Program Name : **Electronics Engineering Programme Group**

Program Code : **DE/EJ/ET/EN/EX/EQ/IS/IC/IE**

Semester : **Fourth**

Course Title : **Microcontroller and Applications**

Course Code : **22426**

1. RATIONALE

Microcontroller is used in almost all the domestic, industrial, consumer goods and other high end products.Automation is used in every field of engineering and microcontroller is inbuilt element of these systems and devices.Diploma engineers have to deal with various microcontroller based systems and maintain them. This course is intended to develop the skills to maintain and solve the application problems related to microcontrollers.

2. COMPETENCY

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

- **Maintain microcontroller based systems.**

3. COURSE OUTCOMES (COs)

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:

a. Analyse architecture of microcontrollerICs.
b. Interpret the program for 8051in assembly language for the given operations.
c. Interpret the program by using timer, interrupt and serial ports /parallel ports.
d. Interface the memory and I/O devices to 8051 microcontroller.
e. Maintain microcontrollerused in differentapplication.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Theory							Practical				
				Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
L	T	P			Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	-	2	6	3	70	28	30*	00	100	40	25#	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *-Practical;* ***C*** *– Credit,* ***ESE*** *-End Semester Examination;* ***PA*** *- Progressive Assessment.*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the

course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

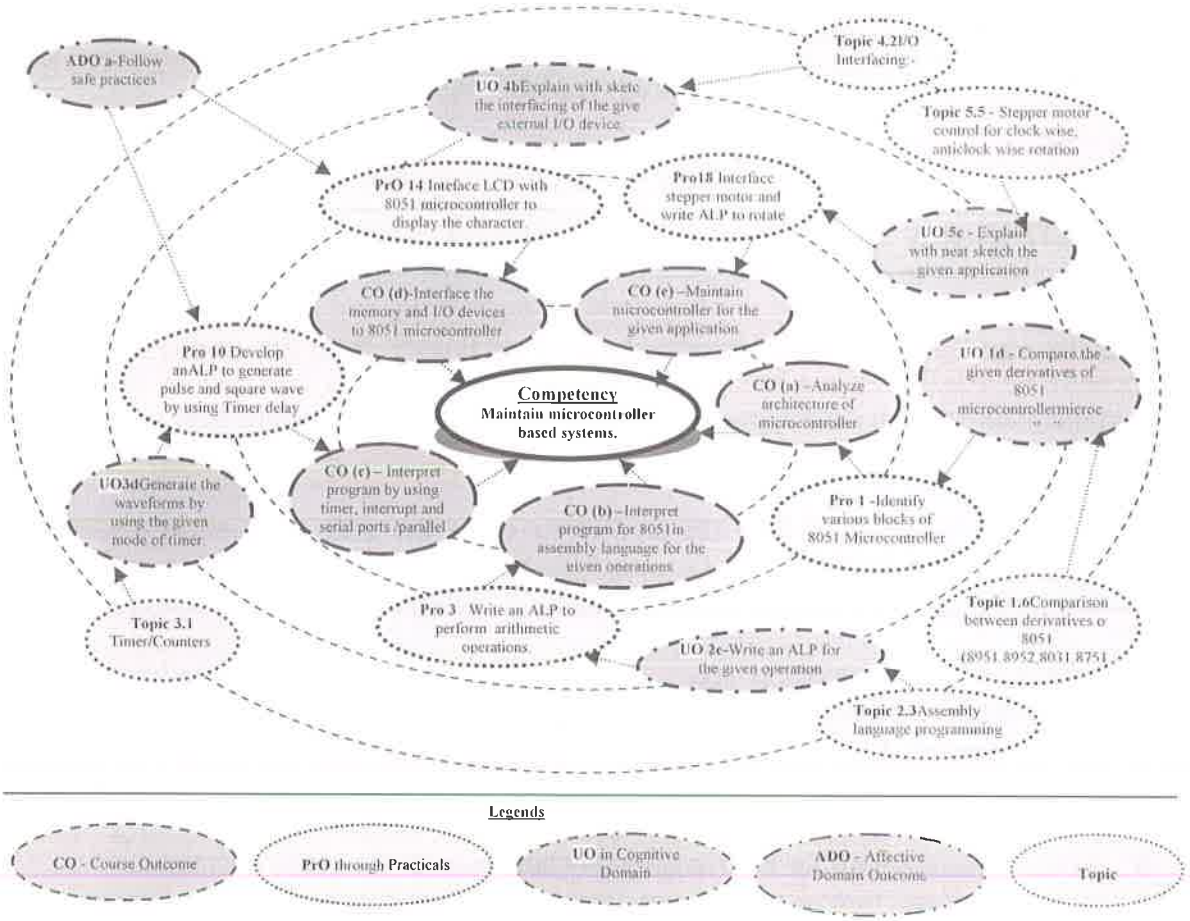


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency:

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Identify various blocks of 8051 microcontroller development board.	I	02*
2	Write sample assembly language program using various addressing modes and assembler directives.	I	02
3	Write an assembly language program (ALP) to perform arithmetic operationsaddition, subtraction, multiplication and division.	II	02
4	Write an ALP to transfer data from source to destination location of internal/external data memory.	II	02*
5	Write an ALP to find smallest/largest number from the given data bytes stored in internal/external data memory locations.	II	02
6	Write an ALP for arranging numbers in ascending /descending order stored in external memory locations.	II	02
7	Write an ALP to generate delay using register.	II	02*
8	Write an ALP to transfer 8 bit data serially on serial port.	III	02

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
9	InterfaceLED with microcontroller and turn it ON with microcontroller interrupt.	III	02
10	Develop an ALP to generate pulse and square wave by using Timer delay.	III	02*
11	Interface 4 X 4 LED matrix with 8051 to display various pattern.	III	02*
12	Interface 7-segment display to display the decimal number from 0 to 9.	IV	02
13	Interfcerelay with microcontroller and turn it ON and OFF.	IV	02*
14	Interface LCD with 8051 microcontroller to display the character and decimal numbers.	IV	02*
15	Interface the given keyboard with 8051and display the key pressed.	IV	02
16	Interface ADC with 8051 microcontroller and verify input/output .	IV	02*
17	Interface DAC with 8051 microcontroller and observefollowingwaveforms: square wave, triangular wave, sawtooth wave.	IV	02*
18	Interface stepper motor to microcontroller and rotate in clockwise and anti-clockwise direction at the given angles.	V	02*
	Total		**36**

Note

i. *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 minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and recording	10
5	Interpretation of result and conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safe practices.
b. Practice good housekeeping.
c. Practice energy conservation.
d. Demonstrate working as a leader/a team member.
e. Maintain tools and equipment.
f. Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organising Level' in 2nd year
- 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Microcontroller kit :-single board systems with 8K RAM,ROM memory with battery back up,16X4,16 X2, LCD display,PC keyboard interfacing facility, Hex keypad facility, single user cross c-compiler,RS-232,USB, interfacing facility with built in power supply or any other equivalent.	All
2	Desktop PC with microcontrollersimulation software.	All
3	Stepper Motor, 50/100 RPM	18
4	CRO- Bandwidth AC 10Hz ~ 20MHz (-3dB). DC ~ 20MHz (-3dB), X10 Probe	17
5	Keyboard 4*4trainer board	15
6	Relay trainer board suitable to interface with 8051 trainer kit	13
7	4 X 4 LED matrix suitable to interface with 8051 trainer kit	
8	7-segment LED Display:- 0.56 in 1-digit, common anode/common cathode	12
9	ADC (0808)trainer board	16
10	DAC (0808)trainer board	17
11	LCD trainer board	14

8. UNDERPINNING THEORY COMPONENTS

The following topicsare to betaught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Basics of Microprocessor and 8051 Microcontroller	1a. Compare salient features microprocessor, microcontroller and microcomputer for the given parameters. 1b. Describewith sketches the function of the specified blocks of the thegiven type of microcontroller architecture. 1c. Explain with sketches memory organization of 8051 microcontroller. 1d. Compare the given derivatives	1.1 Microprocessor ,microcomputers, and microcontrollers (basic introduction and comparison) 1.2 Types of buses,addressbus,data bus and control bus 1.3 Harvard and Von-neuman architecture; 8051 microcontroller:Architecture,Pin configuration, stack ,memory organization 1.4 Boolean processor , power saving options - idle and power down

