SENSOR TECHNOLOGY **Course Code : 313331**

Programme Name/s : Automation and Robotics

Programme Code : AO

Semester : Third

Course Title : SENSOR TECHNOLOGY

Course Code : 313331

I. RATIONALE

Sensor technologies have improved the everyday life of human beings through their applications in almost all fields. Sensor is device that detect changes in the source/environment, collect signals, and accordingly give the reaction. This course will enable the students to understand the principle of various sensors, their construction and applications. This course is a core course that will develop basic skills with regards to electronic sensor based technology used in any robotics and automation industry.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

The aim of this course is to attain the following industry/employer expected outcome through various teaching learning experiences:

Use relevant sensors in the electronic sensor-based systems related to Automation, Robotics and IoT.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

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

- CO1 - Interpret various characteristics of sensors.
- CO2 - Develop signal conditioning circuits using relevant analog ICs.
- CO3 - Select appropriate sensor for given application.
- CO4 - Describe the latest trends in the field of sensor.
- CO5 - Develop an application employing various sensor technologies.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme										
				Actual Contact Hrs./ Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical					
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
313331	SENSOR TECHNOLOGY	STC	DSC	4	-	2	2	8	4	3	30	70	100	40	25	10	-	-	25	10	150

Total IKS Hrs for Sem. : 2 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

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

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Compare transducer, sensor and actuator. TLO 1.2 Classify sensors on basis of various parameters. TLO 1.3 Explain characteristics of sensors. TLO 1.4 Identify the appropriate sensor with reference to given criteria.	**Unit - I Fundamentals of Sensors** 1.1 Transducer, sensor and actuator-definition and its comparison 1.2 Need of sensor, classification of sensors -analog and digital, active and passive, scalar and vector 1.3 Characteristics of sensors : Range, resolution, sensitivity, error, repeatability, linearity and accuracy, impedance, backlash, response time, dead band 1.4 Criteria to choose a sensor: Accuracy, environmental condition, range, calibration, resolution , cost and repeatability	Lecture Using Chalk-Board Video Demonstrations Presentations
2	TLO 2.1 Describe the general structure of measurement system using block diagram. TLO 2.2 Explain the need of signal conditioning in instrumentation system. TLO 2.3 Differentiate the various modes of Op-Amp IC741. TLO 2.4 Explain the working of various applications of Op-Amp using IC741. TLO 2.5 Explain applications of IC555.	**Unit - II Signal Conditioning** 2.1 General structure of measurement system , importance of signal conditioning in instrumentation system. 2.2 Operational Amplifier- IC741 pin diagram, characteristics of Op-Amp IC741, various modes of Op-Amp IC741 2.3 Operational amplifier application using IC741: Amplifiers (inverting and non-inverting), comparator, integrator, differential amplifier and instrumentation amplifier 2.4 Timer IC555-internal diagram, pin diagram, application as astable and monostable multivibrator	Lecture Using Chalk-Board Video Demonstrations Presentations
3	TLO 3.1 Describe importance of mechanical and electromechanical sensors. TLO 3.2 Explain different types of mechanical sensors. TLO 3.3 Explain different types of electro-mechanical sensors.	**Unit - III Mechanical and Electromechanical Sensors** 3.1 Mechanical and electromechanical sensors: Definition, basic principle and applications 3.2 Mechanical sensors: Pressure sensor- C shape bourdon tube, bellows and diaphragm, Pressure measurement in ancient time (IKS) , flow sensor - rotameter, venturi meter and orifice plate	Lecture Using Chalk-Board Presentations Video Demonstrations

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
		3.3 Electro-mechanical sensors: Resistive (potentiometric type), strain gauge, inductive sensor-LVDT, capacitive sensors, thermal (RTD-PT100, thermocouple (J,K,R,S,T)), proximity sensors (inductive, optical, capacitive, magnetic, ultrasonic)	
4	TLO 4.1 Describe stages in the development of sensor technology. TLO 4.2 Describe techniques used in semiconductor sensors and biomedical sensors. TLO 4.3 Describe the operation of smart sensor using its block diagram. TLO 4.4 Compare IR radiation sensors and ultrasonic sensors with respect to technology used and its applications.	**Unit - IV Advance Sensors** 4.1 Development of sensor technology 4.2 Semiconductor sensors: Material and technique, types of semiconductor sensors (thermistor, gas sensor), biomedical sensor: magnetic biosensor 4.3 Smart sensors: Definition, configuration of smart sensor, Microsensors: Micro size microphone, inertial sensor, hall effect sensor 4.4 Colour sensor, IR radiation sensor, thermal detectors, ultrasonic sensors (flow and level sensor), fiberoptic sensors (displacement sensor and humidity sensor)	Lecture Using Chalk-Board Demonstration Video Demonstrations
5	TLO 5.1 Describe working principle of MEMS sensor. TLO 5.2 Explain different MEMS sensors used for speed and pressure measurement. TLO 5.3 Illustrate working of different touch screen sensors.	**Unit - V MEMS (Microelectromechanical Systems) Sensors** 5.1 Microelectromechanical systems: MEMS technology overview and its need, MEMS sensor working principle. 5.2 MEMS accelerometers, MEMS gyroscopes, MEMS pressure sensors, MEMS magnetic field sensors 5.3 Advantages, disadvantages and applications of MEMS sensors 5.4 Touch screen sensors: Resistive, capacitive, infrared and surface acoustic wave (block diagram and its working).	Lecture Using Chalk-Board Video Demonstrations Presentations

