND CASE STUDIES (CL Hrs-08,Marks-13)				
5	**TLO 5.1** Interpret a conceptual block diagram showing the integration of temperature, humidity, and soil sensors with actuators **TLO 5.2** Describe the working of a weather forecasting system using IoT sensors and cloud analytics. **TLO 5.3** Explain the basic concept of smart traffic control using IoT.	5.1 Agriculture: Green house control using IoT, Weather forecasting 5.2 Smart City: Street light control system, Traffic control System, Waste management 5.3 IoT based smart energy meter 5.4 IoT based surveillance system 5.5 Home automation: controlling lights, Fans and smart lock	Classroom Learning, Reference books, NPTEL	**CO5**

	TLO 5.4 Describe IoT based smart Energy meter with the help of block diagram. **TLO 5.5** Describe the conceptual operation of a remote surveillance system using IoT **TLO 5.6** Demonstrate IoT system for Smart home with the help of example. **TLO 5.7** Explain how IoT is used in electric vehicle battery monitoring.	5.6 EV(Electrical Vehicles) battery management using IoT (only basic working with conceptual block diagram)		
UNIT-VI OVERVIEW OF INDUSTRIAL IOT (CL Hrs-06,Marks-08)				
6	**TLO 6.1** Compare IIOT and IOT. **TLO 6.2** Explain roll of IIOT industry 4.0 in smart manufacturing. **TLO 6.3** Identify and explain the layered architecture of an IIoT system. **TLO 6.4** List and explain the function of key IIoT components **TLO 6.5** Describe the working of predictive maintenance systems using vibration, temperature, and operational data.	5.1 IIOT Basics: Difference between IIoT and IOT. Benefits of IIoT. 5.2 Role of IIoT in industry 4.0 and smart manufacturing 5.3 IIoT system layer architecture 5.4 Core components of IIoT 5.6.Challenges of IIoT 5.5 Real-world industrial applications: Predictive Maintenance, Environmental Monitoring.	Classroom Learning, Reference books, NPTEL	**CO6**

V. LABORATORYLEARNINGOUTCOMEANDALIGNEDPRACTICAL/TUTORIALEXPERIENCES.

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment/Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
1*	LLO 1.1 Install and configure Arduino IDE for NodeMCU programming.	Installation and configuration of Arduino IDE for NodeMCU	2	1
2*	LLO 2.1 Interface LED and switch with NodeMCU to turn ON and OFF LED.	Interfacing LED and Switch with NodeMCU	2	2,3
3*	LLO 3.1 Control relay operation using NodeMCU and IR sensor.	Interfacing relay and IR sensor with NodeMCU	2	2,3
4*	LLO 4.1 Measure and display humidity using DHT 11 and NodeMCU	Interfacing Humidity sensor with NodeMCU	2	2,3,5
5*	LLO 5.1 Interface LM35 with NodeMCU and measure temperature.	Interfacing Temperature Sensor (LM35) with NodeMCU	2	2,3,5
6	LLO 6.1 Interface MQ-4 with NodeMCU	Interfacing MQ-4 gas sensor with NodeMCU.	2	2,3,5
7	LLO 7.1 Measure light intensity using LDR and NodeMCU.	Measuring Light Intensity using LDR and NodeMCU.	2	2,3,5
	LLO 8.1 Detect motion using PIR sensor and NodeMCU.	Interfacing PIR Sensor with NodeMCU	2	2,3,5

9*	LLO 9.1 Configure NodeMCU to connect to a Wi-Fi network and troubleshoot connectivity issue.	Connecting NodeMCU to Wi-Fi network	2	2,3
10*	LLO 10.1 Use HTTP protocol to send sensor data from NodeMCU to a web server (use any cloud service).	Data Transmission from NodeMCU to Web Server.	2	2,3,4,5
11*	LLO 11.1 Control intensity of LED according to the data received from cloud. (use any cloud service)	Monitoring and controlling light intensity using NodeMCU	2	2,3,5
12*	LLO 12.1 Design a smart home system using NodeMCU to Control the lights, Fans and Locking system. (use any cloud service)	Implementation of IoT enabled Smart Home applications	2	2,3,5
13	LLO 13.1 Send sensor data to ThingSpeak cloud for visualization and logging.	Publishing Sensor Data to ThingSpeak IoT Cloud Platform	2	4
14*	LLO 14.1Use a mobile app (e.g., Blynk) to control devices connected to NodeMCU.	Controlling Devices via Mobile App Using Blynk and NodeMCU	2	5,6
15	LLO 15.1 Interface a servo motor and control its angle using PWM signal.	DC Motor Control Using NodeMCU	2	5,6
16	LLO 16.1 Implement publish and subscribes mechanism using MQTT with NodeMCU.	MQTT Communication with NodeMCU – Publishing and Subscribing Data	2	4,5,6
17	LLO 17.1 Setup and configure Raspberry pi OS with network settings	Configuring Raspberry pi OS with network settings.	2	2,3
18	LLO 18.1 Interface temperature sensor with Raspberry pi and visualize data.	Interfacing temperature sensor with Raspberry pi.	2	2,3

Note: A suggestive list of PrOs given in the above table. More such PrOs can be added to attain the Cos and competency. A judicial mix of a minimum of 12 or more practical needs to be performed. Out of which, the Practical's marked as'*'are compulsory.

Assignment/Activities

- Mini Project Proposal: IoT Solution for a Real-Life Problem
- Interface a DHT11/LM35 with NodeMCU and log the data on ThingSpeak.
- Research and create a comparison chart between IoT and Industrial IoT.
- Draw a conceptual block diagram for an IoT-based smart-laboratory.
- Design a digital poster for common IoT security threats and best practices. Use creative visuals and simple language.

VI. LABORATORY EQUIPMENT/INSTRUMENTS/TOOLS/SOFTWARE REQUIRED

Sr. No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Software tools- Arduino IDE (open Source)	All
2	Computers/Laptops: with operating system windows 10 or higher version.	All
3	IoT Trainer kit using NodeMCU with switches and LED's	All

4	Sensors: LDR-Light dependent resistor, IR- Infrared sensor,LDR, PIR sensor, DHT11- Humidity and temperature sensor. Actuators :DC Motor, Relays, Servo Motor	2,3,4,5,6,7,8,10,11,12,14,15,16,18
5	Any open source cloud service available (viz. ThingSpeak/ Google cloud / Microsoft Azure/AWS/BLYNK others).	13,14
6	Raspberry Pi OS	17,18
7	Raspberry Pi trainer kit.	

VII. SUGGESTED FOR WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr. No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
SECTION I								
1	**I**	Basics of Internet of Things (IoT)	CO1	8	2	6	4	12
2	**II**	Microcontroller for IOT	CO2	8	2	4	6	12
3	**III**	IoT Sensors and Actuators	CO3	7	2	4	5	11
								35
SECTION II								
4	**IV**	IoT Communication Protocols	CO4	8	4	4	6	14
5	**V**	IoT applications and Case studies	CO5	8	3	4	6	13
6	**VI**	Overview of Industrial IOT	CO6	6	-	2	6	08
								35
		Grand Total		**45**	**13**	**24**	**33**	**70**

VIII. ASSESSMENTMETHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)		Summative Assessment (Assessment of Learning)
1. Tests	4. Self-Learning	1. End Term Exam
2. Assignment	5. Term Work	2. Micro-project
3. Mid-term Exam	6. Seminar/Presentation	

IX. SUGGESTED COs-POs MATRIX FORM

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	PSO-3
CO1	2	-	1	-	2	1	3	1	-	-
CO2	1	3	3	3	3	3	3	3	1	1
CO3	1	3	3	3	3	3	3	3	3	3
CO4	1	-	1	1	1	1	1	1	1	1
CO5	1	3	3	3	3	3	3	3	3	3
CO6	1	3	3	3	3	3	1	3	3	3

Legends:-High:03,**Medium:**02,**Low:**01,**NoMapping:-**
*PSOs are to be formulated at the institute level

X. SUGGESTEDLEARNINGMATERIALS/BOOKS

Sr.No	Author	Title	Publisher
1	Arshdeep Bahga, Vijay Madisetti	Internet of Things: A Hands-On Approach	University Press, ISBN: 9788173719547
2	Raj Kamal	INTERNET OF THINGS Architecture and Design Principles	McGraw Hill Education (India) Private Limited, ISBN: 9789390727384
3	Adrin McEwen & Hakim Cassimality	Designing the Internet of things	Wiley India, ISBN: 9781118430620
4	David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton, Jerome Henry	IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things	Cisco Press, ISBN: 9781587144561
5	Richard Blum	Sams Teach Yourself Arduino™ Programming in 24 Hours	Pearson Education, Inc. ISBN: 9780672337123
6	Alasdair Gilchrist	Industry 4.0 The industrial IOT	Apress, ISBN: 978-1484220467
7	Simon Monk	Raspberry pi Cookbook	O'Reilly Media, ISBN: 978-1491939108
8	Maneesh Rao	IOT with Raspberry pi3	Packt Publishing ISBN:978-1788627402

XI. LEARNINGWEBSITES&PORTALS

Sr.No	Link/Portal	Description
1	https://infyspringboard.onwingspan.com/web/en/app/toc/lex_auth_013000944973053952187 5_shared/overview	IoT Platform
2	https://infyspringboard.onwingspan.com/web/en/app/toc/lex_auth_013294742104276992298 93_shared/overview	"Mastering IoT with Arduino". Infosys Spring board online course for Thinkspeak platform.
3	https://www.arduino.cc/en/software	Arduino IDE software
4	https://www.tinkercad.com/projects?subject=arduino&sort=views	Arduino projects on Tinkercad
5	Introduction to Internet of Things - Course (nptel.ac.in)	Complete coverage of IoT
6	https://infyspringboard.onwingspan.com/web/en/app/toc/lex_auth_013843012953202688286 57_shared/overview	IoT Automation with ESP8266 with Projects
7	https://www.guru99.com/iot-tutorial.html	IoT Tutorial: Introduction to Internet of Things (IoT Basics)
8	https://infyspringboard.onwingspan.com/web/en/app/toc/lex_auth_013000944973053952187 5_shared/overview	IoT Platform
9	https://onlinecourses.nptel.ac.in/noc20_cs69/preview	IIOT NPTEL

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(CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE

'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN E&TC**
PROGRAMME CODE	**03**
COURSE TITLE	**MICROWAVE ENGINEERING & RADAR SYSTEM**
COURSE CODE	**ET51204**
PREREQUISITE COURSE CODE & TITLE	**NA**
CLASS DECLARATION COURSE	**NO**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme										
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TSL				Based on SL	Total Marks
														Practical					
			CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA	
										Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
ET51204	MICROWAVE ENGINEERING &RADAR SYSTEM	DSC	4	-	2	2	8	4	3	30	70	100	40	25	10	25@	10	25	10	175

Total IKS Hrs for Term: 0

Abbreviations: CL-Classroom Learning, **TL**-Tutorial Learning, **LL**-Laboratory Learning, **SLH**-Self Learning Hours, **NLH**-Notional Learning Hours, **FA** - Formative Assessment**, SA** -Summative assessment, **IKS** – Indian Knowledge System, **SLA**- Self Learning Assessment

Legends: @-Internal Assessment, **#** - External Assessment, ***#** - Online Examination, **@$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as '**Detained**' in that course.
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as '**fail**' and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. * Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- Maintain microwave and RADAR based communication systems.

III. COURSE-LEVEL LEARNING OUTCOMES (CO's)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry-oriented COs associated with the above-mentioned competency:

1. Use specified waveguides in microwave communication system.
2. Maintain passive microwave components and devices.
3. Maintain active microwave components and devices.
4. Interpret RADAR based systems for range detection.
5. Maintain various types of RADAR system for the specified application.

