GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)
Competency-focused Outcome-based Green Curriculum-2021 (COGC-2022)
Semester – II

Course Title: Sensors and Measurements
(Course Code: 1234101)

Diploma programme in which this course is offered	Semester in which offered
Automation and Robotics	2nd Semester

1. RATIONALE

The purpose of this course is to present an introduction to the multidisciplinary field of automation and robotics for industrial applications. The course initially covers the important concepts of measurement and how they are used for automation in an industrial setting. It then moves to a discussion of different sensors and categories of sensors. The latter part of the course deals with internal and external sensors in automation and final chapters are devoted to robotics sensors in industry.

2. COMPETENCY

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

- **Able to understand the importance of measurement in Automation**
- **Able to select the sensor for given application**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

CO1	Review Fundamental Concepts of Measurement
CO2	Identify the position of sensor in given application
CO3	Discuss working principle of different Sensors
CO4	Understand significance of Robotic Vision
CO5	Choose appropriate sensor for a given application

Practical COs:

CO1	Plot the input-output relationship / characteristics of given sensor
CO2	Read datasheet and find appropriate information about the given sensor
CO3	Locate the position of Robotic Vision in given Application / System

3. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	2	4	30*	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment 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, **CA** - Continuous Assessment; **ESE** - End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) that are the sub-components of the COs. *Some of the **PrOs** marked **'*'** are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.*

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Convert different measurement units into MKS, CGS form	1	2
2	Find five different sensors for length measurement	1	2
3	Measure accuracy and precision of any given sensor	1	2
4	Read data sheet of given sensor and comment on the features of the given sensor	2	2
5	Prepare a chart of Contact /Non-Contact , Active / Passive and Analog / Digital sensors	2	2
6	Trace and identify the sensor in given loop available in your lab	2	2
7	Adjust Brightness of LED using Pot and measure intensity of light using LDR ,Plot a graph Rotary position vs current passing through LDR	3	2
8	Develop LDR based transducer which converts light intensity into detectable change current and also Plot graph of LDR resistance Vs. current output	3	2
9	Develop a Position Sensor with a potentiometer that will convert rotary input into 4-20mA of output (Use 24VDC as power supply)	3	2
10	Build a High level and Low level alarm system using buzzer (with various tunes) and HC SR 04	3	2
11	Compare measuring lag of IR Proximity , Capacitive Proximity, Inductive Proximity and create a response sheet for different objects	4	2
12	Create and test the working of LVDT. Use copper wire as primary and secondary and metal road as core. Excite your primary by 12-0-12V transformer and check the output voltage	4	2

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
13	Obtain number of rotations from any Optical Encoder	4	2
14	Use Passive Infra-Red sensor to detect human occupancy and generate an alarm	5	2
15	Use Robotic arm as per moment of object using Robotic Vision	5	2
16	Perform person identification with Robotic Vision (Use ESP 32 CAM)	5	2
	Total		**32**

Note

*i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

*ii. The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency..*

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare experimental setup	20
2	Operate the equipment setup or circuit	20
3	Follow safe practices measures	10
4	Record observations correctly	20
5	Interpret the result and conclude	30
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practicals in all institutions across the state.

S. No.	Equipment Name	PrO. No.
1	Multimeter, Voltage source, Current source, and Electronic workbench.	2,3,4,5
2	Pressure transducer trainer kit.	7
3	Ardunio Uno, MQ2 , LCD Screen , Misc Items	8
4	Hook type Weight Scale Standard weights.	10
5	Ardunio Uno, HC SR 04 Sensor , LCD Screen , Misc Items	11
6	Level Measurement Probe / Kit	12
7	Microphone and Oscilloscope	14
8	DSO	17
9	Strain gauge trainer kit, Standard weights.	15

Student should bring toolkit which must contain following items during LAB session:

Electrical Components	Breadboard, 1-10K Pot , Hookup wires, 12VDC adaptor, Female Barrel Jack, LEDs, LDR, Multimeter, Wire Stripper, Resistor Box, Diode, BC 547 Transistor, Soldering Ion, Soldering Wire, Flux, Electrical Insulation Tape, Teflon Tape, 9V battery (2), 9V battery connector, Push Button, 5V Buzzer, 5V DC motor, IR LED , IR Receiver, GPB (2) 12-0-12 Transformer, Tester, MQ 2 Smoke Sensor, piezo electric sensor, one solid copper wire, one solid aluminum/iron wire	1 Nos Each
Mechanical Tools	Plier, Nose Plier, Screw Driver Set, Portable Digital Weighing Scale (hook type), Measurement Tape,	1 Nos Each
Electronics (Optional)	Ardunio UNO , USB to USB B Cable , LM 35 , 741 Op amp , 555 timer, Push Buttons , 16x2 LCD Screen Blue, Ultra Sonic Sensor HC SR04, PIR Sensor, Relay Module, DHT 11/ DHT 22, IR Proximity , Capacitive Proximity, Inductive Proximity	1 Nos Each

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above mentioned COs and PrOs. More could be added to fulfil the development of this competency.

a) Work as a leader/a team member for S&M Mirco project.
b) Follow safety practices and procedure in Lab.
c) Realize the importance of engineering for societal development.
d) Develop gradually the engineering mindset in day to day observation.
e) Practice environmental friendly methods and processes. (Environment related)

8. UNDERPINNING THEORY

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit – I Fundamentals of Measurement Systems	1a. Recognize evolution of Measurement system; 1b. Explain block Diagram of Measurement System with each block 1c. Explain different types of Units based on physical parameter 1d. Enlist Fundamental and Derived Units 1e. Recall Different Unit Systems	1.1 History and evolution of Measurement system 1.1a. Indian Traditional ancient Measurement System v/s Existing Measurement System 1.2 Blocks in Block Diagram of Measurement system a. Primary Sensing Element b. Signal Conditioner c. Output Device 1.3 Units of Measurement ; 1.4 Fundamental and Derived Units 1.5 MKS Units System, CGS Unit System and FPS Unit System 1.6 Conversions based on Prefixes and Different Unit System

Unit – II Features and Placement of Sensors	2.a. List and define Desirable features of Sensors 2.b. Classify and Compare type of Sensors 2.c. Explain block Diagram of Automation System 2.d. Explain each block of Automation System in detail 2.e. Explain Types of Automation System 2.f. Draw automation system and comment on the placement of the sensor in given system	2.1. Features of Sensors: a. Accuracy b. Precision c. Dead Zone d. Threshold e. Sensitivity f. Resolution g. Measuring Lag h. Repeatability i. Reproducibility j. Operating Range k. Span l. Linearity m. Speed of Response n. Error o. calibration 2.2. Types of Sensors a. Active and Passive b. Analog and Digital c. Contact type and Non-Contact type 2.3. Block Diagram of Automation System a. Controlling stage b. Correcting stage c. Plant or process to be controlled d. Measuring stage e. Feedback stage 2.4. Types of Automation System a. Open loop System b. Close loop System 2.5. Symbolic diagram of system a. Air Compressor b. Bottle Filling plant c. HVAC system
Unit - III Sensor Technologies	3.1 Describe the general working principles of given sensor 3.2 Discuss some applications of given sensor	3.a. Capacitive Sensors 3.b. Resistive Sensors 3.c. Magnetic Sensors 3.d. Hall Effect Sensors 3.e. Piezoelectric Transducers 3.f. Strain Gauges 3.g. Piezo-resistive Sensors 3.h. Optical Sensors a. Optical Sensors (Air Path) i. Light sources ii. Light detectors b. Optical Sensors (Fiber Optic) i. Intrinsic sensors ii. Extrinsic sensors