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	of the 8051 microcontroller. 1e. Describe with sketches the procedure to troubleshoot the simple given microcontroller-based circuit.	mode 1.5 Derivatives of 8051 (8951 , 8952 , 8031 ,8751)
Unit-II 8051 Instruction Set and programming	2a. Identify the addressing mode of the given instruction. 2b. Describe the function of the given instruction with suitable examples. 2c. Write an assembly languge program(ALP) for the given operation. 2d. Explain the function of the given software development tools. 2e. Explain the use of the given assembler directives with examples.	2.1 Addressing modes 2.2 Instruction set (Data transfer, Logical, Arithmatic, Branching, Machine control, Stack operation, Boolean) 2.3 Assembly language programming (ALP) 2.4 Software development cycle: editor , assembler , cross-compiler, linker,locator,compiler 2.5 Assembler Directives: ORG , DB , EQU , END,CODE,DATA
Unit III 8051 Timers, Interrupts , Serial and Parallel Communicatio n	3a. Write an ALP to generate a delay for the given crystalfrequencyfor the specified waveform on the given port 3b. Explain with sketch the operation of the given mode for timer and counter. 3c. Explain with sketch the operation of the given mode for serial communication. 3d. Generate the waveforms by using the given mode of timer. 3e. Describe with sketches the procedure to troubleshoot the simple given timer circuit.	3.1 Timer/Counters :SFRs:TMOD,TCON,Timer/Counter - Logic and modes,Simple programs on timer to generate time delay 3.2 Interrupts-SFRs:- IE, IP , Simple programs on interrupts 3.3 Serial communication - SFRs: SCON , SBUF , PCON, Modes of serial communication. Simple programs on serial communication 3.4 I/O port structure and configuration - P0 , P1 , P2 ,P3
Unit–IV 8051 Memory and I/O device Interfacing	4a. Describe with sketch the interfacing of the given external memory. 4b. Explain with sketch the interfacing of the given external I/O device. 4c. Write an assembly languge program to operate the given I/O device. 4d. Describe with sketches the interfacing diagram of the given ADC chip. 4e. Describe with sketches the	4.1 Memory interfacing :-Program and data memory 4.2 I/O Interfacing:-LED, relays, keyboard,LCD,seven segment display,Stepper motor. 4.3 Interfacing DAC - 0808 with 8051 and itssimple programming 4.4 Interfacing ADC - 0808/09 with 8051 and its simple programming

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	procedure to troubleshoot the simple given I/O device.	
Unit– V Applications of 8051 Microcontroller	5a. Generate the specified waveform using 8051 by the given method. 5b. Control the given parameter using 8051microcontronller. 5c. Explain with sketch the given application which uses the specified microcontroller. 5d. Program 8051 for the given application. 5e. Describe with sketches the procedure to troubleshoot the simple given microcontroller-based application.	5.1 Square wave generation using port pins of 8051 5.2 Square and triangular Waveform genertion using DAC 5.3 Water level controller 5.4 Temperature controller using ADC(0808/09). 5.5 Stepper motor control for clock wise, anticlock wise rotation 5.6 Traffic light controller

***Note**:To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FORQUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of Microprocessor and 8051 Microcontroller	16	04	06	08	18
II	8051 Instruction Set and programming	12	02	04	06	12
III	8051 Timers,interrupts ,serial and parallel communication	14	04	04	08	16
IV	8051 Memory and I/O device Interfacing	12	02	04	06	12
V	Applications of 8051 Microcontroller	10	02	04	06	12
Total		**64**	**14**	**22**	**34**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist students for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare

reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Prepare journals based on practical performed inlaboratory.
b. Follow the safety precautions.
c. Give seminar on relevant topic.
d. Library/ Internet survey regarding different data books and manuals.
e. Prepare power point presentation on applications of microcontroller.
f. Undertake a market survey of different microcontrollers.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Demonstrate students thoroughly before they start doing the practice.
g. Encourage students to refer different websites to have deeper understanding of thecorse.
h. Observe continuously and monitor the performance of students in Lab.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. 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. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.Micro project report may be of four to five pages.

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

a. Prepare a chart of various features using data sheets of 8051 microcontroller and its derivatives.
b. Prepare a chart of stepper motor to display its features and steps for its operations using data sheets.

c. Prepare a chart of various features and operations of temepature sensors using data sheets.
d. Prepare a chart of various types of ADC and DAC to display its features and pin functions using data sheets.
e. Prepare a chart of various types of LCDs to display its features,pin functions and steps of operations using data sheets.
f. Prepare a chart of various types of seven segment displays,keyboard to display its features and steps for its operations using data sheets.
g. Build a circuit using 8051 microcontroller to blink LED.
h. Build a circuit using 8051 microcontroller to blink LED in ring fashion.
i. Build a circuit to turn the buzzer ON after 10 seconds.
j. Build a circuit to turn the buzzer ON after a key pressed.
k. Build a circuit to display number 0 to 9 with a given delay.
l. Build a class period bell using microcontroller.
m. Build a room temperature measurement circuit using microcontroller.
n. Build a circuit to generate square waveform using DAC and microcontroller.
o. Build stepper motor controller using microcontrollers.
p. Build traffic light controller for specified delay.
q. Build a water level controller for given parameters.
r. Identify the advanced microcontrollers such as rasberipi,arduino
s. Build application based on advanced microcontroller such as rasberipi,arduino

Note: Use appropriate software for programming. Build the circuit on PCB.
Faculty may suggests other than above metionedmicroprojects.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	8051 Microcontroller Architecture, Programming and Application	Kenneth J.Ayala	PHI Learning New Delhi,July 2004, ISBN: 978-1401861582
2	Microcontroller Theory and Application	Ajay V.Deshmukh	McGraw Hill, New Delhi, 2011, ISBN- 9780070585959
3	Microcontrollers Principle and Application	AjitPal	PHI Learning,New Delhi, 2014, ISBN: 978-81-203-4392-4
4	The 8051 Microcontroller and Embedded system Using Assembly and C	Muhammad Ali Mazidi, Janice GillispieMazidi,Rolin D.Mckinlay	Pearson /Prentice Hall, , 2nd edition, Delhi,2008, ISBN 978-8177589030
5	Microcontroller Architecture Programming, Interfacing and System Design	Raj Kamal	Pearson Education, Delhi, 2012, ISBN:9788131759905
6	Microprocessors and Microcontrollers	Sunil Mathur, JeebanandaPanda	PHI Learning,NewDelhi, 2016,ISBN :978-81-203-5231-5
7	Microprocessors and Microcontrollers:Architecture programming and System Design	Krishna Kant	PHI Learning New Delhi, 2016,ISBN:978-81-203-4853-0

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. Simulation software:-www.keil.com
b. Microcontroller:- www.faqs.org/microcontroller
c. Microcontroller:- www.nptel.ac.in/courses/Webcourse-contents/IITKANPUR/microcontrollers/micro/ui /Course_home2_5.htm
d. Memory:- www.slideshare.net/aismahesh/memory-8051
e. 8051 microcontroller:- www.intorobotics.com/8051-microcontroller-programming-tutorials- simulators-compilers-and-programmers/
f. Microcontroller instructions:- www.electrofriends.com/articles/electronics/microcontroller-electronics-articles/8051-8951/80518951-microcontroller-instruction-set/
g. Microcontroller:- www.ikalogic.com/part-1-introduction-to-8051-microcontrollers
h. Microcontroller:- www.binaryupdates.com/switch-with-8051-microcontroller/
i. Software:-www.edsim51.com
j. Microcontroller:- www.mikroe.com/chapters/view/64/chapter-1-introduction-to-microcontrollers/
k. Microcontroller project:- www.8051projects.net/download-c4-8051-projects.html


MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION MUMBAI

Program Name : Diploma in Automation and Robotics

Program Code : AO

Semester : Fourth

Course Title : Advanced Automation System

Course Code : -

1. RATIONALE

In the present global scenario of manufacturing, industries are moving towards more and more automation. Small scale and medium scale industries require PLC and SCADA technology, So, it is very necessary for an Automation engineer to have knowledge of both PLC and SCADA. So, this course attempts to provide basic configurationally knowledge of these technologies to develop operational competency. Hence this course is very important for Automation engineers who want to specialize in industrial automation.