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant Cos
UNIT I. FUNDAMENTALS OF MICROWAVE COMMUNICATION AND WAVEGUIDES (CL Hrs-10, Marks-12)				
1.	**TLO 1.1**: Summarize the range and applications of the given micro wave frequency bands. **TLO 1.2**: Compare the given parameters of waveguide and transmission line **TLO 1.3**: Explain the properties of the given parameters for the circular waveguide with example. **TLO 1.4**: Calculate the cut off wavelength, cut off frequency, group and phase velocity of the given rectangular waveguide. **TLO 1.5** Describe with relevant sketch the field pattern of the given mode of rectangular waveguide. **TLO 1.6** Compare the features of circular and rectangular waveguide for the given parameters.	**1.1:** Microwave frequency spectrum, band designations and applications of microwave in various fields **1.2:** Comparison of wave guide with Transmission line **1.3:** Types of Waveguides: Rectangular, Circular, Propagation of waves in rectangular waveguides Reflection of waves from a conducting plane, dominant mode, the parallel plane waveguide, cut off wavelength, cut off frequency, group and phase velocity (Simple numerical) **1.4:** Rectangular waveguide modes: TE, TM TEM, field patterns of TE10, TE20, TE11 modes. **1.5:** Circular waveguide: Advantages, disadvantages and applications of circular waveguide	Chalk-Board Presentations Video Demonstrations	**CO1**
UNIT II MICROWAVE PASSIVE COMPONENTS (CL Hrs-10, Marks-10)				
2	**TLO 2.1** Describe with relevant sketch operation of the given microwave passive component. **TLO 2.2** Describe with relevant sketch the working principle of given ferrite components. **TLO 2.3** Describe the procedure to build/prepare the microwave test bench setup with the help of given microwave accessories and components. **TLO 2.4** Explain functions of the given parameters for a directional coupler.	**2.1:** Multiple Junctions: Working principle and applications of - E plane, H plane, Magic Tee, and Rat race ring **2.2:** Ferrites components - Isolator, Circulator, and Gyrator Accessories: Flanges, Rotating coupling, Bends and corners, Taper, and Twist **2.3:** Directional couplers: Two-hole directional coupler - Working principle and applications, directivity, coupling factor, and isolation **2.4:** Basic microwave antenna (Horn and Dish)	Classroom Learning, Reference books, NPTEL	**CO2**

UNIT III MICROWAVE ACTIVE COMPONENTS (CL Hrs-20, Marks-18)				
3	**TLO 3.1:** Describe with relevant sketch the concept of velocity modulation and bunching effect for the given microwave tube. **TLO 3.2:** Prepare/Draw the apple gate diagram for the given parameters of the micro wave tube. **TLO 3.3:** Describe the applications of the given microwave tube. **TLO 3.4:** Compare the performance of Klystron, Magnetron and TWT on the given parameters. **TLO 3.5:** Describe with relevant sketch the transfer electron effect for the given energy level diagram of Gunn Diode. **TLO 3.6:** Describe with relevant sketch the operation of the given active microwave component.	**3.1:** Microwave tubes Classification Two cavity, Reflex klystron 1.Construction 2.Modulation 3.Bunching process 4.Principle of operation 5.Magnetron: construction, operating principle and applications **3.2:** Slow wave devices: helix TWT construction and principle of operation and applications. **3.3:** Compare the performance of Klystron, Magnetron and TWT. **3.4:** TED (Transferred Electron Devices): Gunn diode -construction, operation principle, modes and application of Gunn diode as an oscillator Avalanche transient time device. **3.5:** IMP ATT diode – construction, operation and applications **3.6:** PIN diode: construction, operation and applications Esaki diode: Tunnel diode -V-I Characteristics, equivalent circuit, application as an oscillator and as an amplifier.	Classroom Learning, Reference books, NPTEL	**CO3**
UNIT IV RADAR FUNDAMENTALS (CL Hrs-10, Marks-16)				
4	**TLO 4.1:** Describe with relevant sketch functions of the given component of the RADAR system. **TLO 4.2:** Calculate the maximum RADAR range for the given data. **TLO 4.3:** State the effect on the RADAR range for the given the parameters. **TLO 4.4:** Explain with relevant sketch the given type of scanning and tracking methods used for RADAR communication. **TLO 4.5:** Describe with relevant sketch the construction and working of the given microwave antenna.	**4.1:** Basic block diagram of RADAR system **4.2:** RADAR performance factors: RADAR range equation, factors influencing range, effect of noise **4.3:** Basic pulse RADAR system: Block diagram and description, applications **4.4:** Antenna Scanning (types and principle): Horizontal, vertical, helical and spiral. Antenna Tracking (types and principle): Sequential, conical and mono pulse **4.5:** Antenna feed Mechanism: horn and Cassegrain feed antenna	Classroom Learning, Reference books, NPTEL	**CO4**

UNIT V RADAR SYSTEMS (CL Hrs-10, Marks-14)				
5	**TLO 5.1:** Explain with relevant sketch the working principle of the given type of RADAR. **TLO 5.2:** Describe the applications of the given type of RADAR. **TLO 5.3:** Describe with relevant sketch the working principle of the given type of display used with the RADAR system. **TLO 5.4:** Compare CW and Pulsed RADAR for the given parameters. **TLO 5.5:** Describe with relevant sketch	**5.1:** Doppler effect **5.2**: CW Doppler RADAR: Block diagram, operation, and application FM CW RADAR: Block diagram, operation, and application **5.3:** MTI: Block diagram, operation, concept of blind speed, application, Automatic target detection RADAR **5.4:** Display Methods: A-Scope, PPI, Beacons **5.5:** SONAR system: Working principle and applications	Classroom Learning, Reference books, NPTEL	**CO5**

V. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL/ TUTORIAL EXPERIENCES.

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
1*	LLO 1.1:Calculate the cut off frequency, cut off wavelength for the given mode and waveguide.	Use the frequency meter with the microwave test bench setup to determine the frequency and wavelength of the waveguide for TE10 mode.	02	CO1
2	LLO 2.1: Student should be able to use simulation software such as IIT Mumbai Virtual lab for waveguide calculations.	Use freeware/open-source simulation tools to perform practical related to microwave waveguides.	02	CO1
3*	LLO 3.1: Student should be able to calculate power division in E Plane, H Plane ,T Plane using test bench.	Use the microwave test bench setup to ensure power division in microwave tees: E-plane, H-plane, and E-H plane.	02	CO2
4*	LLO 4.1: Student should be able to perform calculations related to circulator.	Determine the coupling factor and insertion loss for the given circulator.	02	CO2
5	LLO 5.1:Define VSWR.	Measure VSWR for the given Microwave load.	02	CO2
6*	LLO 6.1: State the importance of attenuation for different calculations related to Microwave.	Measure the attenuation of the given attenuator.	02	CO2
7*	LLO 7.1:Describe the procedure to build/prepare the microwave test bench setup with the help of given microwave accessories and components.	Determine the directivity, insertion loss, and coupling factor for the given Multi-Hole Directional Coupler.	02	CO2
8	LLO 8.1:Explain the function of the given parameters for a directional coupler.	Use the given microwave test bench setup to measure the gain of the horn antenna.	02	CO2
9*	LLO 9.1:Compare the performance of Klystron on the basis of chosen parameters.	Use the microwave test bench setup to test the performance of the given Reflex Klystron tube.	02	CO3
10*	LLO 10.1: use simulation software such as IIT Mumbai Virtual lab for microwave active components performance comparison.	Test the performance parameter of the given type of microwave active components on freeware/open-source simulation tools.	02	CO3
11*	LLO 11.1: Describe with relevant sketch he transfer electron effect for the given energy level diagram of GUNN diode.	Test the performance of the Gunn Diode for the following aspects: • i. V-I characteristics • ii. Output power and frequency as a function of voltage.	02	CO3
12*	LLO 12.1:Describe the effect of Doppler effect on the working of RADAR.	Use Doppler RADAR to detect the maximum range.	02	CO5

13	LLO 13.1: Calculate the maximum RADAR range for the given parameters.	Determine the velocity of the moving object with the help of RADAR range.	02	CO4
14*	LLO 14.1: Calculate the maximum RADAR range for the given parameters.	Use the RADAR system to measure the distance traveled by any object.	02	CO4
15*	LLO 15.1: use simulation software such as IIT Mumbai Virtual lab to perform the practical related to RADAR communication.	Use freeware/open-source simulation tools to perform practical related to RADAR communication.	02	CO5
Note: A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of a minimum of 12 or more practical needs to be performed. Out of which, the practical marked as '*' are compulsory.				

VI. SUGGESTED MICRO PROJECT /ASSIGNMENT/ACTIVITIES FOR SPECIFIC LEARNING/ SKILLS DEVELOPMENT (SELF-LEARNING)

Micro project

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her. In special situations where groups have to be formed for micro-projects, the number of students in the group should not exceed three.

The micro-project could be industry application-based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs (Affective Domain Outcomes). Each student will have to maintain an activity chart consisting of individual contributions to the project work and give a seminar presentation of it before submission. The student ought to submit a micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned faculty:

a. Market survey of consumer microwave equipment with respect to working principle, manufacturer, technical specification and submit the detail report of it.
b. Prepare power point presentation to explain various types of wave guides and microwave antennas used in any transmitter station.
c. Prepare survey report on mobile van used for live telecast of any event.
d. Prepare are port on the applications of RADAR for Defence and Air navigation.
e. Prepare power point presentation to explain working of various microwave components and Microwave tubes.
f. Prepare chart showing various microwave components.
g Conduct a Library/Internet based survey of microwave components.
h. Compare specifications of at least two different types of RADAR system
i. Prepare power point presentation to explain working of sonar system with examples.
j. Prepare chart showing various microwave diodes and their applications.

Industrial Visit

Visit the nearby communication industry and prepare a report on techniques used for Microwave applications.

Assignment/Activities

a. Prepare chart showing various microwave components.
b. Prepare /download an animation and share with the class to illustrate the working principle of the following
i. Microwave Tubes
ii. EM wave propagation.
c. Visit a place where waveguides are used for microwave communication (such as earth station, Radio station, telephone exchange, airport, TV broadcast, navigation centre) and prepare the report.
d. Conduct a library/Interest based survey of microwave components.
e. Interpret the various BIS Code for microwave communication.
f. Compare specifications of at least two different types of RADAR system.

VII. LABORATORY EQUIPMENT/ INSTRUMENTS/ TOOLS/ SOFTWARE REQUIRED

Sr. No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Microwave test bench-X Band (klystron based)	1 to 9(Excluding 2)
2	Microwave test bench-X Band(GUNN Diode)	11
3	RADAR trainer kit.	12,13,14
4	List of Software/learning Websites List of software RF Tool box: MATLAB and SIMULINK or any other open source software, EZNEC,HFSS-CST, V sim etc.	2,10,15

VIII. SUGGESTED FOR WEIGHTAGE TO LEARNING EFFORTS &ASSESSMENT PURPOSE (Specification Table)

Sr. No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	FUNDAMENTALS OF MICROWAVE COMMUNICATION AND WAVEGUIDES.	CO1	10	4	4	4	12
2	II	MICROWAVE PASSIVE COMPONENTS	CO2	10	4	4	2	10
3	III	MICROWAVE ACTIVE COMPONENTS	CO3	20	6	6	6	18
4	IV	RADAR FUNDAMENTALS	CO4	10	6	4	6	16
5	V	RADAR SYSTEMS	CO5	10	4	4	6	14
		Grand Total		60	24	22	24	70

IX. ASSESSMENT METHODOLOGIES / TOOLS

Formative assessment (Assessment for Learning)		Summative Assessment (Assessment of Learning)
1. Tests	4. Self-Learning	1. End Term Exam
2. Assignment	5. Term Work	2. Micro-project
3. Midterm Exam	6. Seminar/Presentation	

X. SUGGESTED COS- POS MATRIX FORM

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	PSO-3
CO1	2	2	2	2	2	1	2	-	-	2
CO2	1	2	1	--	-	--	2	2	-	-
CO3	--	2	2	--	1	--	2	-	1	-
CO4	--	2	2	1	1	--	1	1	-	-
CO5	--	--	2	--	2	--	2	3	-	3
CO6	--	--	2	--	2	--	2	1	1	--

Legends:- High:03, **Medium:**02, **Low:**01, **No Mapping:** --
*PSOs are to be formulated at the institute level

SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher
1	RADAR systems and radio aids to navigation.	SenA.K. and Bhattacharya A.B.	Mercury Learning & Information. PVT, LTD. New Delhi ,2017 ISBN:978-1683921189
2	Microwave Engineering.	Das Annapurna and Das S.K.	McGraw Hill New Delhi (3 edition 2017 ISBN: 978-9332902879
3	Microwave Engineering.	Gupta Sanjeev	Khanna Publication ,Naisadak Delhi (3d edition 2015 ISBN:978817409087
4	Microwave and RADAR Engineering	Gautam A.K.	S.K. Kataria Publication, Delhi 2012, ISBN: 978-9350 141519
5	Fundamental of Microwave and RADAR Engineering	Sharma K K.	S.chand and comply PVT,LTD New Delhi 201l1,ISBN:978812 1935371
6	Electronics Communication System	Kennedy, George; Davis, Brendan	McGraw Hill ,,New Delhi (5th edition 2011,ISBN: 978-0071077828

XI. LEARNING WEBSITES & PORTALS

Sr.No	Link/Portal	Description
1.	Microwave component: www.youtube.com/microwave component and devices	Information about microwave devices and components
2.	www.youtube.com/RADARS	Information about RADAR
3.	www.nptelvideos in/microwave engineering	Information about microwave fundamentals
4.	www.academic.edu'waveguide	Information about Waveguides

