



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Instrumentation & Control Engineering

Course / Subject Code: DI03017041

Course/Subject Name: Industrial Transducers

W. e. f. Academic Year:	2024-25
Semester:	3 rd
Category of the Course:	PCC

Prerequisite:	Basic knowledge of physics, mathematics, electrical, electronics, and mechanical elements is essential to understand the principles and applications of various types of industrial transducers.
Rationale:	The measurement of process parameters is a vital aspect of any industrial process. Transducers are extensively used across various industries. Consequently, a diploma engineer in Instrumentation and Control Engineering is expected to understand the importance of measurement in process plants. The course on Industrial Transducers equips engineering diploma students with essential skills in using, installing, testing, maintaining, and diagnosing failures of different types of transducers.

Course Outcome:

After Completion of the Course, Student will be able to:

No	Course Outcomes	RBT Level
CO-1	Review basic concepts of measurement.	R, A
CO-2	Choose the suitable transducer.	R, U
CO-3	Explain the working principles of mechanical transducers and electrical transducers.	R, U, A
CO-4	Explain the working principles of thermoelectric transducers and electrochemical transducers.	R, U, A
CO-5	Explain the working principles of electro-optical transducers, radiation-ionization transducer and ultrasonic transducer.	R, U, A

*Revised Bloom's Taxonomy (RBT)



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Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
L	T	PR	C	Theory		Tutorial / Practical		
				ESE (E)	PA(M)	PA(I)	ESE (V)	
2	0	2	3	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1	Concepts of Measurement	5	10
	1.1. Compare different measurement methods. 1.1.1. Direct Method, Indirect Method, Comparative Method, Substitution Method, Null Method, and Fundamental Method. 1.2. Recall the different types of units used for measuring process parameters (i.e., Level, Temperature, Flow, Pressure, etc.). 1.3. Convert measurement units with prefixes into a different unit system. 1.4. List the errors that occur during measurement along with examples. 1.5. Definition of Range and Span in Transducer.		
2.	Transducer Basics	5	10
	2.1. Explain block diagram of transducer. 2.2. List the transducer based on, a. Principle of transduction. b. Active and passive transducer. c. Primary and Secondary transducers. d. Analog and Digital transducer. 2.3. Classify the control signals. 2.3.1. Standard electronic signal range: 04mA to 20mA DC current		



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	<p>signals.</p> <p>2.3.2. Standard pneumatic signal range: 03 psig (pounds per square inch gauge) to 15 psig pneumatic signals.</p> <p>2.4. Calculation of Error as Percentage of Range and Percentage of Span in transducer.</p> <p>2.5. Prepare a table to identify transducers for different process parameters.</p>		
3	Mechanical Transducers and Electrical Transducers	8	40
	<p>3.1. List the components of different types of mechanical transducers.</p> <p>3.2. Illustrate the working principles of different types of mechanical transducers with schematic diagrams.</p> <p>3.2.1. Mechanical Transducer - Bimetallic Strip, Liquid expansion thermostat, Bellows, Bourdon Tube, Flow Transducers (i.e., Orifice, and Venturi), Level Transducers (i.e., Float type, and Displacement type), and Seismic Displacement Transducer.</p> <p>3.3. List the components of different types of electrical transducers.</p> <p>3.4. Illustrate the working principles of different types of electrical transducers with schematic diagrams.</p> <p>3.4.1. Electrical transducers - Resistive Transducer, Inductive Transducer, Capacitive Transducer, Piezoelectric Transducer, Linear Variable Differential Transformer (L.V.D.T.), Rotary Variable Differential Transformer (R.V.D.T.), and Strain gauge Transducers.</p>		
4.	Thermoelectric Transducers and Electrochemical Transducers	6	20
	<p>4.1. List the components of different types of thermoelectric transducers.</p> <p>4.2. Illustrate the working principles of different types of thermoelectric transducers with schematic diagrams.</p> <p>4.2.1. Thermoelectric transducers – Thermocouple (i.e., based on the Seebeck effect), Resistance Temperature Detector (R.T.D.), and Semiconductor temperature sensors.</p>		