2. COMPETENCY

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

- **Maintain Advanced Industrial Automation systems.**

3. COURSE OUTCOMES (COs)

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**:**

a. Compare Different SCADA systems based on given parameters.
b. Use the relevant Network communication protocol for specific SCADA applications.
c. Develop SCADA based applications in integration with PLC.
d. Use the HMI Panel for given applications.
e. Use the SCADA system to develop the given industrial applications.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory						Practical						
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	-	2	6	3	70	28	30*	00	100	40	25#	10	25	10	50	20

(~): *For the practical only courses, the PA has two components under practical marks i.e. components of the COs), to be developed and assessed in the student to lead to the attainment the assessment of practical's (seen in section 6) has a weightage of 60% (i.e.30 marks) and or the competency. micro-project assessment (seen in section 12) has a weightage of 40% (i.e.20 marks). This is designed to facilitate attainment of UOs holistically, as there is no theory*

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,* ***ESE*** *- End Semester Examination;* ***PA*** *- Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the center of this map**.**

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practical in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency**.**

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Configure and perform hands-on practice to Identify features of any available SCADA software in the laboratory.	I	02*
2	Identify different objects configuration, Dynamic properties (blinking, movement, filling etc.) in SCADA software.	I	02
3	Identify different cables, and network buses with their accessories used in SCADA communication.	II	02*
4	Interface the given Excel database sheet to the SCADA software using DDE connectivity.	II	02*
5	Configure and perform hands on practice to Identify various features of any available open source OPC DA Server software in the laboratory.	III	02*
6	Develop interconnection of a given PLC with the available SCADA software using OPC DA Server.	III	02*
7	Develop SCADA graphic screen and integrate it with PLC to perform START STOP logic using two push buttons and one lamp.	III	02
8	Develop SCADA graphic screen and integrate it with PLC to perform the sequential ON-Off control of Lamps/motors.	III	02*
9	Measure the temperature of a given liquid using RTD or Thermocouple and integrate it in SCADA using PLC.	III	02*
10	Configure the alarm and set a real time trend for the setup used in Experiment no.09.	III	02
11	Develop SCADA graphic screen and integrate it with PLC for pulse counting using limit switch /Proximity sensor.	III	02*
12	Configure available HMI panel and Interface it with PLC /PC	IV	02
13	Apply AND / OR logic using two manual controls for forward stroke of a double acting pneumatic cylinder.	V	02
14	Perform the operation of two double acting cylinders electro pneumatically (Sequence of motion: A+B+B-A-)	V	02

15	Develop and Test PLC program for Single and double Acting Pneumatic Cylinder using single solenoid valve and Inductive proximity sensors.	V	02*
16	Develop SCADA graphic screen and integrate it with PLC for the setup used in experiment no.15	V	02*
	Total		**32**

Note

i. *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 minimum 24 or more practical need to be performed, out of which, the practical marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental setup.	20
2	Setting and operation.	20
3	Safety measures.	10
4	Observation and recording.	10
5	Interpretation of result and conclusion.	20
6	Answer to sample questions.	10
7	Submission of report in time.	10
Total		**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field-based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs

according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organizing Level' in 2nd year
- 'Characterizing Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned**.**

Sr. No.	Equipment Name with Broad Specifications	PrOs Sr. No.
1	Computer system; Operating System: Windows 10 or higher Memory: minimum of 8 GB RAM, Minimum of Intel Core i3 or equivalent	All
2	IEC 1131-3 compatible PLC with programming Software and interfacing hardware, user manual.	5,7-12,16
3	Input and Output devices for PLC: like Lamp, DC Motor, Proximity sensors, Thermocouple/RTD, Red, green, yellow LEDs, limit switches, push button.	7,8,9,11
4	IEC standard compatible latest version of SCADA/HMI software from any reputed manufacturer of SCADA like Ellipse/ Vijeo Citect /Wonderware / RSView32 /WinCC / Cimplicity etc.	1-3,4-12, 16
5	Open source OPC DA Server software	4-12,16
6	Coaxial Cable, UTP Cable, STP Cable, Fiber Optic Cable	03
7	Electro Pneumatic Trainer Kit	13 -16
8	Electro-Pneumatic PLC trainer kit	13-16

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added**.**

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Basics of SCADA System	**1a.** Explain with sketches the function of the given Automation Hierarchy levels **1b.** Describe with sketches the architecture of a	**1.1.** Recall - Knowledge of Industrial automation Hierarchy. **1.2.** Typical SCADA Architecture / layout diagram. **1.3.** Components of SCADA system: RTU, MTU -functions, block

	SCADA system. **1c.** Describe with sketches the function of a given component of a SCADA system. **1d.** Compare the given SCADA software on the given parameters.	diagram. **1.4.** Commercially available SCADA Softwares : Intouch , Vijeo citect , Rsview32 (features, cost, network requirements, Specifications of these softwares)
Unit– II SCADA Network Communication	**2a.** Explain with sketches the specific network topology used in the SCADA system. **2b.** Identify the type of cables used in SCADA network communication. **2c**. Compare between the two given protocols for the given application. **2d.** Describe the process of DDE connectivity of a given database with the given SCADA system.	**2.1** Network topologies, Cables used in SCADA **2.2** Modes of Network communication: Master-slave, Bus arbitration, Token passing, random bus access ,CS(Client-server) **2.3** Modbus- TCP/IP, RTU **2.4** Profibus: PA, DP **2.5** Foundation fieldbus: H1, HSE **2.6** Database and DDE connectivity
Unit– III SCADA System Integration	**3a.** Describe the given feature of a given SCADA software. **3b.** Describe with sketches the working of the given type of drives. **3c.** Interface the given PLC with the SCADA system using the given OPC DA server. **3d.** Describe the steps to integrate the given PLC with the given SCADA software for a given application.	**3.1** SCADA Software- Creating graphics, Real time and Historical Trends, Alarms and Events, database of Tags, display charts, logs and reports, object Library (use of buttons, slider, pipe connection etc.). **3.2** Electric Drives: Need, types, block diagram, functions, characteristics, four quadrant operation. Comparison of AC/DC drives, VFD. **3.3** Introduction to OPC DA server (OLE for Process control) – functions, architecture. **3.4** Steps in Integrating PLC (RTU) with SCADA - Developing PLC Based Applications. - Configuring the OPC Data Access server - Creating Tags database - Configuring SCADA graphic objects, trends and alarms - SCADA runtime environment

Unit– IV Human Machine Interface (HMI)	**4a.** Identify the type of given HMI panel **4b.** Describe the wiring connection of a given HMI panel **4c.** Describe the operation of a given HMI panel **4d.** Explain the steps involved in interfacing of a given HMI panel with given PLC or PC	**4.1** Different types of operator Interfaces – Textual, Graphical **4.2** Connection Wiring of HMI **4.3** Data handling with HMI **4.4** Configuration and Interfacing to PLC and PC
Unit– V SCADA Application development	**5a.** Develop a ladder program for a given industrial application. **5b.** Develop a graphic screen for a given application using a given SCADA software. **5c.** Create a server configuration and tag database for a given SCADA based application using a given OPC DA Server. **5d.** Describe the steps for Integrating a given Pneumatic component with a given SCADA through PLC.	**5.1** Robotic pick and place mechanism **5.2** Temperature control system **5.3** Car washing system **5.4** Sorting and Stacking system **5.5** Water level control system (study of PLC ladder program, OPC DA configuration, tag database, SCADA graphic screen for above examples) **5.6** Integrating Pneumatic components with SCADA through PLC: Single acting, double acting cylinders.