Name & Signature: **Smt. M.S.Datar** Lecturer in E&TC **(Course Expert)**	 **Smt.G.J.Karajagikar** Lecturer in E&TC **(Course Expert)**
Name & Signature: **Dr.Y.V.Chavan** (Programme Head)	**Name & Signature:** **Shri. S.B. Kulkarni** (CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE

'120– NEP' SCHEME

PROGRAMME	**DIPLOMA IN E & TC**
PROGRAMME CODE	**03**
COURSE TITLE	**MOBILE AND WIRELESS COMMUNICATION**
COURSE CODE	**ET41203**
PREREQUISITE COURSE CODE & TITLE	**ET41202**
CLASS DECLARATION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	CourseTitle	Course Type	Learning Scheme					Credits	Assessment Scheme										
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL&TSL Practical				Basedon SL		Total Marks
			CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
										Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
ET41203	MOBILE AND WIRELESS COMMUNICATION	DSC	4	1	2	1	8	4	3	30	70	100	40	25	10	25#	10	25	10	175

Total IKS Hrs for Term: 0 Hrs

Abbreviations:CL-Classroom Learning,**TL**-TutorialLearning,**LL**-Laboratory Learning,**SLH**-Self Learning Hours, **NLH**-Notional Learning Hours, **FA** – Formative Assessment**, SA** -Summative assessment, **IKS** – Indian Knowledge System, **SLA**- Self Learning Assessment

Legends:@-Internal Assessment,**#**-External Assessment, ***#**-Online Examination, **@$**-Internal Online Examination

Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If the candidate does not secure minimum passing marks in **FA-PR**(FormativeAssessment -Practical) of any course, then the candidate shall be declared as **'Detained'** in that course.
2. If the candidate does not a secure minimum passing of marks in the SLA (SelfLearningAssessment) of any course,then the candidate shall be declared as a **'fail'** and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are**(CL+LL+TL+SL)hrs.*15Weeks**
4. **1credit** is equivalent to **30 Notional hours**.
5. *Self-learning hours shall not be reflected in the Timetable.
6. *Self-learning includes micro-projects/assignments/otheractivities.

II. RATIONALE:

In this world of connectivity and collaborative work environment, it is necessary to connect to the network from anywhere, with anybody, at anytime. Wireless communication provides connectivity with mobility, flexibility and convenience. Wireless devices are used across the various industries like Healthcare, Education, Automation, Automobile etc. Effective use of social networking has become possible due to high end wireless devices. This course will help the students to develop skill to handle wireless and mobile communication systems.The course prepares students for careers in telecommunications, network engineering, and mobile system design, while also fostering skills in innovation and critical thinking required for advanced research and industry development in wireless communication.

III. COURSE-LEVEL LEARNING OUTCOMES(CO'S)

Students will be able to achieve & demonstrate the following COs on completion of course-based learning

CO1:Identify the challenges for wireless mobile communication systems.

CO2:Identify the components of mobile cellular systems.
CO3:Analyze various Digital Cellular Mobile Standards.
CO4:Maintain wireless network technologies.
CO5:Interpret 5G system architecture.
CO6:Maintain Adhoc and wireless network.

IV THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes (TLO'S)alignedtoCO's.	Learningcontentmappedwith TLO's.	Suggested Learning Pedagogies	Relevant COs
SECTION I				
UNIT-I INTRODUCTION TO WIRELESS COMMUNICATIONS.(CL-08 Hrs, Marks-10)				
1.	**TLO1.1:**Suggest radio spectrum bands usedfor mobile and wireless communication. **TLO1.2:** Describe the features of the given mobile radio standards. **TLO1.3:**Describe with relevant sketch the working of the specified application of mobile/fixed wireless communication system. **TLO1.4:** Describe with relevant sketch the working of the given fixed wireless network system **TLO1.5:** Describe Challenges in Wireless Communication	1.1 Radio spectrum bands for mobile & wireless communication. 1.2 Wireless network generations Mobile Radio standards: AMPS, N- AMPS, IS -95, GSM, UMTS. 1.3 Mobile wireless Systems : Cordless Telephone system and cellular Telephone system 1.4 Fixed wireless networks: Wireless local loop (WLL) and Local multipoint distribution system (LMDS) 1.5 Challenges in Wireless Communication: Signal degradation, Security issues, Spectrum availability,Power consumption.	Classroom Learning, Reference books, NPTEL	**CO1**
UNIT-II BASICS OF MOBILE COMMUNICATION SYSTEM.(CL-12 Hrs, Marks-15)				
2	**TLO2.1:**Explain with relevant sketch the working principle of the different sections of mobile handset unit 3G. **TLO 2.2:** Explain the given terms with respect to Cellular systems. **TLO 2.3**: Describe Basic cellular system **TLO 2.4:**Choose the handoff mechanism for the given situation with justification **TLO 2.5:** Explain the effect of the given interference on cellular system performance **TLO 2.6:** Select the relevant method to improve coverage and system capacity of the given cellular system with justification.	2.1 Mobile Phone Unit : Block diagram of 3G, working, features of transmitter, receiver section, Frequency Synthesizer, Control unit, Logic Unit of Mobile phone, Sensors: speakers, camera, touch screen, motion sensors and other common sensors. 2.2 Cellular fundamentals: cell, cell structure, cluster, reuse factor, minimum reuse distance, frequency reuse. 2.3 Basic cellular system: mobile station, base station, traffic channel (Forward and Reverse) , control channel (Forward and Reverse), channel assignment strategies. 2.4 Handoff strategies: Concept of handoff, types of handoff: Hard, Soft, Queued, delayed, MAHO(Mobile Assisted handoff), proper and improper Handoff, Umbrella cell approach.	Classroom Learning, Reference books, NPTEL	**CO2**

		2.5 Interference : Co-Channel interference, Adjacent Channel Interference. 2.6 Improving Coverage and capacity in cellular systems: Cell splitting, Sectoring, Microcell Zone concept. Repeaters for range extension		
UNIT-III DIGITAL CELLULAR MOBILE STANDARDS.(CL-10 Hrs, Marks-10)				
	TLO 3.1:Describe with relevant sketch the architecture of the given 3G cellular standards. **TLO 3.2:**Describe with sketch call processing stages in given cellular standards **TLO 3.3:**Explain features of given mobile communication system. **TLO 3.4:**Explain the features of the services and performance of the given type of signaling system	3.1Global System for Mobile communication (GSM): Features and services, GSM radio aspects, GSM architecture, GSM channel types, Security aspects. 3.2 GSM call routing: Mobile terminated call and mobile originated call sequence,stages of call processing in GSM. 3.3 IS 95/CDMA One: Features, Radio aspects, Comparison with GSM standards 3.4 Signalling system No.7(SS7):Network system parts(NSP), Message transfer parts(MTP), Signalling correction control part (SCCP),Services and performance of SS7.	Classroom Learning, Reference books, NPTEL	**CO3**
SECTION II				
UNIT-IV ADVANCED WIRELESS STANDARDS.(CL-12 Hrs, Marks-13)				
4	**TLO4.1**Explain compatibility requirements of the given wireless standards **TLO4.2:**Explain features of the given next generation wireless standards. **TLO4.3:**Describe with relevant sketch the function of the given section ofUMTS network architecture **TLO4.4**:Select the relevant wireless technology for given application	4.1 Need for 3G and 4G technology. 4.2 IMT-2000 global standards :Vision, compatibility, service and spectrum requirements. 4.3 UMTS /W-CDMA standards: Features, architecture, UMTS Air interface specification, security procedure. 4.4 CDMA 2000,features and advanced versions,advantages of CDMA2000 over 3G GSM standards. 4.5Next generation mobile standards Features of 4G and 4G LTE VoLTE,4.5G	Classroom Learning, Reference books, NPTEL	**CO4**
UNIT–V INTRODUCTION TO 5G TECHNOLOGY.(CL-07 Hrs, Marks-10)				
5	**TLO5.1:**Describe 5G network architecture **TLO5.2:**List featuresof IMT 2020 standards	5.1 Introduction to 5G: 5G network architecture, 5G enable technologies. 5.2 IMT 2020 standards.	Classroom Learning, Reference books,	**CO5**

5	. **TLO5.3:** Sketch 5G Radio spectrum. **TLO5.4:**Elaborate 5G network slicing. **TLO5.5:** Describe 5G Spectrum Frequency bands	5.3 5G Radio spectrum : low band, medium band,millimeterwave(Ultrahigh) band,5G service providers, 5.4 5G network slicing. 5.5 5G SpectrumFrequency bands: Low band (<1 GHz), Mid band (1–6 GHz), High band (>24 GHz) Licensed, unlicensed, and shared spectrum, Spectrum challenges and regulatory issues	NPTEL	
UNIT–VI RECENT WIRELESS TECHNOLOGIES & APPLICATIONS. (CL-11 Hrs, Marks-12)				
6	**TLO6.1:**Explain the procedure to connect WiFi **TLO6.2:**Explain theprocedure to connectbluetooth **TLO6.3:** Classify the RFID tags on the basis of the given type ofparameters **TLO6.4:**DescribeApplications of Mobile and Wireless communication	6.1 Features ,architecture, frequency band of Wi-Fi , IEEE 802.11a & 802.11g 6.2 Features ,architecture, frequency band of Bluetooth- BLE (Bluetooth 4.0, Bluetooth Low Energy), IEEE 802.15.1. 6.3 RFID :Concept, frequency band, classification of RFID tags, applications 6.4 Vehicular communication : V2V,Industrial Automation Applications, Smart Cities, Internet of Things(IoT)Application.(a case study for each of these)	Classroom Learning, Reference books, NPTEL	**CO6**

IV. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL/TUTORIAL EXPERIENCES.

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	LaboratoryExperiment/Practical Titles /TutorialTitles	Number of hrs.	Relevant COs
1'*'	LLO 1.1 Identify different sections and componentsof mobile phone such as ringer section, dialer section,receiver section and transmitter section, camera,microphone, speaker, Dash light	Identify different sections and components of mobile phone.	02	CO2
2'*'	LLO 1.2 Identify, access, and test sensors like accelerometer, gyroscope, proximity, and light sensor using diagnostic tools or apps.	Identify the inbuilt sensor of mobile handset and test their performance.	02	CO2
3'*'	LLO1.3 Analyze and verify the functionality of voltage regulation and protection circuits in the power section	Test and study the power supply section of mobile phone unit.	02	CO2
4'*'	LLO1.4Test the charging input, protection ICs, and understand battery charging protocols and power	Test and study the battery charger section and power management unit of mobile phone unit.	02	CO2

	management IC behavior.			
5	LLO1.5 Verify the connectivity, functionality, and signal pathways between the SIM card, display module, and the main board.	Test and study the LCD and SIM section ofmobile phone unit	02	CO2
6 '*'	LLO1.6Test the audio and input components for continuity, signal response, and functionality using multimeters and mobile diagnostic tools.	Test the user interface section (keyboard, Mic, speaker) of mobile phone unit.	02	CO2
7'*'	LLO1.7Apply diagnostic skills to identify faults and implement corrective actions in the charger, display, and SIM sections.	Troubleshoot the battery charger section, LCD section and SIM card section of mobile handset.	02	CO2
8 '*'	LLO1.8 Perform audio signal path testing, isolate issues, and propose/perform hardware/software remedies.	Troubleshoot the speaker problem, microphone problem.	02	CO2
9	LLO1.9 Calculate and compare the coverage area changes using cell splitting concept in mobile communication	Determine the coverage area of a split cell which has radius half the radius of original cell	02	CO2
10'*'	LLO2.0Compute the increase in channel capacity by applying the frequency reuse concept and understand the effect of cell splitting in mobile communication systems.	Determine the channel capacity if each microcell exercise split into 4 mini cell.	02	CO2
11	LLO2.1Carry out SIM/handset setup processes, including IMEI validation, network registration, and device activation using proper tools and procedures.	Perform installation, registration, activation and authentication of mobile	02	CO2
12	LLO2.2Extract and interpret stored SIM data such as IMSI, phonebook, SMS, and network information using SIM card reader software.	Read the content of SIM card using relevant software.	02	CO2
13	LLO2.3Apply AT commands or mobile diagnostic software to simulate and analyze call setup, hold, release, and call forwarding functions.	Execute call control commands using relevant software.	02	CO2
14'*'	LLO2.4 Successfully configure and manage Bluetooth settings to establish a PAN, enabling file transfer or tethering between devices.	Build a Personal Area Network of mobile devices using Bluetooth.	02	CO6

15'*'	LLO2.5Verify the performance and configuration of networking features such as Wi-Fi hotspot, airplane mode, mobile data, and reset options for restoring default settings.	Test the reset function, hotspot and other networking function of given smart phone.	02	CO6
16'*'	LLO2.6 Microproject	Complete a Micro- project based on guidelines provided.	-	All
Note: A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of a minimum of 12 or more practical needs to be performed. Out of which, the Practicals marked * as compulsory.				