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

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Compile a list of transducers,sensors, and actuators available in your institute.	1	*Compilation of a list of transducers, sensors, and actuators available in your institute	2	CO1
LLO 2.1 Determine the gain of the amplifier using IC741.	2	*Gain determination of the Inverting amplifier and Non-Inverting amplifier using IC741	2	CO2
LLO 3.1 Build differentiator circuit using IC741. LLO 3.2 Test differentiator circuit using IC741.	3	Performance of differentiator circuit using IC741	2	CO2
LLO 4.1 Build astable multivibrator using IC555 for the given specifications. LLO 4.2 Test astable multivibrator using IC555 for the given specifications.	4	*Performance of astable multivibrator using IC555 for the given specifications	2	CO2
LLO 5.1 Build comparator circuit consist of IC741. LLO 5.2 Test comparator circuit consist of IC741.	5	*Performance of comparator circuit using of IC741	2	CO2

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 6.1 Use a bourdon tube pressure gauge to measure pressure.	6	*Measurement of pressure using bourdon tube pressure gauge	2	CO3
LLO 7.1 Use LVDT to measure displacement.	7	*Use LVDT to measure displacement	2	CO3
LLO 8.1 Use strain gauge to measure weights.	8	Measurement of weights using strain gauge	2	CO3
LLO 9.1 Use RTD to measure temperature.	9	Temperature measurement using RTD	2	CO3
LLO 10.1 Measure temperature using a thermo couple.	10	*Temperature measurement using a thermocouple	2	CO4
LLO 11.1 Compile a list of biomedical sensor with their physical picture, function and applications.	11	Compilation list of the biomedical sensors with their physical picture, function, and applications	2	CO4
LLO 12.1 Interface an IR sensor with Arduino Uno using any simulation software.	12	Interface IR sensor with Arduino Uno using simulation software	2	CO4
LLO 13.1 Identify sensors used in given mobile.	13	*Identification of various sensors available in a given smart mobile phone.(using relevant code and mobile applications)	2	CO5
LLO 14.1 Build astable multivibrator using IC555 for the given specifications. LLO 14.2 Test astable multivibrator using IC555 for the given specifications.	14	Performance of monostable multivibrator using IC555 for the given specifications	2	CO2
LLO 15.1 Detect different colours using colour sensor trainer.	15	Detection of different colours using colour sensor	2	CO4
LLO 16.1 Measure speed using proximity sensor.	16	Speed measurement using proximity sensor	2	CO4

Note : Out of above suggestive LLOs -

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

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

Micro project

- Use a fire sensor make a small electronic alarm circuit.
- Make a small circuit using LDR as a sensing device.
- Make a power point presentation describing smart garbage segregation systems using sensors.
- Develop a chart depicting the classification table of various types of sensors.
- Make temperature control circuit using thermistor.
- Develop Schmitt trigger using IC555.
- Using a touch sensor make a small electronic circuit.
- Make a astable multivibrator using IC555.

Assignment

- Describe different sensors used in escalator.
- Explain different sensors used in dish washer system.
- Explain Smart traffic management systems using its block diagram.
- Describe different sensors used in biometric readers.
- Explore any car company's website, record various sensors and their functions used in high-end cars.

Field visit

- Visit any of the Mall/Electronic showroom and record different sensors used there,from entry to exit .

Activity

- Explore Nadi Pariksha Device and make a descriptive report on how this device is correlated with ancient medical parameter sensing (*IKS).
- Simulate the performance of a bio-sensor and record responses for different inputs using V-Lab.