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of SCADA System	10	4	6	-	10
II	SCADA Network Communication	14	4	4	6	14
III	SCADA System Integration	14	4	6	6	16
IV	Human Machine Interface (HMI)	10	4	6	-	10
V	SCADA Application development	16	-	8	12	20
Total		64	16	32	22	70

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist students for their learning and to teachers to teach and assess students with respect to attainment of LOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Do the internet survey and make a list of leading manufacturers of the SCADA and other industrial automation tools with their brand name.
b. Read an operating manual of the SCADA of reputed Manufactures.
c. Prepare a PowerPoint presentation on the troubleshooting techniques of SCADA.
d. Read the safety precautions to be followed for installation of SCADA based application systems.
e. Download animated videos from the internet for any theory topic and make a presentation on it.
f. Prepare a list of available analog input /output devices, digital input /output devices available in the market.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various learning outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/subtopics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/subtopics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Video programs/YouTube may be used to teach various topics and sub topics.
f. Demonstrate students thoroughly before they start doing the practice.
g. Encourage students to refer to different books and websites to have a deeper understanding of the subject.
h. Observe continuously and monitor the performance of students in the Lab.
i. Encourage students to use front/rear panel control of electronic instruments.
j. Encourage students to visit nearby electronic instruments repair workshop units or manufacturing industries.
k. Instruct students to safety concerns of handling electronic instruments and also to avoid any damage to the electronic instruments.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student assigned to him/her in the ***Only one micro-project*** is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project is group-based. However, in the fifth and sixth semesters, it should preferably be ***individually*** undertaken to build up the skill and confidence in every student to become a problem solver so that s/he contributes to the projects of the industry. 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. Each student will have to maintain a dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. 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 are given here. Similar micro-projects could be added by the concerned faculty:

a. **Automatic street light controller:** Prepare a SCADA based system to control the street light as per the intensity of natural light.
b. **Automatic agriculture irrigation system:** Prepare a SCADA based system to control drip irrigation.
c. **Railway gate automation:** Prepare a SCADA based system to open or close the 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 SCADA based system for bottle filling.
f. Troubleshoot the Faulty Equipment/Kit available in automation Laboratory.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Supervisory control and Data acquisition	Boyar, S. A.	ISA Publication (4th edition) ISBN: 978-1936007097
2	Practical SCADA for industry	Bailey David; Wright Edwin	Newnes (an imprint of Elsevier), 2003 ISBN: 0750658053
3	PLCs & SCADA - Theory and Practice	Rajesh Mehra, Vikrant Vij	Laxmi Publications Pvt Ltd; First edition ISBN-10 : 9381159114
4	Instrument engineers' handbook: process software and digital networks	Béla G. Lipták	Published September 23, 2011 by CRC Press ISBN 9781439817766
5	Industrial automation and Process control	Stenerson Jon	Prentice hall publication ISBN: 9780130618900

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. https://www.matrikonopc.com/opc-server/opc-data-access-versions.aspx
b. https://www.opcconnect.com/opcintro.php
c. https://www.kepware.com/en-us/products/kepserverex/- for OPC software download.
d. http://thelearningpit.com/lp/logixpro.html
e. https://wonderware-intouch.software.informer.com/ for SCADA/ HMI software download
f. https://rslinx-classic.software.informer.com/
g. https://en.freedownloadmanager.org/Windows-PC/Vijeo-Citect-FREE.html

Program Name : Diploma in Automation and Robotics

Program Code : AO

Semester : Fourth

Course Title : Control System and Components

Course Code : -

1. RATIONALE

Modern civilization is an indication of human endeavor to control nature's forces and to harness them for the benefit of mankind. The laws of nature are such that everything in this universe is controlled. Diploma engineers should be able to control various parameters at desired value in industry. This course helps the students to understand and apply the concepts, principles and procedure of controlling various parameters in industries related to Automation and Robotics. Students will also be able to apply the knowledge of given control systems for basic fault finding in industry.

2. COMPETENCY

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

- Maintain the control systems and components in Automation and Robotics system

3. COURSE OUTCOMES (COs)

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. Choose the relevant control strategy for the given control system.
2. Interpret the given control system for different input signals and test the stability.
3. Maintain control action for controlling various processes.
4. Maintain various Pneumatic and Hydraulic Actuators in the given control system.
5. Maintain various Electromechanical Actuators in the given control system

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	-	4	8	3	70	28	30*	00	100	40	50@	20	50	20	100	40

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the center of this map**.**

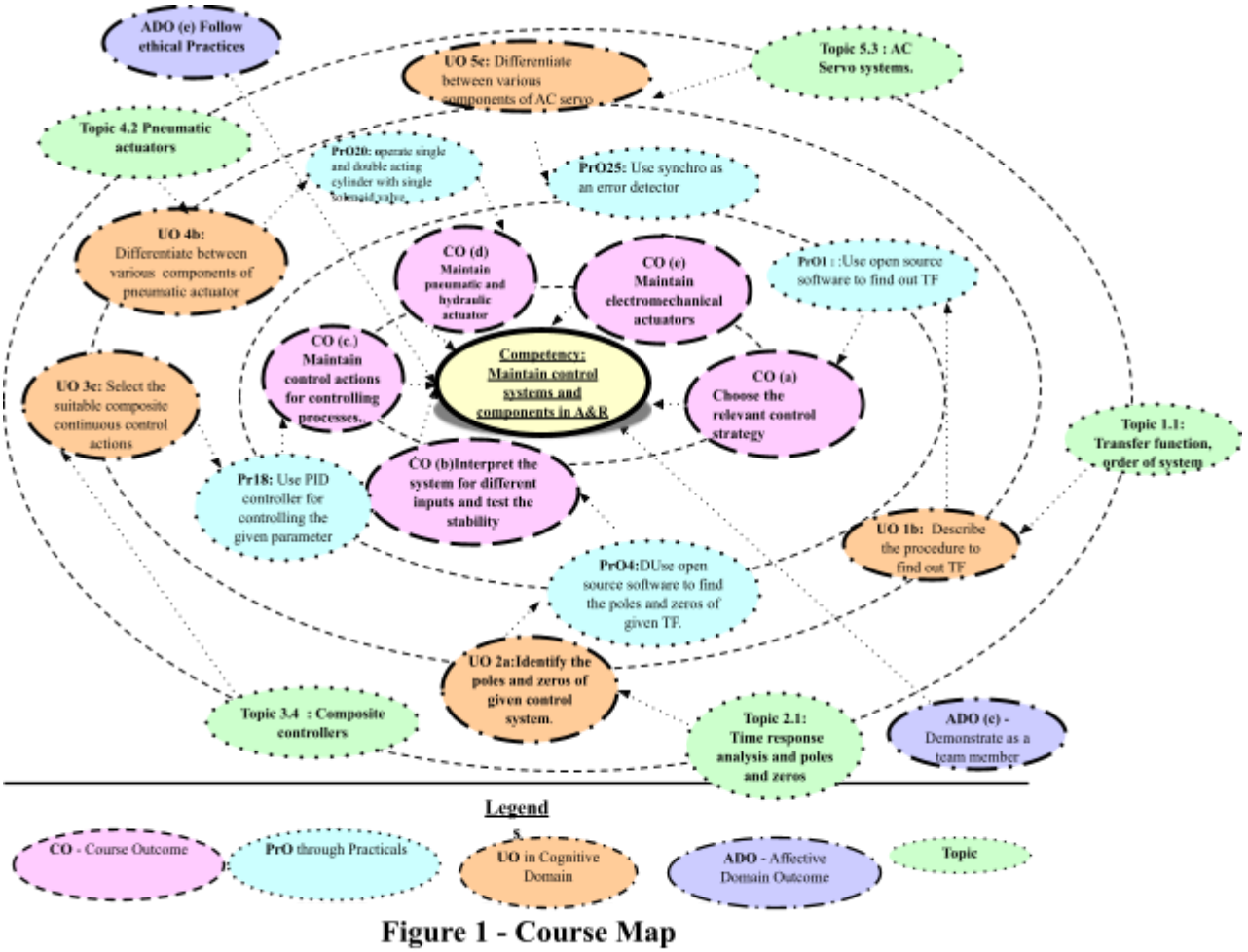


Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency**.**

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Use open source software to find out the transfer function of the given system.	I	2*
2	Use open source software to represent the given transfer function in state variable form.	I	2*
3	Use open source software to obtain the state model of the given transfer function.	I	2
4	Use open source software to find the poles and zeros of given transfer function.	II	2*
5	Use an R-C circuit to analyze the response of a first order system for standard test inputs.	II	2*
6	Use open-source software to analyze the step response of a first order system for various time constants.	II	2*
7	Use R-L-C circuit to analyze the response of a second order system for standard test inputs.	II	2*
8	Use open-source software to analyze the step response of a second order system for various cases of damping factors.	II	2*
9	Use open-source software to find the transient response specifications of a given second order transfer function.	II	2
10	Use the standard test signal generator to analyze the given Type 0 control system.	II	2
11	Use open-source software to analyze the given Type 0 control system.	II	2*
12	Use open-source software to analyze the given Type 1 control system.	II	2
13	Use open-source software to find the Routh's table and hence analyze the stability of the given control system.	II	2*
14	Use an ON-OFF controller for controlling the given process parameter.	III	2*
15	Use a Proportional controller for controlling the given process parameter.	III	2*
16	Use a PI controller for controlling the given process parameter.	III	2*
17	Use a PD controller for controlling the given process parameter.	III	2