VI. SUGGESTED MICROPROJECT/ASSIGNMENT/ACTIVITIES FOR SPECIFIC LEARNING/SKILLS DEVELOPMENT (SELF-LEARNING)

Microproject

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her. In special situations where groups have to beformed formicro-projects, the number of students in the group should not exceed three.

The micro-project could be industryapplication-based, internet-based, workshop-based, laboratory-based, or field-based. Each micro-project should encompass two or more COs which are in fact, an integrationof PrOs, UOs, and ADOs(Affective Domain Outcomes).Each student will have to maintain an activity chart consisting of individual contributions to the project work and give a seminar presentation of it before submission. The student ought to submit a micro-project bythe end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned faculty:

1) Compare the specifications/Technology/features of different types of mobile phones available in market.(Minimum10)
2) Collect the information regarding the special services provided by various mobile service providers in your area.(Minimum5)
3) Market serve on various wireless devices available in market .Examples (wireless speakers, wireless printer, wireless hand phones, wirelesscharger)
4) Prepare a report on TRAI regulation related to mobile communication.(spectrum Allocation)
5) Prepare a report on FCC regulation for spectrum allocation /interferences for mobile Communication.
6) Prepare a report on how radiations from BTS and handsets affect Humanbeings.
7) Prepare a report on Li-Fitechnology.
8) Collect detailed information on various wireless technologies based on IEEE standard, frequency band, speed , range ,advantages and disadvantages and submit the brief report ofit.

Assignments

- Initiatives by Standard Telecom Agencies.
- 5G Initiatives Taken By Government and Standard Agencies.
- 5G Developments Across the World.
- Key areas in which satellites can play a part in 5G.
- Recent Trends in Telecommunication domain.
- 5G network technology & impact on society.
- Roadmap for 5G Architecture in India.
- By using relevant learning material/tutorials,learn how to simulate 4G/5G/6G.
- Collect relevant information/technical specifications required for 4G/5G/6G communication.
- Compare various service providers considering quality of service and cost.

VII. LABORATORY EQUIPMENT /INSTRUMENTS/TOOLS/SOFTWARE REQUIRED

Sr.No	EquipmentNamewithBroadSpecifications	Relevant LLO Number
1	Digital Multimeter 4000 counts large LCD display withauto/manual range, No Power OFF under natural operation ,Data Hold, Max/Min valueHold Capacitance, Frequency/Duty Cycle	2,3,4,5,6,7,8
2	CRO Bandwidth DC-30 MHz (-3 dB)] Ri se time : 12 ns approx Accuracy : ± 3 % InputImpedance : 1 MD 30 pF approx Sensitivity : Internal 5 mm, Ext 0.8 V approxDeflectioncoefficients : Micro-controller based 12 calibrated steps SmV/Div - 20V/Div 1 -2-5sequence X-Y mode : Component Testing	2,3,4,5,6,7,8
3	DSO 100 MHz with 64K color TFT, 16kbps memory, FFTfunction, alternate triggering, Roll Mode, Math Function, digital filter, waveformrecorder,20 automatic measurements, Standard USB host, USB device with waveformanalysis software	2,3,4,5,6,7,8
4	Spectrum Analyzer	2,3,4,5,6,7,8
5	Mobile phone trainer kit Cellular System : EGSM/GSM 900/ 1800 MHz 1,2 to(3GDualband),Rx frequency band(Down link): EGSM 900: 925-960 MHz,GSM 900 :935- 960 MHz GSM 1800 : 1805-1880MHz Tx frequency band (Uplink) : EGSM 900 :880-890MHz GSM 900 : 890- 915 MHz GSM 1800 : 1710-1 785MHz Output power : +5,+33 dBm 3.2 m W . Channel spacing : 200 KHz Display : TFT, 256 K colours,128X 160Pixels, 2.0	1,2,3,4,5,6,7,8
6	3G GSM Mobile phone trainer GSM capability: GSM 900 /1800, E-GSM GSM dataservices: Asynchronous, Transparent & Non Transparent modes. 14.4 K bits/s, SIMInterface : 3 V RF , Transmitter : Maximum output power : 33 dBm +/- 236dB,(EGSM)Maximum output power : 30 dBm +/- 2 dB (DCS) Minimum output power : 5 dBm +/- 5dB (EGSM) Minimum output power : 0 dBm +/- 5 dB (DCS 1800)	2,3,4,5,6,7,8
7	SIM card Reader	12
8	Mobile handset tools Tools to repair any smart phone or mobile phone include - soldering iron, soldering station , solder wire, solder paste, liquid flux, paste flux , jumperwire, tweezers , screwdriver, multimeter, dc power supply, ESD-Safe antistatic wrist strap,mat , apron, hand gloves, LCD tester, Battery tester, PCB holder, PCB Cleaner	2,3,4,5,6,7,8
9	Computer system with modem	9,10,11,12,13,14,15

VIII. SUGGESTED FOR WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (SpecificationTable)

Sr.No	Unit	UnitTitle	AlignedCOs	LearningHours	R-Level	U-Level	A-Level	Total Marks
SECTION I								
1	I	Introduction to wireless communications	CO1	08	4	4	2	10
2	II	Basics of Mobile Communication System	CO2	12	5	5	5	15
3	III	Digital Cellular Mobile Standards	CO3	10	4	4	2	10
								35
SECTION II								
4	IV	Advanced Wireless Standards	CO4	12	4	5	4	13
5	V	Introduction to 5G Technology	CO5	07	2	4	4	10
6	VI	Recent Wireless Technologies & applications.	CO6	11	2	5	5	12
								35
Grand Total				60	21	27	22	70

IX. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two offline unit test of 30 marks and average of two-unit test will considered for out of 30 marks.
- For formative assessment of laboratory learning 25 marks.
- Each practical will be assessed considering 60% weightage to process, 40% weightage to product.

Summative Assessment (Assessment of Learning)

- End semester assessment of 70 marks.
- End semester summative assessment of 25 marks for laboratory learning.

X SUGGESTED COS-POS MATRIX FORM

Course Outcomes (COs)	ProgrammeOutcomes(POs)							ProgrammeSpecific Outcomes*(PSOs)		
	PO-1Basic 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-6Project Management	PO-7 LifeLong Learning	PSO-1	PSO-2	PSO-3
CO1	2	1	2	3	2	1	3	3	3	3
CO2	2	2	3	3	3	3	3	1	3	2
CO3	1	3	3	3	2	3	3	2	3	3
CO4	2	2	3	3	3	3	3	2	3	3
CO5	2	1	3	2	3	2	3	3	3	2
CO6	2	2	3	3	3	3	3	2	3	2

Legends:-High:03,**Medium:**02,**Low:**01,**NoMapping:**-
*PSOsaretobeformulatedattheinstitute level

XI SUGGESTED LEARNING MATERIALS/BOOKS

Sr.No	Author	Title	Publisher
1	William C.Y. Lee	Mobile Cellular Telecommunications	McGraw Hill Education; 2nd edition (1July 2017); McGraw Hill Education (India) Private Limited. ISBN : 978-0070635999
2	Theodore S. Rappaport	Wireless Communications Principles & Practice	Pearson Education India; 2nd edition (1January 2010), ISBN : 978-8131731864
3	T.L.Singal	Wireless Communications	McGraw Hill Education (1 July 2017) (India) Private Limited,New Delhi ISBN : 978-0070681781
4	Simon Haykin,Michael Moher	Modern WirelessCommunication	Pearson Education India; 1st edition (1January 2011), ISBN: 978-8131704431
5	Lin Yi-Bang Clamtac	Wireless and Mobile network Architectures	Imrich,John Wiley &sons,New Delhi,2001 ISBN: 9788126515608

XII. LEARNING WEB SITES & PORTALS

Sr.No	Link/Portal	Description
1.	www.philadelphia.edu.jo/newlibrary	eBook
2.	http://gallucci.net	Mobile networkstandards
3.	www.mobilecellphonerepairing.com	Mobile phone repairing tools and equipments
4.	http://youtu.be/oBiGDhnRI8M	GSM
5.	http://youtu.be/Ftknj4geu1a	IS-95
6	http://youtu.be/r9392Wi7G6E	Wi-Fi
7	www.radio-electronics	Bluetooth technology
8	http://youtu.be/S67OfmwFSkw	Wi-Max
9	www.nptel.com	Mobile and wireless communication
10	https://www.linkedin.com/pulse/applications-5g-technology-ramya-chandran-swprc	Applications of 5G

Name&Signature: **Smt.B.J.Nimbalkar** Lecturer in E&TC (Course Experts)	**Dr.Y.V.Chavan** HOD E&TC (Course Experts)
Name& Signature: **Dr.Y.V.Chavan** (Programme Head)	Name & Signature: **Shri. S.B. Kulkarni** (CDCIn-charge)

GOVERNMENT POLYTECHNIC, PUNE

'120 – NEP' SCHEMES

PROGRAMME	**DIPLOMA IN E& TC**
PROGRAMME CODE	**03**
COURSE TITLE	**ROBOTICS**
COURSE CODE	**ET51205**
PREREQUISITE COURSE CODE & TITLE	**NA**
CLASS DECLARATION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TSL				Based on SL		Total Marks
														Practical						
			CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
										Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
ET51205	ROBOTICS	DSE	3	1	2	-	6	3	3	30	70	100	40	25	10	25#	10	-	-	150

Total IKS Hrs for Term: 0 Hrs

Abbreviations: CL-Classroom Learning, **TL**-Tutorial Learning, **LL**-Laboratory Learning, **SLH**-Self Learning Hours, **NLH**-Notional Learning Hours, **FA** - Formative Assessment**, SA** -Summative assessment, **IKS** – Indian Knowledge System, **SLA**- Self Learning Assessment

Legends: @-Internal Assessment, **#** - External Assessment, ***#** - Online Examination, **@$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as '**Detained**' in that course
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as **'fail'** and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. * Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

The Robots are used to enhance efficiency, precision, and safety across various industries. Robots can operate in dangerous environments and hazardous industrial settings. Robotics integrates engineering, computer science, and artificial intelligence to create automated systems that can perform tasks traditionally done by humans. Robotics is transforming industries by improving efficiency and enabling new possibilities. The purpose of integrating Robotics course into the curriculum is based on its ability to enhance learning, develop critical skills, and prepare students for future technological advancements.

III. COURSE-LEVEL LEARNING OUTCOMES (CO's)

Students will be able to achieve & demonstrate the following COs on completion of course-based learning

CO 1: Understanding industrial robot and safety.

CO 2: Identify basic components of industrial robot.

CO 3: Select Industrial robot for given applications.

CO 4: Select actuator and sensor for given robotic application.

CO 5: Maintain industrial robot.

CO 6: Program robot for given application.