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	<p>4.3. List the components of different types of Electrochemical transducers.</p> <p>4.4. Illustrate the working principles of different types of Electrochemical transducers with schematic diagrams.</p> <p>4.4.1. Electrochemical transducers – Gas-sensing electrode, Metal-Oxide-Semiconductor (MOS) gas Sensors and Ion Selective Electrode.</p>		
5.	Electro-optical Transducers, Radiation-ionization Transducer and Ultrasonic Transducer	6	20
	<p>5.1. List the components of different types of electro-optical transducers.</p> <p>5.2. Illustrate the working principles of different types of electro-optical transducers with schematic diagrams.</p> <p>5.2.1 Optoelectronics devices: Infrared emitter, Photodiode, Photo transistor, Photovoltaic cells, Light Dependent Resistor (L.D.R.), Opto-coupler, Digital Encoders (Incremental/ Absolute).</p> <p>5.3. List the components of radiation ionization transducer and Ultrasonic transducer.</p> <p>5.4. Illustrate the working principles of different types of Radiation ionization transducer with schematic diagrams.</p> <p>5.4.1. Radiation ionization transducer - Geiger Muller Counter.</p> <p>5.5. Illustrate the working principles of Ultrasonic transducer (i.e. Level) with schematic diagram.</p>		
	Total	30	100 %

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	U Level	A Level	N Level	E Level	C Level
40 %	40 %	20 %	--	--	--



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Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

Sr. No.	Title of Book	Author	Publication
1.	A Course in ELECTRICAL AND ELECTRONIC MEASUREMENTS AND INSTRUMENTATION	A. K. Sawhney	Shree Hari Publications (1 January 2021), ASIN : B092TMDW24.
2.	TRANSDUCERS AND INSTRUMENTATION	Murty D.V.S	Prentice Hall India Learning Private Limited; 2nd edition (1 January 2008), ISBN-10 : 8120335694, ISBN-13 : 978-8120335691.
3.	Sensors and Transducers	Patranabis	ASIN : 8120321987, PHI Learning; 2nd edition, ISBN-10 : 9788120321984, ISBN-13 : 978-8120321984.
4.	Industrial Instrumentation and Control	S. K. Singh	Tata McGraw-Hill Publication, New Delhi, ISBN-10 : 0070678200, ISBN-13 : 978-0070678200.
5.	Sensors and Transducers: Characteristics, Applications, Instrumentation, Interfacing	M.J. Usher , D.A. Keating,	Palgrave Macmillan , ISBN-10 : 0333604873, ISBN-13 : 978-0333604878.
6.	Transducer Engineering	B.Rampriya B.Nagaraj, S.Renuka.	Anuradha, ISBN-10 : 8184720874, ISBN-13 : 978-8184720877.
7.	Measurement and Instrumentation Principles	Alan S. Morris	Butterworth-Heinemann Ltd; 3rd edition (9 March 2001), ISBN-10 : 0750650818, ISBN-13 : 978-0750650816.



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8.	Mechanical and Industrial Measurements (Process Instrumentation and Control)	Er. R.K. Jain	Khanna Publishers (1 January 1995); Khanna Publishers, ISBN-10 : 8174091912 , ISBN-13 : 978-8174091918
9.	Instrumentation: Devices and Systems	C. Rangan, G Sarma, V.S.V. Mani	McGraw Hill Education; 2nd edition (1 July 2017), ASIN : 0074633503, ISBN-10 : 9780074633502, ISBN-13 : 978-0074633502.
10.	Electronic Instrumentation	H. S. Kalsi	McGraw Hill Education; 3rd edition (1 July 2017), ASIN : 0070702063, ISBN-10 : 9780070702066, ISBN-13 : 978-0070702066.
11.	Instrument and Automation Engineers' Handbook: Process Measurement and Analysis, Fifth Edition - Volume 1,2	Bela G. Liptak, Kriszta Venczel,	ASIN : 1466559322, CRC Press; 5th edition (4 October 2016); TAYLOR & FRANCIS, ISBN-10 : 9781466559325, ISBN-13 : 978-1466559325.
12.	Instrument Engineers' Handbook, Fourth Edition, Volume One: Process Measurement and Analysis: Volume 3	Bela G. Liptak	CRC Press; 4th edition (27 June 2003), ISBN-10 : 0849310830, ISBN-13 : 978-0849310836.
13.	Introduction to Measurements and Instrumentation	Arun K. Ghosh	4th edition, PHI Publication, 2012, ISBN: 978-8120346253.