18	Use a PID controller for controlling the given process parameter.	III	2*
19	Use open-source software to verify the equation of PID controller	III	2*
20	Use Electro-Pneumatics Trainer kit to operate single acting and double acting cylinder with single solenoid valve (direct actuation and relay actuation)	IV	2*
21	Use Electro-Pneumatics Trainer kit to apply AND and OR logic using two manual controls for forward stroke of a double acting cylinder (with direct actuation of solenoid and with relay)	IV	2*
22	Use Electro-Pneumatics Trainer kit to operate double acting cylinder with single solenoid valve and double solenoid valve (with and without manual forward stroke and automatic return stroke as it reaches forward end) and for continuous operation with double solenoid valve	IV	2
23	Use Electro-Pneumatics Trainer kit to operate two double acting cylinders electro pneumatically (Sequence of motion: A+B+A-B- and A+B+B-A-)	IV	2*
24	Use Electro-Pneumatics Trainer kit for single cycle ON and OFF delay operation of single acting cylinder using single solenoid valve (use OFF delay timer for solenoid actuation) and double acting cylinder using double solenoid valve	IV	2
25	Use Electro-Pneumatics Trainer kit to operate double acting cylinder using double solenoid valve with capacitive sensor,inductive sensor and photoelectric sensor	IV	2
26	Use Electro-Pneumatics Trainer kit to operate double acting cylinder using double solenoid valve and lamp with P/I converter and pressure sensor and for multi cycle operation with electrical limit switch.	IV	2
27	Use open-source simulation for the operation of Hydraulic actuator	IV	2*
28	Use potentiometer as an error detector.	V	2
29	Use synchro as an error detector.	V	2*
30	Use different servo components for controlling the angular position of the given DC Servo system	V	2*
31	Use different servo components for controlling angular position of the given AC Servo system	V	2
32	Use a stepper motor as a servo system component and measure its speed by applying generated pulses.	V	2
	Total		**64**

Note

i. *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 minimum 24 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental setup.	20
2	Setting and operation.	20
3	Safety measures.	10
4	Observation and recording.	10
5	Interpretation of result and conclusion.	20
6	Answer to sample questions.	10
7	Submission of report in time.	10
Total		**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organizing Level' in 2nd year
- 'Characterizing Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned**.**

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Any Open source software to find out poles, zeros, TF, SSR, time response and stability of the given system and for PID stimulation	1,2,3,4,,6,8,9,11,12,13 ,19

2	Standard test signal generator kit: Step, Ramp, and parabolic signals.	10
3	Type 0 system trainer kit	10
4	On-off controller: heater, Temperature sensor , Relay.	14
5	Proportional, PI, PD, PID controllers and the control system setup	15,16,17,18
6	Electro pneumatic trainer kit	20-26
7	Any open-source simulation for the operation of pneumatics and Hydraulic actuator	27
8	Potentiometer as an error detector trainer kit.	28
9	Synchro transmitter, control transformer and power supply.	29
10	D.C. Position control system trainer kit.	30
11	A.C. Position control system trainer kit.	31
12	Stepper motor trainer kit.	32

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added**.**

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit– I **Fundamentals of control systems**	1a. Classify the given type(s) of control system. 1b. Describe the procedure to determine the transfer function of the given control system. 1c. Determine the transfer function of the given control system. 1d. Form the state variable for the given system.	1.1 Control system: Open loop, closed loop, linear, non linear, time variant, time invariant. 1.2 Transfer function; Order of a control system (0, 1, 2), transfer function with respect to R-C and R-L-C electrical circuits 1.3 Block diagram reduction technique: Need, reduction rules. 1.4 State space representation: Advantages, state variables identification, State space models from transfer functions.

Unit– II **Time response analysis and Stability**	2a. Identify the poles and zeros of a given control system with justification. 2b. Explain the salient features of the given type of test inputs/responses/control system. 2c. Determine the transient response of the given control system using the relevant standard test inputs. 2d. Determine the steady state response of the given control system using the relevant standard test input signals. 2e. Explain the conditions for stability of the given control system. 2f. Determine the stability of the given control system using Routh's stability criteria.	2.1 Time domain analysis: Transient and steady state response, Standard test inputs (Step, Ramp, Parabolic and Impulse), Poles and zeros. 2.2 First order control system: Analysis for unit step input, Concept of time constant. 2.3 Second order control system: Analysis for unit step input, Concept and effect of damping. 2.4 Time response specifications (no derivations) Tp, Ts, Tr, Td, Mp, e_{ss}; numerical Problems. 2.5 Steady state analysis: Type 0, type 1, type 2 systems, Steady state error and error constants. 2.6 Stability: Definition of stability, Analysis of stable and unstable systems based on the location of the Poles in the S-plane, Relative stability and marginal stability. 2.7 Routh's stability criterion:method, Numerical Problems for stable and unstable systems, Range of K for the system to be stable (No special cases of auxiliary equation and zero in the first column)
Unit –III **Process Control Actions**	3a. Explain with sketches the discontinuous control actions used for controlling the given process control system. 3b. Differentiate between the basic continuous control actions used in the process control system. 3c. Select suitable composite continuous control action for controlling the given process control system. 3d. Identify relevant control action(s) for the given process control system with justification and sketches.	3.1 Process control system: Block diagram, function of each block. 3.2 Discontinuous control actions - two position or ON-OFF: Operation, differential gap 3.3 Continuous control actions- proportional, integral and derivative: operation, output equations, corresponding transfer function, Response graph. 3.4 Composite controllers - PI, PD, PID controllers : operation, output equations, Response graph, comparison, application 3.5 Electronic op-amp based PI, PD, PID controllers: circuit diagram, equations.

Unit-IV **Pneumatic and Hydraulic Actuators**	4.a. Compare pneumatic and hydraulic circuitry 4.b. Differentiate between various components of Pneumatic actuators. 4.c. Differentiate between different components of Hydraulic actuators 4.d. Choose the relevant actuator for the given situation with justification	4.1 Basic principles of pneumatic and hydraulic circuitry, Comparison of pneumatic and hydraulic circuitry and their applications 4.2 Pneumatic actuators: ● Single acting and double acting cylinder, Directional control valve ● Principles of pneumatic control,Pneumatic circuit diagram ● Basic Pneumatic circuits (flow amplification, signal inversion, memory, delay, single acting cylinder control, double acting cylinder control) 4.3 Hydraulic actuators:Linear -Single acting, double acting,Double Rod Cylinder 4.4 Selection of actuators based on principle of operation, performance characteristics, maximum loading condition, safety
Unit-V **Electromechanical Actuators**	5a. Identify the components of a given servo system with justification. 5b. Explain different components of the given DC servo system. 5c. Differentiate between various components of the given AC servo system. 5d. Use a stepper motor as a control system component in the given servo system. 5e. Choose the relevant Electromechanical actuators for the given application	5.1 Electromechanical actuators: concept and types (Servomotor , stepper motor, DC motors,Solenoid Actuators, Brushless DC motor), Concept and generalized block diagram of Servo system. 5.2 DC servo system: functional diagram, potentiometer as error detector, DC servo motor - characteristics, difference from a normal DC motor. 5.3 AC servo system: functional diagram, synchro as error detector, AC servo motor-characteristics, difference from a normal 2 phase induction motor. 5.4 Stepper motor (PM and variable reluctance type): Working and applications 5.5 Principle and working of Solenoid Actuators and Brushless DC motor

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Fundamentals of control system	14	04	04	06	14
II	Time response analysis and stability	18	02	06	10	18
III	Process Control actions	08	02	04	06	12
IV	Pneumatic and Hydraulic Actuators	14	02	06	06	14
V	Electrical Actuators	10	02	04	06	12
Total		64	12	24	34	70

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Prepare a report on the market survey for availability of different Servo components.
b. Prepare a report on the market survey for availability of different controllers.
c. Visit nearby process industries and prepare a report on control systems used.
d. Visit nearby engineering institutes and prepare a report on different control systems used in that institute laboratory.
e. Prepare a chart on comparison of different control actions.
f. Prepare a chart on the effect of damping on the response of different types of control systems.
g. Prepare a chart on the effect of location of poles on the stability of different types of control systems.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various learning outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/subtopics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/subtopics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).