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant Cos
		SECTION I		
	UNIT I INTRODUCTION TO ROBOTICS & SAFETY (CL Hrs-06, Marks-09)			
1.	**TLO 1.1:** Explain the need of industrial robot. **TLO 1.2:** Identify type of given automation. **TLO1.3:** Perform the safety practices while using robot.	1.1 Introduction, Definition, need, brief history of Industrial Robots 1.2 Automation: Type of automation, Need for Automation 1.3 Application of Robots in Industries 1.4 Types of Robots 1.5 Laws' of Robot. 1.6 Safe Practices while Handling the Robot-Safety Symbols, Safety Gear, Applicable Safety Standards, Genera Safety Information, Safety Symbols on the Robotic Arm, Robot Controller, and Teach Pendant. 1.7 Risk Assessment, Workspace, and Safety Zones, Personal Safety Equipment Moving the Robot without Power Residual Risks.	Lecture Using Chalk-Board, Presentations, Video Demonstratio ns	**CO1**
	UNIT-II COMPONENTS AND ANATOMY OF ROBOT (CL Hrs-10, Marks-14)			
2	**TLO 2.1:** Explain fundamental terminology in robotics. **TLO 2.2:** Identify the type of configuration of given industrial robot. **TLÓ 2.3:** Explain basic elements of robotic system. **TLO 2.4:** Classify robot end effector. **TLO 2.5:** Select end effector for the given application.	2.1 Robot configurations- Polar (Spherical), Cylindrical, Cartesian Coordinate, Jointed arm (Articulated) SCARA (Selective Compliance Assembly Robot Arm). 2.2 Basic elements of Robot system (Robot Anatomy): - Base, Manipulator arm, End Effectors, Sensors and transducers, Actuators and Drives, Control systems 2.3 Robot specification: - Degree of Freedom, Work envelope, Load carrying capacity, Speed of movement, Accuracy Repeatability, Control Resolution, Spatial resolution, 2.4 Basic Robot motions: - Vertical motions, Radial motions, Rotational motions, Pitch motions, Roll motions, Yaw motions. 2.5 Types mechanical joints used in Robotics system: - Linear Joint, Orthogonal joint, Rotational Joint, Twisting Joint, Revolving Joint (Symbol Notations) 2.6 Robots End Effectors: Types of End Effectors -Gripper and Tools, Grippers- Mechanical, Pneumatic, Magnetic, Vacuum,	Lecture Using Chalk-Board, Model, Presentations, Video Demonstratio ns	**CO2**

		adhesive, Considerations in gripper selection.		
UNIT-III INDUSTRIAL ROBOT SELECTION (CL Hrs-06, Marks-12)				
3	**TLO 3.1**: Explain the significance of use of industrial robot. **TLO 3.2:** Select the industrial robot for given application. **TLO 3.3**: List the industrial robot manufacturers.	3.1 Why to use a Robot? 3.2 Selection and Classification of Industrial Robot 3.3 Defining Parameters of Robots. 3.4 World Statistics of Industrial Robotics 3.5 Robots in Industry 3.6 Major Robot Manufacturers	Lecture Using Chalk-Board, Model, Presentations, Video Demonstrations, Site/Industry visit	**CO3**
SECTION II				
UNIT-IV INDUSTRIAL ROBOT: ACTUATORS, DRIVERS AND SENSORS (CL Hrs-08, Marks-12)				
4	**TLO 4.1:** Compare different actuators for robotic system. **TLO 4.2:** Explain the different drive system of industrial robot. **TLO 4.3**. Select robot sensor for the given application.	4.1 Actuators and types: Pneumatic Hydraulic and Electric 4.2 Need of Pneumatic System, Basic Components of Pneumatic System Compressor, Valves, Actuators 4.3 Different Electric Rotary Actuators, Recent Advances in Actuators 4.4 Drive and drive system: Pneumatic Hydraulic and Electric Drive Systems. 4.5 Robotic Sensors: Introduction to Sensors in robotics, classification of Sensors- Tactile Sensors, Touch sensors, Force sensors, Force sensing wrist, Joint sensing, Tactile array sensors, Proximity and Range Sensors, Miscellaneous Sensors and Sensor based Systems, Uses of Sensors in Robotics. 4.6 Encoders: Incremental and Absolute Encoders. 4.7 Desirable features of sensors in Robotics.	Lecture Using Chalk-Board, Model, Presentations, Video Demonstrations	**CO4**
UNIT –V. INDUSTRIAL ROBOT: INSTALLATION PROGRAMMING AND MAINTENANCE. (CL Hrs-10, Marks-13)				
5	**TLO 5.1:** Perform installation of industrial robot. **TLO 5.2**: Use teach pendant for industrial robot teaching. **TLO 5.3:** Operate the industrial robot for given condition. **TLO5.4:** Perform maintenance of industrial robot.	5.1 Industrial Robot Installation: Lifting and Mounting of Robotic Arm and Controller. 5.2 Connecting Power Cables, Encoder Cables, and Teach Pendant 5.3 Robot Operation, Switching Modes Jogging, Homing the Robot 5.4 Managing Robot Errors and Faults Logging in and Configuring I/O 5.5 Robot Programming: Brief Introduction to Teach Pendant, Robot Programming Instructions, Jogging of Robot, Overview or Teach Pendant, Robot Arm, and Robo Controller, Central Processing Unit (CPU) I/O Channels, CAN I/O Module, Removable Storage, Basic Robot Program Instructions	Lecture Using Chalk-Board, Presentations, Model Demonstration, Video Demonstrations.	**CO5**

		MOVE, POINT, WAIT, SET, IF, ELSE LOOP, HALT, JUMP, 5.6 Maintenance of Industrial Robot: Inspection of Belts and Pulleys, Changing Belts, Parameters Measurement (Voltage/ Current), Recommended Spares, Troubleshooting, Fault List.		
	UNIT –VI APPLICATIONS OF INDUSTRIAL ROBOT (CL Hrs-05, Marks-10)			
6	**TLO 6.1** Identify type of robot used for the given industrial applications. **TLO 6.2** Explain the working of industrial robot in various applications.	6.1 Robots in material handling- Pick and Place, Palletization. 6.2 Robots in processing operations - Spot welding, Continuous arc welding 6.3 Robots for Spray painting 6.4 Robots in Logistic operations. 6.5 Robots in automated assemblies & inspections (vision, colour, material). 6.6 Path and voice following Robots.	Lecture Using Chalk-Board, Presentations, Model Demonstration, Video Demonstrations.	**CO6**

V. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL/ TUTORIAL EXPERIENCES.

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles/Tutorial Titles	Number of hrs.	Relevant COs
1*	LLO 1.1 Identify different basic robotic components and its working for given system.	Introduction to Industrial robotics lab and safety	02	CO1
2*	LLO2.1 Prepare control panel wiring	Robot installation and control panel wiring	02	CO5
3*	LLO 3.1 Make use of teach Pendant.	Demonstration of teach pendant	02	CO2
4*	LLO 4.1 Jogging robot with different motion commands for given application.	Operate robot for basic motions using teach pendant	02	CO5
5*	LLO5.1 Identify the types of Motor and drive used in robotics	Demonstration of Motor and drive	02	CO2
6	LLO 6.1 Make use of pneumatic System for industrial Robotic system.	Demonstration of pneumatic system	02	CO2
7*	LLO 7.1 Make use of end effector for given application.	Interfacing of end effectors	02	CO2
8*	LLO 8.1 Select sensor for given application.	Interfacing of sensors.	02	CO4
9*	LLO 9.1 Make use of basic commands in robotics.	Robot programming basic- Basic Robot Program Instructions: MOVE, POINT, WAIT, SET, IF, ELSE COOP, HALT, JUMP	02	CO5

10*	LLO 10.1 Make use of conditional statements for robotic application.	Robot programming for Conditional Statements.	02	CO5
11	LLO 11.1 Make use of merged movements command for robotic application.	Industrial robot program for Merged Movements Circular and Arc Movements	02	CO5
12	LLO 12.1 Program robot for machine tending application.	Setup and Programming for Machine Tending with Industrial Robotic Arm	02	CO6
13	LLO 13.1 Program robot for MIG Welding.	Setup and Programming for Robotic MIG Welding	02	CO6
14	LLO 14.1 Apply robot vision system for given application	Setup and Programming for Vision System	02	CO5
15	LLO 15.1 Program robot to follow 2D path.	Setup and Programming for 2D Path Following	02	CO5, CO6
16	LLO 16.1 Apply voice command for given robotic application.	Setup and Programming for Voice Command	02	CO5, CO6
17	LLO 17.1 Apply colour sensor for given robotic application.	Setup and Programming for Colour Sensing	02	CO5, CO6
18	LLO 18.1 Program robot to identify material.	Setup and Programming for Material Sensing	02	CO5, CO6
19	LLO 19.1 Program robot for pelleting palletizing application.	Setup and Programming for Palletizing	02	CO5, CO6
20	LLO 20.1 Program robot for pick and place operation using Magnetic gripper	Setup and Programming for Magnetic Pick and Place	02	CO5, CO6
21	LLO 21.1 Program Robot for logistic sorting system.	Setup and Programming for Logistic Sorting System	02	CO5, CO6
22	LLO 22.1 Program robot for spray painting.	Setup and Programming for Robotic Spray Painting	02	CO5, CO6
Note: A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of a minimum of 12 or more practical needs to be performed. Out of which, the practicals marked as ' *' are compulsory.				

VI. SUGGESTED MICRO PROJECT /ASSIGNMENT/ACTIVITIES FOR SPECIFIC LEARNING/ SKILLS DEVELOPMENT (SELF-LEARNING)

A suggestive list of micro projects / assignments are given here. Similar microprojects/ assignments could be added by the concern faculty:

Assignments

- Prepare a report on latest technology of industrial robot.
- Prepare a report on robot manufacturing industries.
- Prepare a report on gripper manufacturing industries.
- Prepare a report on types of industrial robots.
- Prepare a report on industries using robots.

Microprojects

- Visit industries having robots and prepare detail report on operational and maintenance practices.
- Simulate various robot programs on free robot simulation software.
- Develop robot programs for performing the various industrial operations
- Develop a simple model for any one DoF.
- Develop a model for any one type of industrial robot.
- Case study on robotics systems used in automobile/ manufacturing industry.
- Case study on future robot technologies.
  • Case study on various future applications of robotic systems.

VII. LABORATORY EQUIPMENT/ INSTRUMENTS/ TOOLS/ SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Machine Tending compatible with Industrial Robot - Dummy Parts, Application Panel, Safety Fence, Operating Panel & HMI - Cell Peripheral Items (Wire, Cables, Flux, Cable Tie, etc.) - Robot with Control Panel, Teach Pendant, Power Cable, Adaptor Plate & Pedestal, - Belt Conveyor - Dummy CNC machine Pneumatic Panel	1,2,14,
2	PLC with Cable and Software	9,10
3	Electro Pneumatic Training Cell - Solenoid Valve, Pneumatic Cylinder, FRL Unit - Limit Switch, I/O Box - Pneumatic Peripherals Display Table	6
4	Motor Training Cell - Connections for PLC with Cable and Software - Servo Motor with Drive, Stepper Motor with Drive, Induction Motor, BLDC Motor - I/O Box - Display Table	5
5	EOAT (End of Arm Tooling) Lab - Suction Cups, Vacuum Generator (Venturi), Vacuum Cups Fittings - Pneumatic Gripper Training Kit, 2-Jaw Pneumatic Cylinder, Pneumatic Cylinder Connectors - 24VDC Electromagnetic Gripper - Solenoid Valve, Mounting Bracket, Manifold, FRL Unit	1,7

	I/O Box, Peripherals, Display Table, Pneumatic Tubing	
6	MIG Welding Setup - MIG Power Source, Wire Feeder, Gas Regulator, Welding Torch, Welding Fixture - Power Cable, Earthing Cable -Robot with Control Panel, Teach Pendant, Power Cable, Adaptor Plate & Pedestal - Trigger Cable, Wire Spool (additional spools to be purchased by the college) Parts for Welding - Additional parts must be purchased by the college	15
7	Vision System - Microcontroller Board, Image Camera for Microcontroller Board, External Lighting, Ethernet Switch Suction Cups, Vacuum Generator (Venturi), Vacuum Cups Fittings, Solenoid Valve, Pneumatic Tubing	16, 25
8	2D Path Following - Microcontroller Board, 24VDC Power Supply, Wire Loop, Contact Sensor CAD-2-Motion Software Package	17
9	Voice Command - Microcontroller Board, Android App (Downloadable, without phone) Integration Cables	18
10	Colour Sensing - Microcontroller Board, Image Sensor, External Lip•hting Suction Cups, Vacuum Generator (Venturi), Vacuum Cups Fittings, Solenoid Valve, Pneumatic Tubing	19
1l	Material Sensing - Microcontroller Board, Inductive Sensor Suction Cups, Vacuum Generator (Venturi), Pneumatic Tubing, Solenoid Valve	20
12	Static Palletising - Conveyor, Gravity Feed, Empty Pallet/Box Dispenser Suction Cups, Vacuum Generator (Venturi), Vacuum Cups Fittings, Solenoid Valve, Pneumatic Tubing	21
13	Magnetic Pick and Place - 24VDC Electromagnetic Gripper, Mounting Bracket Metal & Non-Metal Parts, Parts Holding Fixture	22
14	Gluing Application - Robot with Control Panel, Teach Pendant, Power Cable, Adaptor Plate & Pedestal - Pneumatic Glue Dispenser, Glue Cartridge, Dispensing Part, Part Holding Fixture Solenoid Valve, Pneumatic Tubing	24, 28
15	Logistic Sorting System - Microcontroller Board, Suction Cups, Vacuum Generator	25