		3.i. Distributed sensors 3.j. Ultrasonic Transducers 3.k. Micro sensors (MEMS Sensors)
Unit - IV Robotic Sensors	4.1. Categorize various robotic sensors 4.2. List various Internal and External sensors used in Robotic Application 4.3. List various Contact and Non-Contact sensors used in Robotic Application 4.4. Describe the general working principles of given sensor 4.5. Explain Construction and Working of given Robotic sensor with neat sketch 4.6. Discuss some applications of given sensor 4.7. Write procedure to choose right sensor for particular Application	4.a. TYPES OF SENSORS IN ROBOTS i. Internal Sensors ii. External Sensors iii. Contact sensors iv. Non-contact sensors 4.b. Position and Displacement Sensor i. Potentiometers ii. Optical Encoders 1. Absolute 2. Incremental iii. LVDT 4.c. Touch or Tactile Sensor i. Binary Sensor ii. Analog Sensor 4.d. Proximity Sensor i. Contact Proximity ii. Non-Contact Proximity iii. Optical iv. Ultrasonic v. Eddy Current vi. Inductive vii. Hall Effective viii. Capacitive 4.e. Procedure to choose right sensor for particular Application
Unit - V Robotic Vision	5.1. Explain Basic fundamental of Robotic Vision 5.2. Create a block diagram of Robotic Vision Systems (RVS) 5.3. Give examples of Industrial Application of Vision Controlled Robotic System 5.4. Explain different setups of cameras for RVS 5.5. Recreate a block diagram of process of Imaging 5.6. Recreate an Architecture of Robotic Vision	5.a. Basic fundamental of Robotic Vision 5.b. Robotic Vision Systems 5.c. Industrial Application of Vision Controlled Robotic System 5.d. Setup of Single overhead stationery camera 5.e. Block Diagram of Multiple cameras for Manipulator Control 5.f. Process of Imaging 5.g. Architecture of Robotic Vision

***Note**: The UOs need to be formulated at the 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.*

9. SUGGESTED SPECIFICATION TABLE FOR SEMINAR FINAL ESE (VIVA) DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A	Total Marks
I	Fundamentals of Measurement Systems	5	3	1	0	4
II	Features and Placement of Sensors	7	3	1	0	4
III	Sensor Technologies	12	3	3	2	8
IV	Robotic Sensors	10	3	3	2	8
V	Robotic Vision	7	3	3	0	6
Total		**42**	**12**	**11**	**4**	**30**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*

Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary slightly 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 specification of some electrical, electronic components.
b) Give seminar on industrial instrumentation system.
c) Undertake a market survey of different electronic Sensors and Instruments.
d) Give seminar on advanced industrial instrumentation
e) Prepare the Charts that spread awareness on environmental effect due to industrial accidents.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES

Following Sample strategies teacher can use to accelerate the attainment of the various outcomes in this course:

a) Guide Student to read books on Measurement and Sensors, Instruct to note down summary / create a summery audio / video of that book.
b) Prepare a small note on particular application of a sensor
c) Guide students to make presentation on any one sensor with help of datasheet
d) Guide students for make presentation on any sensor based case study.

12. SUGGESTED MICRO-PROJECTS

One group based micro-project is planned to be undertaken by a students.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4***means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods.
e) With respect to ***section No.10***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Guide students on how to address issues on environment and sustainability.
g) Guide students for reading manuals.

13. SUGGESTED LEARNING RESOURCES (MUST READ ONES!!!)

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Industrial Instrumentation and Control	S.K.Singh	Tata, McGraw-Hill, New Delhi ISBN: 9789351340102, 9789351340102
2	Measurements and Instrument principles	Allen Morris	ButterWorth Heinamann
3	Mechanical and Industrial Measurements (Process Instrumentation and Control)	R.K. Jain	Khanna Publishers New Delhi Latest Edition
4	Fundamentals of Industrial Instrumentation	William C Dunn	Tata, McGraw-Hill,New Delhi, Latest Edition
5	Measurement and Instrumentation : Theory and Application - Second Edition	Alan S. Morris Reza Langari	ISBN: 978-0-12-800884-3 Academic Press is an imprint of Elsevier
6	Industrial Automation and Robotics	Er R K Rajput	S Chand
7	Robotics and Control	R K Mittal ; I Nagrath	McGraw Hill Education ISBN-10 : 9780070482937

14. SOFTWARE/LEARNING WEBSITES

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15. PO-COMPETENCY-CO MAPPING

Semester III	Sensors and Measurements (Course Code: 1324101)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Review Fundamental Concepts of Measurement	3	-	-	-	-	-	1
Trace position of sensor in given application	2	-	2	1	1	-	1
Discuss working principle of different Sensors	1	-	1	-	-	-	1
Understand significance of Robotic Vision	1	-	1	-	-	-	-
Choose appropriate sensor for a given application	1	3	-	1	2	-	2

Legend: '**3'** for high, '**2**' for medium, **'1'** for low or **'-'** for the relevant correlation of each competency, CO, with PO/ PSO

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Member – Board of Studies (GTU), Electrical and Allied branches

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