(b) Open-source software and website:

1. <https://www.britannica.com/science/International-System-of-Units>
2. <https://www.linquip.com/blog/types-of-sensors-detectors-transducers/>
3. https://mec.edu.in/mvlc/ppt/l_bme/ppt_bsm.pdf
4. <https://mathematicalexplorations.co.in/ancient-measurement-systems/>
5. <https://www.mathnstuff.com/math/spoken/here/2class/110/milli/metric.htm>
6. <https://www.nist.gov/pml/owm/metric-si-prefixes>
7. <https://courses.lumenlearning.com/suny-mcc-introductorychemistry/chapter/2-4-converting-units-prefix-conversions/>
8. <https://testbook.com/physics/errors-in-measurements>
9. <https://www.elprocus.com/what-are-errors-in-measurement-types-of-errors-with-calculation/>



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10. <https://automationforum.co/why-4-20-ma-current-signal-is-preferred-over-voltage-signal-in-instrumentation/>
11. <https://automationforum.co/why-not-use-0-20ma-0-15psi-instead-of-4-20ma-3-15psi/>
12. <https://www.basicelectronics.com/what-is-transducers-what-are-its-types/>
13. <https://www.instrumentationtoolbox.com>
14. <https://blog.mensor.com/blog/how-to-choose-the-right-pressure-transducer>
15. <https://www.electronicshub.org/types-of-transducers/>
16. <https://www.elprocus.com/transducer-types-and-their-applications/>
17. <https://www.slideshare.net/slideshow/mechanical-transducers/240806260>
18. <http://gpmalkangiri.co.in/wp-content/uploads/2020/05/transducer.pdf>
19. https://www.sensorsportal.com/HTML/BOOKSTORE/Advances_in_Sensors_VI.pdf
20. https://www.sensorsportal.com/DOWNLOADS/Books/Advances_in_Sensors_III.pdf
21. https://www.co2meter.com/en-in/blogs/news/types-of-gas-detectors?srsId=AfmBOopHiLeOOof1IiTEMEN_rWojzoLj-g9BHKjlHqxFruly3cBQsYAQh
22. <https://www.renkeer.com/gas-sensors-types-working-principles/>
23. https://www.processensing.com/en-us/blog/how-do-electrochemical-sensors-work.htm?srsId=AfmBOoo1EN64z0lixGnp_B_vgRoQaEyfJZ__WdVvNli4cIl-m60CFHSO
24. [https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Instrumental_Analysis_\(LibreTexts\)/23%3A_Potentiometry/23.03%3A_Membrane_Indicator_Electrodes](https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Instrumental_Analysis_(LibreTexts)/23%3A_Potentiometry/23.03%3A_Membrane_Indicator_Electrodes)
25. <https://www.elprocus.com/optoelectronics-devices-with-their-applications/>
26. <https://www.intechopen.com/chapters/48796>
27. <https://www.watelectronics.com/ultrasonic-transducer/>
28. <https://archive.nptel.ac.in/courses/108/105/108105064/>
29. <https://archive.nptel.ac.in/courses/103/105/103105130/>
30. <https://instrumentationtools.com>
31. <https://instrumentationandcontrol.net/>
32. <https://www.vlab.co.in/>
33. <https://control.com/>
34. <https://www.priyamstudycentre.com/2022/05/ion-selective-electrode.html>
35. http://publications.iupac.org/analytical_compendium/Cha08sec322.pdf
36. <https://circuitglobe.com/seismic-transducer.html>

Suggested Course Practical list:

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Course Outcome	Approx. hours required.
1.	Convert various measurement units into their MKS and CGS forms.	1	1	2
2.	Prepare a table of transducers based on different methods of	1	1	2



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	measurement.			
3.	Prepare table for measurement units and output signal units of available transducers.	1	1	2
4.	Find out Relative Error, uncertainty while measuring A.C. voltage with multimeter. (Ref. https://www.webassign.net/question_assets/unccolphysmechl1/measurements/manual.html)	1	1	4
5.	Identify the different components of a given transducer based on its block diagram.	2	2	2
6.	List the process parameters and their measuring instruments in your process lab, Draw figure of any two process parameter measuring instruments.	2	2	2
7.	Prepare a transducer with a potentiometer that will convert rotary input into 4mA to 20mA of output (Use 24V.D.C. as power supply).	2	2	4
8.	Demonstrate and verify the output pressure range of 03psig to 15psig from an air compressor using a pressure gauge.	2	2	2
9.	Calculate Percentage of Range and Span Using the Given Transducer.	2	2	2
10.	Prepare a table for the selection of different types of transducers for different process parameters.	2	2	2
11.	Demonstrate the operation of a C-type Bourdon tube.	3	3	2
12.	Demonstrate the operation of a Liquid expansion thermostat.	3	3	2
13.	Demonstrate the operation of Flow transducers.	3	3	4
14.	Demonstrate the operation of Level transducers.	3	3	4
15.	Demonstrate the operation of a Seismic Displacement transducer.	3	3	4
16.	Demonstrate the operation of Resistive transducer.	3	3	2
17.	Demonstrate the operation of Inductive transducer.	3	3	2
18.	Demonstrate the operation of Capacitive transducer.	3	3	2
19.	Demonstrate the operation of Piezoelectric transducer.	3	3	2
20.	Demonstrate the operation of L.V.D.T..	3	3	2
21.	Demonstrate the operation of R.V.D.T..	3	3	2
22.	Demonstrate the operation of Strain gauge transducer.	3	3	2
23.	Demonstrate the operation of Thermocouple.	4	4	2
24.	Demonstrate the operation of R.T.D..	4	4	2