	(Venturi), Vacuum Cups Fittings, Solenoid Valve Conveyor Belt, Pneumatic Tubing	
16	Additive Manufacturing System - Additive MFG (FDM 3D Printer) FDM Spool	29
18	Spray Painting Lab - Spray Painting Booth, Spray Painting Gun (Robotic Automatic) - Spray Painting Gun Mounting Bracket, Painting Stand - Solenoid Valve, TR10 Robot with Control Panel, Teach Pendant, Power Cable, Adaptor Plate & Pedestal Pneumatic Tubing, Pneumatic Flow Control Valve	26
19	Robots Part Library - Timing Pulley, Timing Belt, Bevel Gears, Drive Shaft - Bearings (Ultra Thin, Angular, Thrust, Double Row, etc.) SMC Covers, Ultra Flexible Cable, Military Grade Pokayoke Connectors	1, 2, 3
20	Other Parts - Encoder, Current Noise Filter, SMPS, Compact Relays	All

VIII. SUGGESTED FOR WEIGHTAGE TO LEARNING EFFORTS &ASSESSMENT PURPOSE (Specification Table)

Sr. No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
SECTION-I								
1	I	**Introduction to Industrial Robotics & Safety**	**CO1**	6	2	3	4	09
2	II	**Components & Anatomy of Industrial Robot**	**CO2**	10	4	4	6	14
3	III	**Industrial Robot Selection**	**CO3**	6	2	6	4	12
								35
SECTION-II								
4	IV	**Industrial Robot: Actuators, Drives & Sensors**	**CO4**	8	4	4	4	12
5	V	**Industrial Robot: Installation, Programming & Maintenance**	**CO5**	10	2	4	7	13
6	VI	**Applications of Industrial Robot.**	**CO6**	5	2	4	4	10
								35
Grand Total				**45**	**16**	**23**	**31**	**70**

IX. ASSESSMENT METHODOLOGIES / TOOLS

Formative assessment (Assessment for Learning)		Summative Assessment (Assessment of Learning)
1. Tests	4. Self-Learning	1. End Term Exam
2. Assignment	5. Term Work	2. Micro-project
3. Midterm Exam	6. Seminar/Presentation	

X. SUGGESTED COS- POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes(POs)							Programme Specific Outcomes*(PSO)		
	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	PSO-3
CO1	1	1	1	1	3	1	3	-	-	1
CO2	1	1	1	2	-	-	1	1	1	1
CO3	2	2	2	2	1	2	1	2	1	3
CO4	1	3	3	3	1	1	1	3	3	3
CO5	2	3	3	3	2	-	1	3	3	3
CO6	1	3	3	3	3	3	2	3	3	3

Legends:- High:03, **Medium:**02, **Low:**01, **No Mapping:** -
*PSOs are to be formulated at the institute level

XI. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher
1	Mikell P. Grooves Michell Weiss Roger N. Nagel Nicholas G. Odrey & Ashish Dutta	Industrial Robotics	McGraw Hill Education (India) Pvt. Ltd., Chennai 2012, ISBN (13): 978-1-25-900621-0
2	Ramchandran Nagarajan	Introduction to Industrial Robotics	Pearson Education India, New Delhi, 2006, ISBN: 978-93-325-4480-2
3	R. K. Rajput	Robotics and Industrial Automation	S. Chand limited, 2008 ISBN- 9788121929974
4	R. K. Mittal & I. I Nagrath	Robotics and Control	TATA McGraw Hill education India Pvt. Ltd. New Delhi, 2010 ISBN:0-07-048293-4
5	Ganesh S. Hegde	A Textbook on Industria Robotics	University Science Press, New Delhi, 2009, ISBN: C-16689/08/12

6	D. J. Todd	Fundamentals of Robo Technology	British library Cataloguing in Publication Data ISBN (13): 978-94-011-6770-3
7	Ghosal, Ashitava	Robotics — Fundamenta Concepts and Analysis	Oxford University Press 2006, ISBN (10) — 978-0-07-026509-7

XII. LEARNING WEBSITES & PORTALS

Sr.No	Link/Portal	Description
1.	https://ifr.org/	International Federation of Robotics
2.	https://www.exeter.ac.uk/	In collaboration with COROT Project
3.	https://www.gre.ae.uk/	In collaboration with COROT Project
4.	https://nptel.ac.in/courses/112105319	NPTEL Course - Industrial Robotics: Theories forImplementation
5.	https://nptel.ac.in/courses/112105249	NPTEL Course - Robotics
6.	http://www.mechanalyzer.com/downloads-roboana1yzer.html	Simulation Software- Roboanalyser
7.	http://www.roboanalyzer.com/tutorials.html	Simulation Software - tutorials
8.	https://www.youtiibe.com/watch?v=ll gRr_NI4BU	Introduction to Industrial Robot
9.	https://www.youtube.com/watch?v=X7iBT5l599c	Industrial Robot Manipulator
10.	https://www.youtube.corn/watch?v=_eanCYWZPsc&t =227s	Animation of Work Envelope
11.	http://vlabs.iitkgp.emet.in/mr/exp0/index.htm1#	Virtual Lab — IIT Kharagpur

Name & Signature: **Smt. P.M.Zilpe** Lecturer in E&TC	**Dr.S.R.Adhau** Lecturer in Mechanical Engg.
(Course Experts)	
Name & Signature: **Dr. Y.V.Chavan** (Program Heads)	**Name & Signature:** **Shri. S.B.Kulkarni** (CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE

'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN E & TC**
PROGRAMME CODE	**03**
COURSE TITLE	**SATELLITE COMMUNICATION**
COURSE CODE	**ET51208**
PREREQUISITE COURSE CODE & TITLE	**NA**
CLASS DECLARATION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme											
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TSL				Based on SL		Total Marks
														Practical						
			CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
										Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
ET51208	SATELLITE COMMUNICATION	DSE	3	1	2	-	6	3	3	30	70	100	40	25	10	25#	10	-	-	150

Total IKS Hrs for Term: 0 Hrs

Abbreviations: CL-Classroom Learning, **TL**-Tutorial Learning, **LL**-Laboratory Learning, **SLH**-Self Learning Hours, **NLH**-Notional Learning Hours, **FA** - Formative Assessment**, SA** -Summative assessment, **IKS** – Indian Knowledge System, **SLA**- Self Learning Assessment

Legends: @-Internal Assessment, **#** - External Assessment, ***#** - Online Examination, **@$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as **'Detained'** in that course.
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as **'fail'** and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. * Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

Satellite communication plays a crucial role in enabling global communication, particularly in remote and underserved areas where traditional terrestrial infrastructure (like cables or fiber optics) isn't feasible. With the rise of technologies like 5G, satellite networks (like Low Earth Orbit satellites) are becoming more integral to providing fast, reliable internet access anywhere on Earth. The course aims to understand the basics of satellite communications, antennas used for satellite communication, various losses in satellite channel, Link analysis, satellite transponder and various methods of satellite access. This course will also facilitate students to apply the basic principles of satellite communication system to maintain different types of applications based on it.

III. COURSE-LEVEL LEARNING OUTCOMES (CO's)

Students will be able to achieve & demonstrate the following COs on completion of course-based learning

CO1 :Analyze different satellite orbits (LEO, MEO, GEO) and their uses.

CO2:Use relevant type of antenna for satellite communication application and Interpret various losses in

satellite channel.

CO3:Analyze satellite communication link and depolarization.

CO4: Elaborate the electronic hardware systems associated with the earth station and Satellite transponder

CO5:Apply various communication techniques for satellite applications..

CO6:Explain role of satellite in various recent applications

THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant COs
UNIT I. OVERVIEW OF SATELLITE COMMUNICATION (CL Hrs-08, Marks-13)				
1.	**TLO 1.1:**Describe with sketches the working principles of the given type of satellite **TLO 1.2:** Understand basic terminologies used in satellite communication **TLO 1.3:** Explain Kepler's law of planetary motion with respect to the given criteria. **TLO 1.4:** Explain the parameters with respect to the given type of satellite orbit.	1.1 Historical background, basic components of Satellite system Earth segment, Space segment, active and passive satellite, geostationary and geosynchronous satellites, Frequency allocations for satellite services. 1.2 Basic terminologies used in satellite communication: latitude, longitude, look angle, Azimuth angle , elevation angle, station keeping, propagation delay time , velocity and footprint. 1.3 Orbital mechanics: Kepler's First Law, Kepler's Second Law, Kepler's Third Law 1.4 Communication Satellite orbits and its types: LEO, MEO, elliptical orbit and GEO. Parameters and characteristics of various Orbits. 1.5 Orbitals effects in communication system performance, Apogee and Perigee Heights, Orbit Perturbations, Effects of a non-spherical earth.	Chalk-Board Presentations Video Demonstrations	**CO1**
UNIT II SATELLITE CHANNEL & TYPES OF ANTENNA (CL Hrs-08, Marks-12)				
2	**TLO 2.1:** Understand different satellite channels **TLO 2.2:** Learn various types of antenna and its propagation patterns for satellite communication **TLO 2.3:** Understand various losses in satellite channel **TLO 2.4:** Learn comparison of various transmission technologies.	2.1 Satellite channel and Electromagnetic field propagation, power flow 2.2 Types of antenna for satellite communication and propagation patterns 2.3 Losses in satellite channel :.Atmospheric losses, power loss, rainfall effects, Receiver noise, temperature noise, noise figure 2.4 Comparison of Network Transmission technologies.	Chalk-Board, Reference books, NPTEL	**CO2**

UNIT III SATELLITE LINK (CL Hrs-07, Marks-10)				
3	**TLO 3.1** :Analyse different links for satellite **TLO 3.2:** Describe polarization and depolarization **TLO 3.3:** Understand concept of frequency reuse.	3.1 Satellite link analysis: satellite uplink, satellite down link, direct broadcasting, up down link analysis and satellite cross-links. 3.2 Frequency, polarization and depolarization of spot beams, satellite down links, Frequency reuse with spot beams, Multiple beams. 3.3 Ionospheric Depolarization, Rain Depolarization, Ice Depolarization	Classroom Learning, Presentations, NPTEL	**CO3**
SECTION II				
UNIT IV SATELLITE TRANSPONDER (CL Hrs -08, Marks-12)				
4	**TLO 4.1:** Describe with sketch the functions of the given sub- system of the satellite earth station. **TLO 4.2:** Describe the given type of control systems associated with the Satellite. **TLO 4.3:** Describe with sketches Transponder model of satellite. **TLO 4.4:** Explain nonlinear satellite amplifier. .	4.1 Satellite earth station:Block, diagram; Antenna subsystem, LNA, Power subsystem, Telemetry Tracking and Command (TTAC) subsystem. 4.2 The transponder model, The satellite front end, front end noise, Front-end filter, front-end wave forms. 4.3 Filtering of digital carriers, satellite signal processing. Transponder Limitations 4.4 Nonlinear satellite Amplifiers AM/AM conversion, AM/PM conversion on nonlinear amplifier model, Effect of nonlinear amplification of digital carrier.	Classroom Learning, Reference books, NPTEL	**CO4**
UNIT V SATELLITE ACCESS (CL Hrs-07, Marks-12)				
5	**TLO 5.1**: Understand different Satellite single access. **TLO 5.2**:Describe FDMA for satellite **TLO 5.3:** Explain different coding techniques of signal access for satellite communication.	5.1 Introduction to Single access 5.2 Preassigned FDMA, Demand-Assigned FDMA, Satellite Access 5.3 Spade System 5.4 TDMA ,Pre-assigned TDMA, Demand-assigned TDMA, Satellite-Switched TDMA 5.5 CDMA	Classroom Learning, Reference books, NPTEL	**CO5**

UNIT VI SATELLITE APPLICATIONS (CL Hrs-07, Marks-11)				
6	**TLO 6.1:** Describe with sketch home satellite TV applications with frequency band **TLO 6.2:** Explain architecture and working principle of VSAT. **TLO 6.3:** Describe GPS system **TLO 6.4:** Explain recent applications of satellite	6.1 C-Band and Ku-Band Home Satellite TV 6.2 Digital DBS TV, DBS-TV System Design 6.3 Satellite Mobile Services: VSATs (Overview, architecture and working principle) 6.4 Global Positioning Satellite System (GPS): concept, working principle, transmitter and receiver.	Classroom Learning, Reference books, NPTEL	**CO6**

IV. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL/ TUTORIAL EXPERIENCES.