d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***..
e. Video programs/YouTube may be used to teach various topics and sub topics.
f. Use proper equivalent analogy to explain different concepts.
g. Use Flash/Animations to explain various control actions

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project is group-based. However, in the fifth and sixth semesters, it should preferably be ***individually*** undertaken to build up the skill and confidence in every student to become a problem solver so that s/he contributes to the projects of the industry. 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. Each student will have to maintain a dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. 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 are given here. Similar micro-projects could be added by the concerned faculty:

a. Build/test an automatic feedback temperature control system.
b. Build/test an automatic feedback water level control system.
c. Build/test RC circuit and check its output response.
d. Build/test RLC circuit for a stable system using MATLAB.
e. Build / test ON-OFF controller for the given type of control loop.
f. Build / test opamp based P controller for the given type of control loop.
g. Build / test opamp based PI controller for the given type of control loop.
h. Build / test op amp based PD controller for the given type of control loop.
i. Build / test op amp based PID controller for the given type of control loop.
j. Build a model of Single acting cylinder
k. Build a model of double acting cylinder
l. Build /test Potentiometer as an error detector for the given control system.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Control System Engineering	Nagrath I.J, M. Gopal	New age International, New Delhi, Sixth edition, ISBN: 9788122420081
2	Control Systems	Varmah K.R	Tata McGraw Hill, New Delhi,2010 ISBN: 9780070678750
3	Modern Control Engineering	Ogata K.	Pearson India, Noida,Fifth edition ISBN: 978-9332550162

4	Modern Control Systems	Dorf Richard, Bishop Robert	Pearson India, Noida, Twelfth edition ISBN: 978-9332518629
5	Process Control Instrumentation Technology	Johnson C. D.	Prentice hall of India, NewDelhi,2015 ISBN: 978-9332549456
6	Hydraulics and Pneumatics	Andrew A. Parr	Elsevier Science & Technology Books, March1999, ISBN: 0750644192

14. SUGGESTED SOFTWARE / LEARNING WEBSITES:

A. www.scilab.org/scilab
B. www.nptel.ac.in/courses/108101037/
C. www.nptel.ac.in/courses/101108056/23
D. www.nptel.ac.in/courses/108101037/3
E. www.nptel.ac.in/courses/108101037/14
F. www.nptel.ac.in/courses/108101037/46
G. www.nptel.ac.in/courses/108105062/12
H. www.nptel.ac.in/courses/108101037/20
I. www.nptel.ac.in/courses/108103008/12
J. www.electrical4u.com/control-engineering
K. www.automationfederation.org/filestore/af/resources/control
L. https://fluidsim.en.uptodown.com/windows/download

Program Name : Diploma in Automation and Robotics

Program Code : AO

Semester : Fourth

Course Title : Python Programming

Course Code : -

1. RATIONALE

Robotics industry needs to build microcontroller based applications which are developed using Python. This course deals with concept of programming to enhance programming skills of diploma students. This course will enable the students to inculcate programming concepts and methodology to solve engineering problems.

2. COMPETENCY

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

- Develop a program using Python to solve problems

3. COURSE OUTCOMES (COs)

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. Develop a python program using conditional statements and operators.
2. Perform Data Structure operations.
3. Develop a function and module for given problem.
4. Develop Python program using classes and inheritance.
5. Develop Python program to handle exception.

4. TEACHING AND EXAMINATION SCHEME

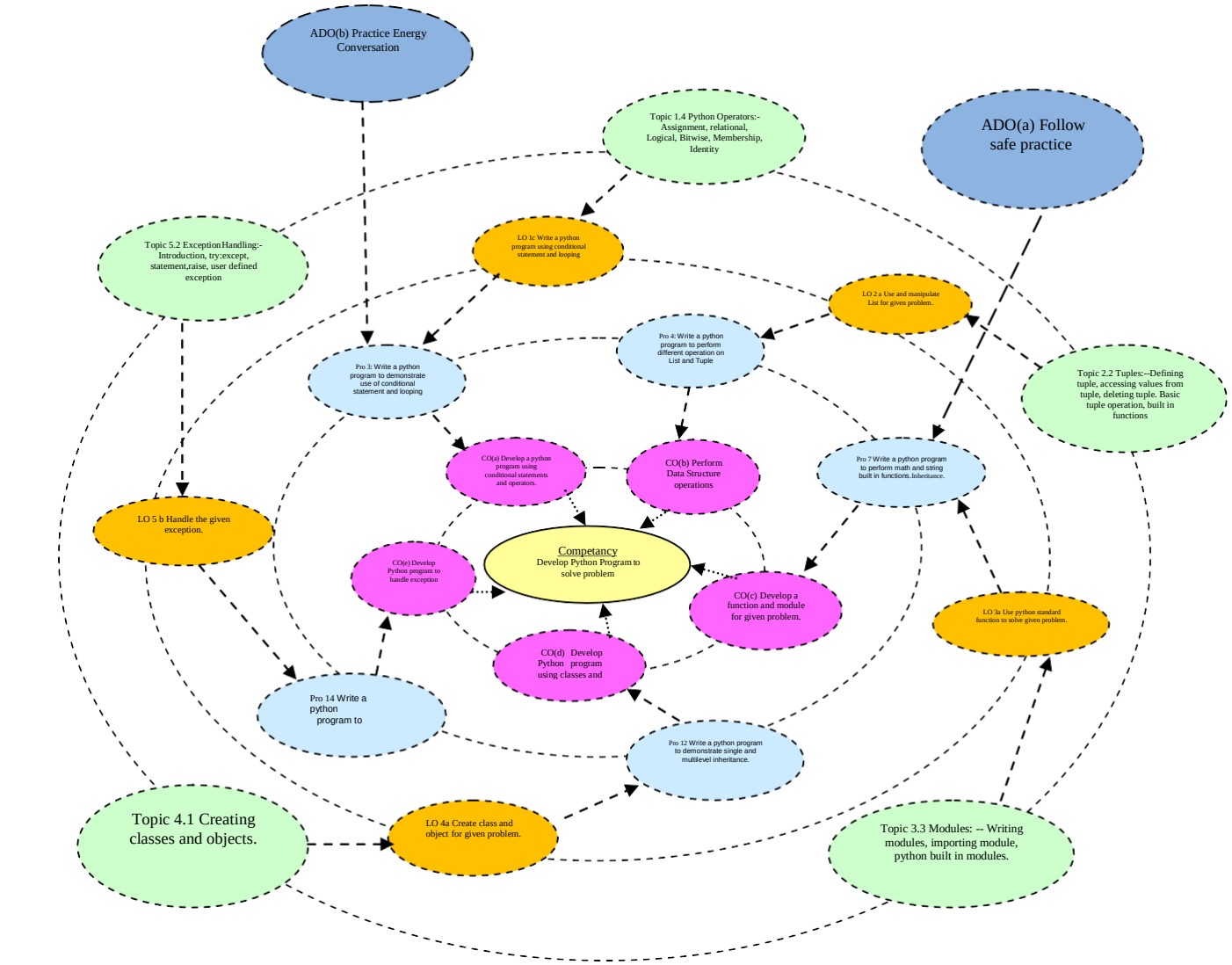
Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory						Practical						
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total		Grand Total
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	
3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20	150

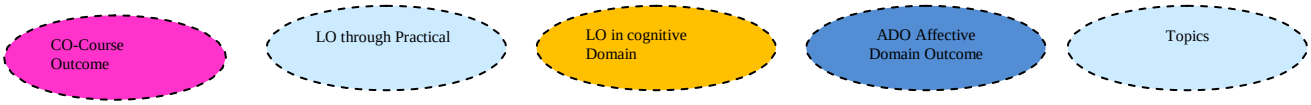
(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the UOs required for the attainment of the COs.

***Legends: L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **ESE** - End Semester Examination; **PA** - Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the center of this map..