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25.	Demonstrate the operation of Semiconductor temperature sensors.	4	4	4
26.	Demonstrate the operation of Thermoelectric transducer (Temperature Transducer).	4	4	2
27.	Demonstrate the operation of Gas-sensing electrode.	4	4	2
28.	Demonstrate the operation of Metal-Oxide-Semiconductor (MOS) gas sensors.	4	4	2
29.	Demonstrate the operation of Ion selective electrode.	4	4	4
30.	Adjust Brightness of L.E.D. using Pot and measure intensity of light using L.D.R., Plot a graph Rotary position vs. current passing through L.D.R..	5	5	2
31.	Prepare L.D.R. based transducer which converts light intensity into detectable change current and also Plot graph of L.D.R. resistance vs. current output.	5	5	2
32.	Demonstrate the operation of Infrared emitter and Photodiode.	5	5	2
33.	Demonstrate the operation of Photodiode.	5	5	2
34.	Demonstrate the operation of Photo transistor.	5	5	2
35.	Demonstrate the operation of Photovoltaic cells.	5	5	2
36.	Demonstrate the operation of Opto-coupler.	5	5	2
37.	Demonstrate the operation of Digital Encoder.	5	5	2
38.	Demonstrate the operation of Geiger Muller Counter.	5	5	4
39.	Demonstrate the operation of Ultrasonic transducer.	5	5	4
Minimum 10 to 12 Practical Exercises				30 Hrs

List of Laboratory/Learning Resources Required:

1. M.K.S. and C.G.S. chart conversion.
2. Electronic work bench.
3. Multimeter.
4. D.C. Regulated Power Supply (Variable voltage range : 0 to 30 V (+10%), Variable current range : 0 to 0.5 A (+10%).
5. Switch Mode Power Supply (SMPS for Output +12VDC).
6. Current & Voltage Signal Generator (0mA to 24mA and 0VDC to 24VDC).
7. Voltage to Current Converter (V to I) with power supply.
8. Bourdon gauge trainer kit.
9. Liquid expansion thermostat trainer kit.



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10. Bellows trainer kit.
11. Flow Control Trainer. (It must include a Flow transducer.)
12. Level Measurement trainer kit. (It must include a Level transducer.)
13. Seismograph Lab Model.
14. Resistive Transducer trainer Kit
15. Inductive transducer trainer Kit
16. Capacitive transducer
17. Piezoelectric Transducer trainer kit.
18. Magnetostrictive transducer trainer kit.
19. Hall-effect transducer trainer kit.
20. Tachometer transducer trainer kit.
21. L.V.D.T. trainer kit.
22. R.V.D.T. trainer kit.
23. Strain gauge trainer kit.
24. Thermocouple Trainer Kit
25. R.T.D. Trainer Kit.
26. Thermistor trainer kit.
27. Semiconductor temperature sensor trainer kit.
28. Temperature Transducer trainer kit.
29. Gas detector trainer kit.
30. Metal-Oxide-Semiconductor (MOS) gas sensors trainer kit.
31. Ion Selective Electrode trainer kit.
32. L.E.D. Characteristics trainer kit.
33. L.D.R. trainer kit.
34. Infrared emitter.
35. Photodiode trainer kit.
36. Photo transistor trainer kit.
37. Photoconductive cell trainer kit.
38. Photovoltaic cells trainer kit.
39. Opto-coupler trainer kit.
40. Optoelectronic trainer kit