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
1*	LLO 1.1 Test the working of satellite communication system.	An overview of the kit which allows studying basic satellite communication systems through uplink transmission, satellite link, and downlink reception.	02	CO1
2	LLO 2.1 Calculate the time period of a satellite for the given velocity and altitude.	Develop a program using a relevant simulation tool to calculate the time period of a satellite for the given velocity and altitude based on Kepler's third law.	02	CO1
3*	LLO 3.1 Observe the radiation pattern of patch antenna.	To generate radiation pattern for patch antenna.	02	CO2
4*	LLO 4.1 Identify different types of losses in satellite link.	Study of various types of losses in satellite link.	02	CO2
5	LLO 5.1 Establish communication link between transmitter and receiver.	To setup a communication link between uplink transmitter and downlink receiver using Satellite.	02	CO3
6*	LLO 6.1 Observe the performance of audio satellite link for the specified uplink and downlink frequency.	Test the performance of audio satellite link for the specified uplink and downlink frequency.	02	CO3
7*	LLO 7.1 Identify the satellite link fail operations and re-establish the link.	Detect the satellite link fail operations and re-establish the link.	02	CO3
8	LLO 8.1.Trasmit three signal simultaneously through satellite link.	Establish a link to transmit and receive three separate signals (audio, video, tone) simultaneously through satellite link.	02	CO3

9*	LLO 9.1 Identify voice & Video signal through satellite link.	To communicate voice & Video signal through satellite link.	02	CO3
10*	LLO 10.1 Observe the effects and impact of rain attenuation(in dB) on satellite communication	To analyze effects and impact of rain attenuation(in dB) on satellite communication	02	CO3
11*	LLO 11.1 Observe the working of Satellite earth station.	Study of Satellite earth station(faculty may arrange visit).	02	CO4
12	LLO 12.1Analyze the concept of TDMA and FDMA with respect to satellite communication	Study of TDMA and FDMA with respect to satellite communication	02	CO5
13	LLO 13.1 Identify different services provided by INMARSAT communication system.	Analysis of data services in INMARSAT communication system.	02	CO6
14*	LLO 14.1 Observe longitude, latitude of any location using GPS receiver	To study GPS data like longitude, latitude using GPS receiver	02	CO6
15*	LLO 15.1 Observe the working of home television.	Demonstrate working of home television	02	CO6
16	LLO 16.1 observe the different sections of satellite communication industry	Visit the nearby satellite communication industry and prepare a report on techniques used .	02	All

V. SUGGESTED MICRO PROJECT /ASSIGNMENT/ACTIVITIES FOR SPECIFIC LEARNING/ SKILLS DEVELOPMENT (SELF-LEARNING)

Micro project

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her. In special situations where groups have to be formed for micro-projects, the number of students in the group should not exceed three.

The micro-project could be industry application-based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs (Affective Domain Outcomes). Each student will have to maintain an activity chart consisting of individual contributions to the project work and give a seminar presentation of it before submission. The student ought to submit a micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. Similar micro-projects could be added by the concerned faculty:

Assignment/Activities

- Visit ISRO website and collect the information related to satellite launching and submit report on it.
- Collect the information related to Indian satellites program.
- Prepare report on satellite
- Prepare a chart to add key details for satellite communication system.

VI. LABORATORY EQUIPMENT/ INSTRUMENTS/ TOOLS/ SOFTWARE REQUIRED

Sr. No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Satellite Trainer Kit (ST2272)/ (STC 24): Up linking frequency 2414/2432/2450/2468 MHz,4MHz clock frequency,PIC 16F84-8 bit RISC processor based on PLL,16MHz bandwidth,FM Modulation of audio and video 5/5.5/8 MHz audio and video modulation,detachable dish antenna,radiated power 25milli watt approximately, 4 downlink frequencies 2414/2432/2450/2468 MHz	1,3,4,5,6,7,8,9
2	Spectrum analyser frequency range 2.4-2.495 GHz,Resolution 26KHZ-3MHz,resolution bandwidth 58.036 to 812.500 KHz	1,3,4,5,6,7,8,9
3	Personal computer with latest configuration and internet facility	ALL

VII. SUGGESTED FOR WEIGHTAGE TO LEARNING EFFORTS &ASSESSMENT PURPOSE (Specification Table)

Sr. No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
SECTION I								
1	**I**	**OVERVIEW OF SATELLITE SYSTEMS AND SATELLITE ORBITS**	**CO1**	**8**	**3**	**6**	**4**	**13**
2	**II**	**SATELLITE CHANNEL & TYPES OF ANTENNA**	**CO2**	**8**	**2**	**4**	**6**	**12**
3	**III**	**SATELLITE LINK**	**CO3**	**7**	**4**	**4**	**2**	**10**
								35
SECTION II								
4	**IV**	**SATELLITE TRANSPONDER**	**CO4**	**8**	**2**	**4**	**6**	**12**
5	**V**	**SATELLITE ACCESS**	**CO5**	**7**	**2**	**4**	**6**	**12**
6	**VI**	**SATELLITE APPLICATIONS**	**CO6**	**7**	**-**	**5**	**6**	**11**
								35
Grand Total				**45**	**13**	**27**	**30**	**70**

VIII. ASSESSMENT METHODOLOGIES / TOOLS

Formative assessment (Assessment for Learning)		Summative Assessment (Assessment of Learning)
1. Tests	4. Self-Learning	1. End Term Exam
2. Assignment	5. Term Work	2. Micro-project
3. Midterm Exam	6. Seminar/Presentation	

IX. SUGGESTED COS- POS MATRIX FORM

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	PSO-3
CO1	1	2	2	2	2	1	2	-	-	2
CO2	1	2	1	2	-	--	2	2	3	2
CO3	1	2	2	2	1	--	2	-	-	2
CO4	--	2	1	1	1	--	1	2	2	2
CO5	--	--	2	--	2	--	2	1	3	2
CO6	--	--	1	--	2	--	2	1	3	2

Legends:- High:03, **Medium:**02, **Low:**01, **No Mapping:** --
*PSOs are to be formulated at the institute level

X. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher
1	Timothy Pratt,Charles Bostian,Jeremy Allnutt	Satellite Communications	Wiley Publications, second edition ,2014 ,ISBN-13**:** 978-81-265-0833-4
2	Roddy Dennis	Satellite Communications	Tata McGraw-Hill, New Delhi, fourth edition ,2017 ISBN-13: 978-0070077850
3	Katiyar, Sapna	Satellite Communication	Katson publications, 3rd edition 2013 ISBN-978-93-5014-481-7
4	Rao Raja K. N	Satellite communication concepts and applications	PHI learning Private limited ,New Delhi , second edition, 2012 ISBN-978-81 -203-4725-0
5	Gerard Maral, Bousquet Michel, Zhili Sun	Satellite communication systems, techniques and technology	Wiley publication, New Delhi 5th Edition,2009 ISBN: 978-0-470-71458-4

XI. LEARNING WEBSITES & PORTALS

Sr.No	Link/Portal	Description
1.	www.nptel.com	Lectures related to satellite communication
2.	https://www.isro.gov.in/	Isro website to get information about satellite
3.	https://www.nasa.gov/	Nasa website to get information about satellite

Name & Signature: **Smt. S.S.Chhatwani** Lecturer in E&TC **(Course Experts)**	**Smt. J.J.Pathan** Lecturer in E&TC **(Course Experts)**
Name & Signature: **Dr.Y.V.Chavan** (Programme Head)	Name & Signature: **Shri. S.B. Kulkarni** (CDC In-charge)

GOVERNMENT POLYTECHNIC, PUNE
'120 – NEP' SCHEME

PROGRAMME	**DIPLOMA IN E& TC**
PROGRAMME CODE	**03**
COURSE TITLE	**VLSI**
COURSE CODE	**ET41206**
PREREQUISITE COURSE CODE & TITLE	---
CLASS DECLARATION COURSE	**YES**

I. LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Course Type	Learning Scheme					Credits	Assessment Scheme										
			Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TSL				Based on SL	Total Marks
														Practical					
			CL	TL	LL					FA - TH	SA-TH	Total		FA-PR		SA-PR		SLA	
										Max	Max	Max	Min	Max	Min	Max	Min	Max	Min
ET41206	VLSI	DSE	3	1	2		6	3	3	30	70	100	40	25	10	25#	10	-	-	150

Total IKS Hrs for Term: 0 Hrs

Abbreviations: CL-Classroom Learning, **TL**-Tutorial Learning, **LL**-Laboratory Learning, **SLH**-Self Learning Hours, **NLH**-Notional Learning Hours, **FA** - Formative Assessment**, SA** -Summative assessment, **IKS** – Indian Knowledge System, **SLA**- Self Learning Assessment

Legends: @-Internal Assessment, **#** - External Assessment, ***#** - Online Examination, **@$** - Internal Online Examination

Note:

FA-TH represents an average of two class tests of 30 marks each conducted during the semester.

1. If a candidate is not securing minimum passing marks in **FA-PR** (Formative Assessment - Practical) of any course, then the candidate shall be declared as '**Detained**' in that course.
2. If a candidate does not secure minimum passing marks in SLA (Self Learning Assessment) of any course, then the candidate shall be declared as '**fail**' and will have to repeat and resubmit SLA work.
3. **Notional learning hours** for the semester are **(CL + LL + TL + SL) hrs. * 15 Weeks**
4. **1 credit** is equivalent to **30 Notional hours**.
5. * Self-learning hours shall not be reflected in the Timetable.
6. * Self-learning includes micro-projects/assignments/other activities.

II. RATIONALE:

VLSI (Very-Large-Scale Integration) design equips aspiring engineers with hands-on experience in both front-end and back-end processes. As a rapidly evolving technology in the industry, VLSI offers vast opportunities for innovation. This course provides students with fundamental skills to develop applications in VLSI using VHDL programming. Additionally, it enables them to utilize FPGA and ASIC chips for design and implement various applications.

III. COURSE-LEVEL LEARNING OUTCOMES (CO's)

Students will be able to achieve & demonstrate the following COs on completion of course-based learning

CO1: Interpret CMOS technology circuits and its applications.

CO2: Develop digital circuits on CPLD and FPGA devices .

CO3: Use VHDL to develop and test digital circuits

CO4: Develop VHDL program for given application using Sequential circuits.

CO5: Develop VHDL program for given application using Combinational circuits.

CO6: Interpret VHDL simulation and synthesis.

IV. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr. No	Theory Learning Outcomes (TLO'S) aligned to CO's.	Learning content mapped with TLO's.	Suggested Learning Pedagogies	Relevant Cos
		SECTION I		
		UNIT - I INTRODUCTION TO CMOS TECHNOLOGY (CL Hrs-9, Marks-12)		
1.	**TLO 1.1** Describe working of MOS transistor as a switch. **TLO 1.2** Sketch the given gates using CMOS logic circuits. **TLO 1.3** Explain stepwise process of CMOS fabrication. **TLO 1.4** Differentiate between the nwell and pwell CMOS. **TLO 1.5** Define the given specification/characteristics of CMOS logic family**.**	1.1 MOS Transistor: switch level modes connection, behavior of series & parallel MOS transistor switch, transmission gates and tristate logic 1.2 CMOS fabrication process: Wafer processing, oxidation, epitaxy deposition, ion-implementation, diffusion, metallization, packaging 1.3 Types of CMOS fabrication: nwell, pwell, twin tub process 1.4 Specifications of CMOS logic family: metastability, noise margins, power dissipation, fan-out, skew, figure of merits (Definitions only) and the parameter values 1.5 CMOS circuits for Boolean function.	Chalk-Board Presentations Video Demonstrations	**CO1**
		UNIT- II ADVANCE PROGRAMMING DIGITAL DEVICES (CPLD, FPGA, ASIC) (CL Hrs-06, Marks-10)		
2	TLO 2.1 Differentiate between Asynchronous and synchronous logic circuits with the help of suitable examples. TLO 2.2 Explain the Moore and Mealy machine design method with the help of suitable diagram and example. TLO 2.3 Describe the functions of each block of the given type of CPLD, FPGA ASIC IC. TLO 2.4Interpret FPGA, CPLA and ASIC parameters.	2.1 Review of Sequential Logic circuits, comparison of Asynchronous and Synchronous logic circuits. 2.2 Moore and Mealy machine: block diagram. 2.3 Design examples on Moore and Mealy such as counter, sequence detector 2.4CPLD: concept, architecture, internal block diagram, applications 2.5FPGA: concept, block diagram, architecture, applications. differentiate between FPGA and CPLD 2.6 ASIC: concept and design flow	Classroom Learning, Reference books, NPTEL	**CO2**
		UNIT – III INTRODUCTION TO VLSI DESIGN CONCEPT (CL Hrs-07, Marks-13)		
3	TLO3.1 Differentiate between VHDL and Verilog on the given parameters. TLO 3.2 Optimize VHDL programming steps with its syntax. TLO 3.3 Use basic elements of VHDL programming and develop the simple code for the given	3.1 Hardware Description Languages (HDL): Very High-Speed HDL(VHDL) vs Verilog, and their functionality and comparison 3.2 VHDL: Features, structure and elements of VHDL (entity, architecture, configuration, package, library only definitions) 3.3 Basic Language Elements: Identifiers,	Classroom Learning, Reference books, NPTEL	**CO3**