6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency**.**

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Write simple program using script mode and Interactive mode.	I	2*
2	Write a python program using operators.	I	2
3	Write a python program to demonstrate use of conditional statement and looping	I	2*
4	Write a python program to perform different operation on List and Tuple	II	2*
5	Write a python program to perform different operation on Set.	II	2*
6	Write a python program to perform different operation on dictionaries.	II	2
7	Write a python program to perform math and string built in functions.	III	2
8	Develop a program to demonstrate user defined function.	III	2*
9	Develop a program to demonstrate built in module.	III	2*
10	Write a python program to demonstrate built in packages(Numpy, pandas,matplotlib) and user defined packages.	III	2*
11	Write a python program on method overloading and overriding.	IV	2
12	Write a python program to demonstrate single and multilevel inheritance.	IV	2*
13	Write a python program to perform file operation.	V	2
14	Write a python program to handle exception.	V	2*
15	Installation of Python libraries for robotics.	V	2*
16	Write a Python program on 4 axis robotic arm.	V	2
	Total		**32**

Note

i. *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 minimum 12 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. *The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:*

S. No.	Performance Indicators	Weightage in %
1	Correct Logic	20
2	Debug ,test and execution of program	40
3	Quality of input output display(Formatting)	10
4	Answer to sample questions.	20
5	Submission of report in time.	10
Total		**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organizing Level' in 2nd year
- 'Characterizing Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned**.**

Sr. No.	Equipment Name with Broad Specifications	PrO. S. No.
1	Computer System (Any computer system with basic configuration)	All
2	Python Interpreter/ IDE	

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added**.**

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Basic Of Python	1a. Installation of Python 1b. Develop python program using different operators. 1c. Write a python program using conditional statement and looping	1.1 Python Features 1.2 Python building blocks:-Identifier, keywords, Indentation, variables,comments 1.3 Python Data Types:- Number, string, Tuple, List,Sets, Dictionaries 1.4 Python Operators:- Assignment, relational, Logical, Bitwise, Membership, Identity 1.5 Conditional statement:- if, if….else, nested if 1.6 Looping :- while, for, nested loop 1.7 Loop manipulation:- pass, break, continue

Unit– II Python Data Structure	2a. Use and manipulate List for given problem. 2b. Use and manipulate Tuple for given problem 2c. Use and manipulate Set for given problem 2d. Use and manipulate Dictionaries for given problem.	2.1 List :- defining list, accessing values from list, deleting values, updating list,. Basic List operations, Built in list functions 2.2 Tuples:--Defining tuple, accessing values from tuple, deleting tuple. Basic tuple operation, built in functions. 2.3 Sets:- Defining set, accessing values from set, deleting set, updating set. Basic set operation, Built in functions. 2.4 Dictionaries:- Defining ,accessing values , deleting values, updating dictionaries. Basic operations, Built in functions.
Unit– III Python function, module and packages	3a. Use python standard function to solve given problem. 3b. Develop user defined function for given problem. 3c. Write python module for given problem. 3d. Write Python packager given problem	3.1 Built in functions(maths, string) 3.2 User defined function: - function definition, function calling, function arguments and parameter passing, Return statement, scope of variables(Global and Local) 3.3 Modules: -- Writing modules, importing module, python built in modules. 3.4 Python packages:-- writing packages, using standard packages (Numpy, matplotlib, pandas scipy) and user defined packages.
Unit– IV Python OOP	4a. Create class and object for given problem. 4b. Write python code for data hiding. 4c. Write a program to use inheritance.	4.1 Creating classes and objects. 4.2 Data Hiding 4.3 Method overloading and overriding. 4.4 Inheritance
Unit-V File Handling, Exception Handling and Python Libraries for Robotics	5a. Read and data data on file. 5b. Handle the given exception. 5c.Install Python libraries.	5.1 File Handling:- Opening file in different modes, accessing file content, reading and writing file, closing file, renaming file. 5.2 Exception Handling:- Introduction, try:except, statement,raise, user defined exception. 5.3 Python Libraries:-- opencv,pybotics, DART

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	**Basic Of Python**	08	02	04	08	14
II	**Python Data Structure**	12	02	06	08	16
III	**Python function, module and packages**	12	02	02	10	14
IV	**Python OOP**	08	02	04	08	14
V	**File Handling, Exception Handling and Python Libraries for Robotics**	08	02	02	08	12
Total		48	10	18	42	70

Legends: *R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of LOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table*.

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Prepare journals based on practical performed in laboratory.
b. Undertake microprojects using object oriented concept

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various learning outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/subtopics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/subtopics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***..
e. Video programs/YouTube may be used to teach various topics and sub topics.
f. Demonstrate students thoroughly before they start doing the practice.
g. Encourage students to refer to different books and websites to have a deeper understanding of the subject.
h. Observe continuously and monitor the performance of students in the Lab.
i. Encourage students to use front/rear panel control of electronic instruments.

j. Encourage students to visit nearby electronic instruments repair workshop units or manufacturing industries.
k. Instruct students to safety concern of handling electronic instruments and also to avoid any damage to the electronic instruments.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student assigned to him/her in the ***Only one micro-project*** is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project is group-based. However, in the fifth and sixth semesters, it should preferably be ***individually*** undertaken to build up the skill and confidence in every student to become a problem solver so that s/he contributes to the projects of the industry. 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. Each student will have to maintain a dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. 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 are given here. Similar micro-projects could be added by the concerned faculty:

a. Create simple calculator.
b. Currency converter
c. Tic Tac Toe Game
d. Quiz Game
e. Reminder Application
f. Time Converter
g. Ball catching game
h. Any other micro-projects suggested by subject faculty on similar line.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Python Programming	Rao, K. Nageswara Shaikh Akbar	*Scitech Publications(India) Pvt, Ltd. ISBN:9789385983450*
2	Learning Python	Lutz, Mark	5th Edition, O'Reilly Publication ISBN-13: 978-1449355739
3	Python Essential Reference	Beazley, David	4th Edition, Addison-Wesley Professional, ISBN: 9780672329784

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. https://www.javatpoint.com/python-tutorial
b. https://www.tutorialspoint.com/python/index.htm
c. https://www.w3schools.com/python/
d. https://pypi.org/project/pybotics/
e. https://spoken-tutorial.org

Program Name : Diploma in Automation and Robotics

Program Code : AO

Semester : Forth

Course Title : Sensors in Automation and Robotics

Course Code : -

1. RATIONALE

In the industry environment, Automation and Robotics diploma graduates are expected to handle various sensors and actuators. The sensors and actuators are an integral part of robotics. Industrial sensors include the electronics required to detect, position, or identify an object or rotating axis in a Robotic controlled system. They utilize a variety of technologies, including inductive, magneto-resistive, capacitive, optical, pressure, and ultrasonic.

2. COMPETENCY

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

- **Use relevant sensors for different applications related to Automation and Robotics.**

3. COURSE OUTCOMES (COs)

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**:**

a. Select the relevant sensors or transducer for measuring various parameters
b. Describe the different types of force measuring transducers in automation
c. Select the different types of temperature measuring transducer for given application
d. Identify various sensors to measure the dimensions,colour.
e. Use various transducer to measure the speed, position

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
4	-	2	6	03	70	28	30*	00	100	40	25@	10	25	10	50	20

(~): *For the practical only courses, the PA has two components under practical marks i.e. components of the COs), to be developed and assessed in the student to lead to the attainment the assessment of practicals (seen in section 6) has a weightage of 60% (i.e.30 marks) and or the competency. micro-project assessment (seen in section 12) has a weightage of 40% (i.e.20 marks). This is designed to facilitate attainment of UOs holistically, as there is no theory*

Legends: L*-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,* ***ESE*** *- End Semester Examination;* ***PA*** *- Progressive Assessment*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the center of this map..