Note :

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

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Models and charts of various sensors and actuators	1
2	Thermocouple Trainer Kit Complete with thermocouple sensor, thermometer, glass beaker , instruction manual,inbuilt regulated power supply ±12 volts DC, null balance and amplification circuit.	10
3	Simulation software any open source software for interfacing Arduino uno or software like Proteus	12
4	Computer Processor Intel i5 or equivalent AMD, memory: 8 GB RAM minimum, storage: 500 GB) minimum, with Web camera and mic	12
5	Mobile phone having smart phone characteristics	13
6	Colour Sensor Trainer Advance Technology provides RGB color sensor which is 8051 compatible which can detect different color up to 10 colors,16*2 LCD display to show value of color,on board power supply section with power indicator and test point	15
7	Proximity Sensor Trainer On board proximity sensor, on board DC motor,test points to analyse the signal, variable supply to vary the speed of DC motor ON/OFF switch and LED for power indication.	16
8	CRO Sensitivity in 1, 2, 5 sequence : 5mv/cm to 10 v/m, band width : dc to 15 m hz/, rise time : 24 ns, accuracy : ±3%, max. input voltage dc + ac peak : 400 v, input impedance : 1 m/35 pf	2,3,4,5,14
9	Operational Amplifier Trainer Inbuilt variable/fixed DC regulated power supplies output voltages : 0-5VDC (variable) (2Nos.), +12VDC (fixed) , transistor & components Provided IC : 741, transistor : CL 100 (NPN), resistors, capacitors, power requirement : 230 VAC, 10%, 50Hz	2,3,5
10	Multivibrator using 555 timer trainer kit On board includes: Monostable mutivibrator, astable mutivibrator, bistable mutivibrator circuits Fuse for short circuit protection, instruction manual, connections are brought out through	4,14

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
	2mm colored sockets, patch cords 2mm.	
11	Bourdon Pressure Gauge Trainer Parameter Measured: Pressure, type : C type bourdon tube and spring loaded core type LVDT, Measurement Range : 0 to 10 Kg, Operating Voltage : 230V, + 10%, accessories: chamber for pressure developing and releasing, Foot pump to develop pressure in chamber	6,7
12	Strain gauge trainer Parameter measured: Strain in terms of kilograms Wheatstone bridge principle range: 0 – 500 grams, actual strain: by weights placed in a plate fixed on the beam, excitation source: DC regulated source	8
13	RTD trainer kit Digital meters: Voltmeter 200mv, DC power supplies: DC supply IC regulated +12v DC, 150MA, operated on mains power 230v, 50HZ	9

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

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Fundamentals of Sensors	CO1	10	4	4	4	12
2	II	Signal Conditioning	CO2	12	4	6	6	16
3	III	Mechanical and Electromechanical Sensors	CO3	14	4	6	6	16
4	IV	Advance Sensors	CO4	12	4	4	8	16
5	V	MEMS (Microelectromechanical Systems) Sensors	CO5	12	2	4	4	10
Grand Total				**60**	**18**	**24**	**28**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Two offline unit tests of 30 marks and average of two-unit test marks will be consider for out of 30 marks.

For formative assessment of laboratory learning 25 marks.
Each practical will be assessed considering 60% weightage to process, 40% weightage to product.

Summative Assessment (Assessment of Learning)

- End semester assessment of 70 marks.

End semester summative assessment of 25 marks for laboratory learning

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	1	2	1	2	2	1	2			

CO2	2	2	2	2	-	1	2			
CO3	1	2	1	2	2	1	2			
CO4	1	2	1	2	2	1	2			
CO5	1	2	1	2	2	1	2			

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

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Patranabis D.	Sensors and Transducers	PHI Learning Private Limited, ISBN: 978-8120321984
2	Gayakwad Ramakant A.	Op-Amps and Linear Integrated Circuits	Pearson Education, ISBN: 978-9332549913
3	Botkar K. R.	Integrated Circuits	Khanna Publishers, ISBN: 81740920801
4	Murty D.V.S	Transducers and Instrumentation	Prentice Hall India Learning Private Limited, ISBN: 978-8120335691
5	Edited by Korvin Jan G. K and Paul Oliver	MEMS: A Practical Guide to Design, Analysis, and Applications	Springer-Verlag GmbH & Co. KG, ISBN : 3540211179
6	Jain V.K.	Internet of Things	Khanna Publisher, ISBN: 8195207529
7	Liptak Bela G.	Process Measurement and Analysis	CRC Press, ISBN: 0849310830

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://www.farnell.com/datasheets/1504633.pdf	Touch screen sensor design guide.
2	https://www.bosch-mobility.com/en/solutions/electronic-compo nents/mems-sensors/	MEMS sensors information
3	https://nptel.ac.in/courses/117105082	MEMS sensors overview
4	https://sl-coep.vlabs.ac.in/List%20of%20experiments.html	Sensor simulation using virtual lab
5	https://www.bharathuniv.ac.in/page_images/pdf/ courseware_eee /Notes/NE3/BEE026%20MEMS.pdf	MEMS sensors introduction
6	https://courses.cs.washington.edu/courses/cse466/15au/pdfs/l ectures/MEMS%20Sensors.pdf	MEMS sensors course
7	https://www.classcentral.com/course/youtube-electronics-mems -microsystems-47673	Short duration online course for MEMS sensors
8	https://nptel.ac.in/courses/108108147	Sensors and actuators overview
9	https://nptel.ac.in/courses/117107094	Operational amplifier information

Note :

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