	function. TLO 3.4 Describe various data types used in VHDL programming with examples. TLO 3.5 Use VHDL operators to develop mathematical expressions.	VHDL objects: signal, variables and constant (syntax and use) 3.4 VHDL data types: scalar, array, composite, enumerated 3.5 VHDL operators: relational, arithmetic, logical and shift.		
SECTION II				
UNIT - IV VHDL PROGRAMMING FOR COMBINETIONAL CIRCUIT (CL Hrs-06, Marks-12)				
4	TLO 4.1 Compare the VHDL modelling style. TLO 4.2 Develop VHDL program using concurrent statement for the given application TLO4.3Implement given combinational logic circuits using VHDL.	4.1 VHDL Modeling: data flow, behavioral, structural 4.2 Concurrent constructs (when, with) 4.3 Sequential constructs (process, if, case, loop, assert, wait) 4.3 VHDL code for combinational circuits – Logic gates, adder, subtractor, multiplexer, demultiplexer, encoder, decoder, comparator, 4-bit ALU	Classroom Learning, Reference books, NPTEL	**CO4**
UNIT- V VHDL PROGRAMMING FOR SEQUENTIAL CIRCUIT (CL Hrs-07, Marks-12)				
5	. TLO 5.1 Develop VHDL program using sequential statement for given application. TLO 5.2 Implement given sequential logic circuits using VHDL. TLO 5.3 Develop VHDL test bench code for the given circuit**.**	5.1 VHDL code for Sequential circuits – D, T and JK flip-flop, 4 bit up/down counter, MOD counter, shift registers (4-bit SISO and PIPO) 5.2 Test bench: simple test bench for a combinational circuit (full adder) and sequential logic circuit (D/T flipflop)	Classroom Learning, Reference books, NPTEL	**CO5**
UNIT - VI HDL SIMULATION SYNTHESIS (CL Hrs-10, Marks-11)				
6	TLO 6.1 Describe the features of the given type of simulator with a suitable example. TLO 6.2 Define the given component in HDL simulation process. TLO 6.3 Prepare flowchart for the HDL design synthesis process. TLO 6.4 Summarize stepwise HDL design flow.	6.1 Types of simulators: event based and cycle based 6.2 Components: Event scheduling, sensitivity list, zero modelling, simulation cycle 6.3 HDL synthesis process: Pre and Prosynthesis, Boolean optimization, flattering, factoring, mapping to gates 6.4 HDL Design flow: RTL simulation, gate-level verification, place and route	Classroom Learning, Reference books, NPTEL	**CO6**

V. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL/ TUTORIAL EXPERIENCES.

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
1*	LLO 1.1 Identify various blocks of FPGA and CPLD. LLO 1.2 Test the functionality of various pins of FPGA and CPLD.	*Identification of internal block and pin configuration of FPGA & CPLD	02	CO3
2*	LLO 2.1 Install relevant EDA (such as Xilinx software) tool for VHDL. LLO 2.2 Check the VHDL libraries installed in VHDL environment.	*Installation of EDA tool and the relevant libraries for VLSI code development	02	CO3
3*	LLO 3.1 Test the functionality of basic logic gates using VHDL Data flow model. LLO 3.2 Test the functionality of universal logic gates using VHDL Data flow model.	*Develop VHDL code for basic and universal gate for data flow model	02	CO4
4*	LLO 4.1 Test the functionality of basic logic gates using VHDL behavioral model. LLO 4.2 Test the functionality of universal logic gate using VHDL behavioral model.	*Develop VHDL code for basic and universal gate for behavioral model	02	CO4
5*	LLO 5.1 Test the functionality of half and full adder using VHDL code. LLO 5.2 Test the simulated Test bench waveform..	*Realize the half and full Adder on FPGA board	02	CO4
6*	LLO 6.1 Test the functionality of 4:1 multiplexer using VHDL code..	*Realize the Multiplexer on FPGA board	02	CO4
7*	LLO 7.1 Test the functionality of 1:8 De-multiplexer using VHDL code.	*Realize the De-multiplexer on FPGA board.	02	CO4
8	LLO 8.1 Interpret the output of 4:2 encoder using VHDL code.	Design 4:2 encoder on FPGA board	02	CO4
9*	LLO 9.1 Interpret the output of 3:8 decoder using VHDL code.	*(Design 3:8 decoder on FPGA board	02	CO4
10*	LLO 10.1 Test the functionality of D flipflop using VHDL code. LLO 10.2 Test the functionality of T flipflop using VHDL code	*Realize the D and T flipflop on FPGA board	02	CO4
11*	LLO 11.1 Test the functionality of 2-bit comparator using VHDL code.	*Design Comparator on FPGA board	02	CO4

Sr. No	Practical/Tutorial/Laboratory Learning Outcome (LLO)	Laboratory Experiment / Practical Titles /Tutorial Titles	Number of hrs.	Relevant COs
12*	LLO 12.1 Interpret the output of Mod-10 Up counter using VHDL code.	*Design Up Counter on FPGA board	02	CO4
13	LLO 13.1 Develop VHDL code for 4-bit Up/Down Synchronous counter and test the circuit on FPGA board..	Design Synchronous counter on FPGA board	02	CO4
14*	LLO 14.1 Test the functionality of 4-bit binary to gray code converter & Synthesize using FPGA.	*Design binary to gray code converter circuit using FPGA board	02	CO4
15*	LLO 15.1 Develop VHDL code for 8-bit Digital to analog converter (DAC) & test the circuit on FPGA board	*Design digital to analog converter (DAC) using FPGA board	02	CO5
16*	LLO 16.1 Optimize the VHDL code to rotate stepper motor in clockwise direction.	*Design stepper motor Controller using FPGA board	02	CO6
17	LLO 17.1 Develop VHDL code for 4-bit ALU and simulate it using FPGA.	Design of 4-bit ALU/ sequence detector using FPGA board	02	CO6
Note: A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of a minimum of 12 or more practical needs to be performed. Out of which, the practicals marked as ' *' are compulsory.				

V. SUGGESTED MICRO PROJECT /ASSIGNMENT/ACTIVITIES FOR SPECIFIC LEARNING/ SKILLS DEVELOPMENT (SELF-LEARNING)

Assignment

- Develop the flowchart for simulation used in VHDL.
- Write syntax for concurrent and sequential statements.
- Write test bench code of universal shift register using VHDL.
- Describe architecture of CPLD/FPGA with function of each block.
- Develop flow chart of CMOS IC fabrication in p-well and n-well process.

Micro project

- Build a small ASIC system for your Home /Community.
- Develop four-bit addition/subtraction circuit using VHDL code.
- Develop square wave generator system of frequency = 1 Hz/100Hz
- Develop a VLSI based alarm system when a customer enters into the shop through exits door.
- Build a VLSI based system for vehicle security system.
- Design traffic light system using CPLD/FPGA.
- Design Lift controller system using CPLD/FPGA.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities

VI. LABORATORY EQUIPMENT/ INSTRUMENTS/ TOOLS/ SOFTWARE REQUIRED

Sr. No	Equipment Name with Broad Specifications	Relevant LLO Number
1	VLSI trainer kit along with DAC/ADC trainer kit.	15
2	VLSI trainer kit along with stepper motor.	16
3	FPGA trainer kit with Accessories	2,4,5,6,7,8,9,10,11,12,13,14,15,16,17
4	JTAG cable, DMM, Bread board	3,4,5,6,7,8,9,10,11,12,13,14,15,16,17
5	VLSI trainer kit with accessories such as switches,LED,seven segment display etc.	4,5,6,7,8,9,10,11,12,13,14,15
6	Personal computer with latest configuration.	All

VII. SUGGESTED FOR WEIGHTAGE TO LEARNING EFFORTS &ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
SECTION I								
1	I	Introduction to CMOS Technology	CO1	9	2	4	6	12
2	II	Advance Programmable Digital Devices (CPLD, FPGA, ASIC)	CO2	6	2	6	2	10
3	III	INTRODUCTION TO VLSI DESIGN CONCEPTS SEQUENTIAL CIRCUIT	CO3	7	4	5	4	13
								35
SECTION II								
4	IV	VHDL PROGRAMMING USING	CO4	6	2	4	6	12
5	V	VHDL PROGRAMMING USING COMBINATIONAL CIRCUIT	CO5	7	2	4	6	12
6	VI	HDL Simulation and Synthesis	CO6	10	3	4	4	11
								35
			Grand Total	45	15	27	28	70

VI. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two offline unit test of 30 marks and average of two-unit test will considered for out of 30 marks.
- For formative assessment of laboratory learning 25 marks.
- Each practical will be assessed considering 60% weightage to process, 40% weightage to product.

Summative Assessment (Assessment of Learning)

- End semester assessment of 70 marks.
- End semester summative assessment of 25 marks for laboratory learning.

I. SUGGESTED COS- POS MATRIX FOR

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	PSO-3
CO1	3	1	1	1	1	1	2	1	1	1
CO2	3	2	1	1	1	1	2	1	1	1
CO3	3	2	1	1	1	1	2	1	3	1
CO4	3	2	2	2	2	2	3	3	3	1
CO5	3	3	3	3	2	2	3	3	3	1
CO6	3	3	3	2	2	2	3	2	1	3

Legends:- High:03, **Medium:**02, **Low:**01, **No Mapping:** --

*PSOs are to be formulated at the institute level

II. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher
1	VHDL Basics to programming Gaganpreet Kaur Pearson Education India, 2011 ISBN 13: 9788131732113	VHDL Basics to programming Gaganpreet Kaur Pearson Education India, 2011 ISBN 13: 9788131732113	VHDL Basics to programming Gaganpreet Kaur Pearson Education India, 2011 ISBN 13: 9788131732113
2	Digital Logic: Application and design John M. Yarbrough C.L Engineering, ISBN 13: 9780314066756	Digital Logic: Application and design John M. Yarbrough C.L Engineering, ISBN 13: 9780314066756	Digital Logic: Application and design John M. Yarbrough C.L Engineering, ISBN 13: 9780314066756
3	An engineering approach to digital design Willian I. Fletcher Prentice- Hall of India ISBN-13: 978-0132776998	An engineering approach to digital design Willian I. Fletcher Prentice- Hall of India ISBN-13: 978-0132776998	An engineering approach to digital design Willian I. Fletcher Prentice- Hall of India ISBN-13: 978-0132776998
4	Principles of CMOS VLSI Design: A system perspective Neil H. E. Weste Kamran Eshraghian Pearson Education India, 2011 ISBN 13: 9780201082227	Principles of CMOS VLSI Design: A system perspective Neil H. E. Weste Kamran Eshraghian Pearson Education India, 2011 ISBN 13: 9780201082227	Principles of CMOS VLSI Design: A system perspective Neil H. E. Weste Kamran Eshraghian Pearson Education India, 2011 ISBN 13: 9780201082227
5	VHDL programming by example Douglas Perry Tata Mcgraw-hill; 4 edition (2002) ISBN-13: 978-0070499447	VHDL programming by example Douglas Perry Tata Mcgraw-hill; 4 edition (2002) ISBN-13: 978-0070499447	VHDL programming by example Douglas Perry Tata Mcgraw-hill; 4 edition (2002) ISBN-13: 978-0070499447
6	Introduction to VLSI Design Eugene D. Fabricus McGraw Hill ISBN-13: 978-0070199484	Introduction to VLSI Design Eugene D. Fabricus McGraw Hill ISBN-13: 978-0070199484	Introduction to VLSI Design Eugene D. Fabricus McGraw Hill ISBN-13: 978-0070199484

X.LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://docs.amd.com/v/u/en-US/ug1655-ise-documentation	ISE documentation for version 14.7
2	https://web.eecs.utk.edu/~dbouldin/protected/xilinx-ise-quick-start.pdf	ISE quick start tutorial
3	https://faculty.kfupm.edu.sa/COE/aimane/coe405/Tutorial_Nexys3_ISE14.7.pdf	Xilinx 14.7 setup manual
4	https://www.allaboutelectronics.org/cmos-logic-gates-explained/	Logic gates implementation using CMOS inverter
5	https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=018f62f6176afb8427b8d75d7175d13af15f8f8b	CPLD and FPGA architecture.
6	https://www.geeksforgeeks.org/vhdl-very-high-speed-integrated-circuit-hardware-description-language/	VHDL programming.
7	https://nptel.ac.in/courses/117106092	NPTEL- VLSI Design Course

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

Name & Signature:

1. **Smt. C. D. Pophale**
Lecturer in E&TC
(Course Expert)

2. **Smt. G. J. Karajagikar**
Lecturer in E&TC
(Course Expert)

Name & Signature:

Dr.Y.V.Chavan
(Programme Head)

Name & Signature:

Shri. S.B. Kulkarni
(CDC In-charge)