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41. Digital Encoder trainer kit.
42. Geiger Muller Counter trainer kit.
43. Ultrasonic transducer trainer kit.
44. Pressure Transducer trainer kit.
45. Pressure Measurement Trainer kit. (It must include Manometer and Pressure Transducer.)
46. Pneumatic trainer kit.
47. Digital Storage Oscilloscope (D.S.O.).
48. Electrical components - Soldering Iron, Soldering Wire, Flux, Electrical Insulation Tape, Teflon Tape, GPB (2) 12-0-12 Transformer, Tester, Solid copper wire, one solid aluminum/iron wire).
49. Mechanical Tools - Plier, Nose Plier, Screw Driver Set, Portable Digital Weighing Scale (hook type), Measurement Tape,
50. Electronics - Breadboard, 1-10K Pot , Hookup wires, 12VDC adaptor, Female Barrel Jack, LEDs, LDR, Multimeter, Wire Stripper, Resistor Box, Diode, BC 547 Transistor, HC SR 04 Sensor, MQ2 based Smoke Sensor, Arduinio 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 Emmiter, IR Proximity/ Receiver, 9V battery (2), 9V battery ,connector, Push Button, 5V Buzzer, 5V DC motor, LED , IR, , Piezo electric sensor, Magnetostrictive sensor, Connectors (Probes/ Alligator Clips Electrical Test Leads).
51. Calculating Accuracy, Resolution, and Precision: Standard reference instruments (e.g., calibrated weights, rulers), Calculator or spreadsheet software.

Suggested Project List:

The projects serve as practical learning experiences for students in the field of Instrumentation and Control Engineering. These projects integrate theoretical knowledge with hands-on application, fostering competency development across various Course Outcomes (COs). Below are guidelines for designing and executing projects:

- **Project Types:**
 - It can be industry-based, internet-based, workshop-based, laboratory-based, or field-based.
 - Each project should align with specific COs and address real-world challenges.
- **CO Integration:**
 - It should encompass two or more COs.



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- Integration involves aligning Program Outcomes (PrOs), Unit Outcomes (UOs), and Assessment and Design Outcomes (ADOs).
- **Project Duration:**
 - Students are encouraged to maintain a dated work diary to document their individual contributions and sufficient engagement time for each project should be allocated by faculty during the course.
- **Seminar Presentation:**
 - Before submission, students must give a seminar presentation on their project.
 - The presentation should highlight the project's objectives, methodology, results, and relevance to industry-oriented COs.

Following are suggestive projects, and additional ones can be tailored to specific course objectives. Encourage students to explore innovative solutions and apply their engineering skills effectively.

1. Transducer failure Analysis:

- Research and compile information about Transducer failure.
- Analyse the causes, effects, and consequences of Transducer failure.
- Investigate strategies used to prevent such incidents.
- Present your findings in a seminar or report.
- Students can also explore case studies related to transducers used in specific industries (e.g., chemical plants, oil refineries, nuclear facilities) and discuss safety measures.

2. Transducer based model Making:

- Choose an innovative transducer related to instrumentation or control systems.
- Create a physical model or prototype that demonstrates the concept.
- Explain how the different components of transducer work together.
- Consider projects like smart home automation, environmental monitoring, or industrial process optimization.

3. Transducer selection simulation:

- Simulate the process of selecting transducer for a given application.
- Define process parameters (e.g., temperature, pressure, flow rate) for a specific scenario.
- Research and recommend suitable transducer.
- Discuss factors like accuracy, range, response time, and compatibility.
- Prepare a detailed report summarizing your choices.



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4. Different transducer Market Survey:

- Choose a specific type of Transducer.
- Conduct a market survey to compare available options from different manufacturers.
- Evaluate features, scalability, reliability, and ease of integration.
- Consider factors like Input measurement and Output signal.
- Provide recommendations based on your analysis.

5. Visit of Industrial site:

- Visit the Industrial sites, where different types of transducer installed.
- Prepare Industrial visit report.

Suggested Activities for Students:

In addition to classroom and laboratory learning, students are encouraged to engage in co-curricular activities that enhance their understanding and practical skills. These activities can be conducted in groups and should be documented in 5-page reports. Collecting physical evidence of their work will also contribute to their portfolio, which can be valuable during placement interviews.

- Collaborate in groups to create detailed specifications for various industrial measuring devices. Consider accuracy, range, resolution, and environmental factors.
- Form teams and work on Transducer related projects. Apply theoretical knowledge to practical scenarios, such as designing a temperature control system or Pressure/ level/ flow measurement setup.
- Deliver a seminar on safety practices specific to instrumentation systems. Cover topics like Operation/ Function of Transducer or Transducer failure.
- Organize a seminar focusing on cutting-edge Transducer technologies. Discuss trends, innovations, and their applications in industry.
- Conduct a comprehensive market survey to explore available Transducers. Analyze their features, costs, and suitability for different applications.
- Prepare portfolios showcasing your instrumentation-related work. Include project reports, photographs, and evidence of practical implementation.
- Discuss in groups the specifications of Industrial Transducers, considering accuracy, range, resolution, and environment.
- Prepare a poster showing the specifications of Industrial Transducer, focusing on accuracy, range, resolution, and environmental conditions.

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