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Use LVDT to measure displacement.	I	2*
2	Use strain gauge to measure weighs.	I	2*
3	Use Bourdon tube pressure gauge to measure pressure.	II	2*
4	Use strain gauge load cell to measure applied weight.	II	2*
5	Use RTD to measure temperature.	III	2*

6	Use Thermocouple to measure temperature.	III	2*
7	Use differential roller LVDT for thickness measurement.	IV	2*
8	Use a magnetic reed switch to detect metal objects.	IV	2
9	Use a colour sensor to detect the colours of the given object..	IV	2*
10	Interface different sensors in an online open source platform. (TinkerCad).	V	2
11	Use a combination of two types of proximity sensors to detect presence of metallic or non metallic objects.	V	2
12	Use an optical encoder for speed measurement.	V	2*
13	Measure speed of rotating device using optical tachometer	V	2
14	Calibrate Optical tachometer	V	2
15	Measure speed of rotating device using encoder	V	2*
16	Use an inductive proximity sensor as a positional counter on a linear rail and carriage arrangement in object sorting application.	V	2
	Total		**32**

Note

i. 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 minimum 24 or more practical need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental setup.	20
2	Setting and operation.	20
3	Safety measures.	10
4	Observation and recording.	10
5	Interpretation of result and conclusion.	20
6	Answer to sample questions.	10
7	Submission of report in time.	10
Total		**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year

- 'Organizing Level' in 2nd year
- 'Characterizing Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

Sr. No.	Equipment Name with Broad Specifications	PrO. S. No.
1	LVDT trainer Kit	1,7
2	Strain gauge trainer kit /Load cell kit	2,4
3	Bourdon tube pressure gauge	3
4	RTD- thermocouple temperature measurement kit	5,6
5	Proximity, magnetic reed switch ,relay trainer kit	8,9
6	optical encoder trainer kit or rotary encoder kit	13,14,15
7	Colour sensor setup	9,10
8	Simulation software- open source software	9,10,11,12,13,14, 15,16

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Introduction to transducer	1a. Explain the concept of transducer 1b. Describe classification of transducer with example 1c. Explain with construction and working of the given types of transducer. 1d. Select the relevant types of transducer for given application with justification	1.1 Transducer: Need of sensor or transducer, Classification: Active and Passive,Analog and Digital, Primary and Secondary,Mechanical and Electrical 1.2 Mechanical transducer: Bellows,diaphragm , bourdon tube, bimetallic strip 1.3 Electrical Transducer: resistive transducer- linear and Angular,Potentiometers, Strain gauge-types,gauge factor 1.4 Capacitive Transducer 1.5 Inductive transducer -LVDT, RVDT,Magnetostrictive 1.6 Piezoelectric transducer 1.7 Selection criterion of transducers
Unit– II Force, Pressure measurement	2a. Explain the concept of force and pressure with definition and units 2b. State different types of pressure	2.1 Definition: force, pressure, weight and its units 2.2 Types of pressure 2.3 Different types of pressure and force measuring gauges. 2.3.1 Manometer-

	2c. Describe with sketches the working of the given types of pressure transducer. 2d. Describe with sketches the working of the given types of force transducer. 2e. Prepare the specification of the given pressure and force transducer.	U-tube,Inclined,well type 2.3.2 Bellows,diaphragm , bourdon tube, bimetallic strip 2.4 Force meter : 2.4.1 Pneumatic Force meter 2.4.2 Hydraulic Force meter 2.4.3 strain gauge load cell 2.4.4 Piezoelectric Load cell 2.4.5 Pressductor load cell 2.4 Specifications of electric transducers used for force and pressure measurement.
Unit– III Temperature measurement	3a. Explain the concept of temperature and its units and scale of measurement 3b. Explain the different types of thermometer 3c. Discuss working principles of different types of electrical temperature transducer 3d. List specification for given type of temperature transducer	3.1 Definition and units 3.2 First law of thermodynamics 3.3 Different temperature scales & their conversions 3.4 · Classification of temperature measuring transducers : 3.4.1 Filled system type thermometer. 3.4.2 Bimetallic thermometer 3.4.3 Electrical Temperature transducer ● Thermistors ● RTD – (PT-100) , 2 /3/4 wire systems (circuit diagram only) ● Thermocouple – working principle -Seeback & Peltier effect , Types J, K, R , S, T ● etc. (Based on material, temperature ranges) ● Pyrometer - Optical, Radiation 3.5 Specifications of thermistor,RTD and Thermocouple.
Unit-IV Miscellaneous measurement -Part 1	4a. Explain the concept of dimension and units. 4b. Explain with sketches the working of the given type of thickness measurement transducer 4c. Explain with the sketches the given type of length,width measuring transducer 4d. Describe the concept of colour sensor, reed switch	4.1 Dimension : thickness and its units 4.1.1 types: ● Differential roller type ● Inductive pickup ● capacitive pickup ● Radiation type 4.2 Laser based length measurement 4.3 Camera based width measurement 4.4 Basic colour sensor. 4.5 Magnetic reed switch
Unit -V	5a. Describe with sketches the construction and	5.1 Speed Measurement: Define speed, its units- types 5.1.1 Non-contact type

Miscellaneous measurement-part II	working of the given type of speed transducer 5b.Compare different types of speed measuring transducer. 5c. Explain different types of Proximity sensors 5d. Prepare specification of the given speed transducer.	● Magnetic pickup ● Photo pickup ● Stroboscope ● Optical Encoder 5.1.2 Contact type ● DC tachometer ● AC tachometer 5.2 Position sensor: Proximity sensor 5.2.1 Types- inductive , capacitive , photoelectric and ultrasonic type. 5.3 Prepare specification for it

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	**Introduction to transducer**	**12**	**02**	**06**	**06**	**14**
II	**Force, Pressure measurement**	**12**	**02**	**04**	**04**	**10**
III	**Temperature measurement**	**16**	**04**	**08**	**08**	**20**
IV	**Miscellaneous measurement -Part 1**	**12**	**02**	**04**	**06**	**12**
V	**Miscellaneous measurement -Part 1I**	**12**	**04**	**04**	**06**	**14**
Total		**64**	**14**	**26**	**30**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist students for their learning and to teachers to teach and assess students with respect to attainment of LOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Compare types of sensors based on working principle, construction
b. Internet survey of various force ,pressure measuring gauges
c. Internet survey of latest temperature sensors IC.
d. Prepare broad specifications for basic sensors used for pressure,temperature, speed, dimension measurement.

e. Prepare a schematic chart of Measurement of various parameters like pressure, temperature etc.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various learning outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/subtopics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/subtopics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***..
e. Video programs/YouTube may be used to teach various topics and sub topics.
f. Demonstrate students thoroughly before they start doing the practice.
g. Encourage students to refer to different books and websites to have a deeper understanding of the subject.
h. Observe continuously and monitor the performance of students in the Lab.
i. Encourage students to use front/rear panel control of electronic instruments.
j. Encourage students to visit nearby electronic instruments repair workshop units or manufacturing industries.
k. Instruct students to safety concerns of handling electronic instruments and also to avoid any damage to the electronic instruments.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student assigned to him/her in the ***Only one micro-project*** is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project is group-based. However, in the fifth and sixth semesters, it should preferably be ***individually*** undertaken to build up the skill and confidence in every student to become a problem solver so that s/he contributes to the projects of the industry. 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. Each student will have to maintain a dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course. 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 are given here. Similar micro-projects could be added by the concerned faculty:

a. Build the footstep power generator using a Piezoelectric sensor.
b. Build the digital counter circuit to count the number of objects present in the container.
c. Build the model to measure thickness of paper sheet using LVDT
d. Build the model of metal container detection mechanism using magnetic reed switch
e. Build the model of identifying metal and non-metal objects using inductive sensors

f. Build the model of identifying the thickness of metal and non-metal objects using appropriate sensors.
g. Build the amplifier circuit to display the temperature of the given stream.
h. Calibrate the given pressure gauge using a dead weight tester.
i. Build a capacitive sensor based circuit to measure thickness of paper.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Industrial Instrumentation	Singh S.K	Mcgraw Hill publishing, N. Delhi 2010; ISBN:-9780070678200
2	Course in electrical and electronic measurement and instrumentation	Sawhney A.K	Dhanpat Rai and Sons,N.Delhi 201; ISBN: 9788177001006
3	Instrumentation systems and devices	Rangan C.S; Sharma G.R; Mani S.V	Mcgraw Hill publishing, N. New Delhi 2011; ISBN:-978004633502
4	Process measurement instrument engineers Handbook	Liptak .B.G	Chilton book.Co.U.S.A.1970 ISBN:97807450622547
5	Instrumentation ,measurement and analysis	Nakra.B.C;Choudhary.K.K	Mcgraw Hill publishing, N. Delhi 2015; ISBN:-9780070151277

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. https://nptel.ac.in/courses/115/107/115107122/ - sensors
b. https://nptel.ac.in/courses/108/108/108108147/ - sensors
c. https://www.azom.com/materials-video-details.aspx?VidID=346 - piezoelectric sensors
d. https://youtu.be/7TabKYSbdH4 - piezoelectric sensor
e. https://youtu.be/f15uUSdVkKQ - proximity sensor