Program Name : **Diploma in Automation and Robotics**

Program Code : **AO**

Semester : **Fourth**

Course Title : **Sensors in Automation and Robotics**

Course Code : **22477**

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..

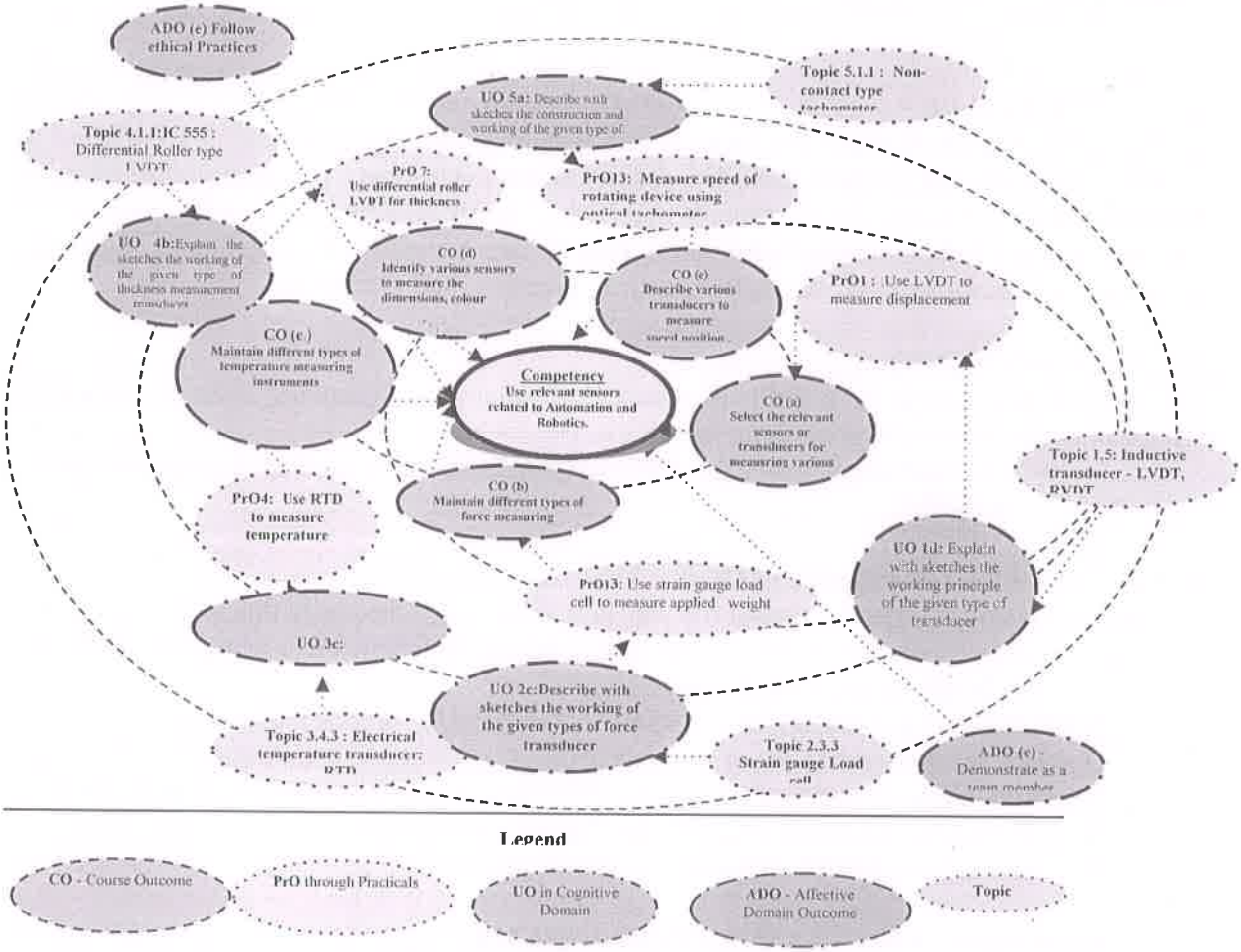

Figure 1 - Course Map

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.

	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.	2.3.1 Manometer- 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