C.U.SHAH UNIVERSITY

FACULTY OF: - Technology & Engineering
DEPARTMENT OF: -Instrumentation & Control Engineering
SEMESTER: - IV
CODE: - 4TE04TMP1
NAME – Transducers and Measurement Practice

Teaching & Evaluation Scheme

Subject Code	Name of the Subject	Teaching Scheme (Hours)				Credits	Evaluation Scheme							
							Theory				Practical (Marks)			
							Sessional Exam		University Exam		Internal		University	Total
		Th	Tu	Pr	Total		Marks	Hrs	Marks	Hrs	Pr/Viva	TW	Pr	
4TE04TMP1	Transducers and Measurement Practice	4	0	2	6	5	30	1.5	70	3	30	20	---	**150**

Objectives

- To study fundamentals of major types of sensors/transducers.
- To study the performance characteristics and source of errors of various transducers.
- To design and develop new sensors/transducers for industrial as well as commercial applications.

Pre-requisite

- Basics of Digital Instruments.

Course Outlines

Sr. No.	Course Contents	No. of Hours
1.	**MEASUREMENT, INSTRUMENTATION & CALIBRATION** Introduction, measurement, classification of transducers, performance characteristics, errors in measurement, calibration and standards.	4
2.	**TEMPERATURE MEASUREMENT**: **I. Concept of heat and temperature**, Defining temperature **II. Temperature scale:** Centigrade, Kelvin, Fahrenheit, and Rankine, comparison of temperature scale, System Thermometry, Expansion Thermometers; **III. Resistance Temperature Detector (RTD):** Temperature coefficient of resistivity of various metals; metals used in RTD; Platinum Resistance Thermometers; Various RTD standards: ASTM – 3711, IEC60751, BS 1904, DIN 43760, and Mil – T – 24388; RTD resistance measurement with Wheatstone Bridge Circuits: two – wire	12

	circuit, three – wire circuit, four – wire measurement circuit, RTD resistance measurement with Constant Current Source, Industrial RTD assembly, Thermowell assembly, RTD applications; **IV. Thermistors:** Theory; materials; types; and applications **V. Thermocouples:** Seebeck effect; Peltier effect; Thomson effect; thermoelectric diagram; thermoelectric inversion; law of intermediate metals; law of intermediate temperature; cold junction compensation; Thermocouple materials: Base Metal Thermocouple, types - E, J, K, T, and N; Precious Metal Thermocouple, types – B, R, and S; thermocouple construction: plain wire thermocouple, Sheathed thermocouple, Mineral – insulated thermocouple, surface contact thermocouple, hot metal thermocouple, liquid metal thermocouple, thermopiles; thermocouple compensating cables; Thermocouple Tables (standard), use of thermocouple in various applications **VI. Radiation Thermometers:** Theory of black body radiation; realization of black body radiation; Prevost's theory of exchange; Stefan – Boltzmann law; Wien's law (distribution of energy in spectrum); Radiation thermometer types: total radiation thermometers, thermopile used in total radiation measurement, Surface radiation thermometer; Pyroelectric techniques; applications. **VII. Miscellaneous Measurement Techniques:** Pyroelectric cone, temperature sensitive pigments, liquid crystals, applications.	
3.	**PRESSURE MEASUREMENT**: **I. Defining pressure;** Concept of atmospheric, absolute, vacuum, and gauge pressure; Units of pressure **II. Manometers:** Principle; types **III. Elastic type:** Bourdon tube; types, materials, construction; Metallic Diaphragm elements, construction; Capsule type; Bellows type, **IV. Electric methods of pressure measurements:** Strain gauge pressure measurement, capacitance pressure measurement, potentiometric pressure measurements, resonant wire pressure measurements, piezoelectric pressure measurement, magnetic pressure measurement, optical pressure measurement **V. Special Pressure Measurement Techniques:** Piston type pressure measurement; Pressure sensitive wire transducer, Bulk Modulus Cell Pressure Transducer; Dead Weight Piston Gauges **VI. Vacuum Measurement: Mechanical Vacuum Gauges:** McLeod Vacuum Gauge, Molecular Momentum Vacuum gauge, Sinning Ball Element Type Vacuum Gauge; Thermal Vacuum Gauges: Knudsen Gauge, Thermal Conductivity Gauges, Pirani (Resistance Wire) Vacuum gauge, Thermistor Vacuum gauge, Thermocouple Vacuum Gauge; Ionisation Vacuum Gauges – Hot Cathode Ionization Gauge, Cold Cathode Ionization Gauge, Radioactive Source Ionization Gauge	12

4.	**LEVEL MEASUREMENT** **I. Level and Volume;** Relation of level and volume; Importance of level and volume measurement; **II. Level Measurement** Using Gauge Glass Technique, Construction, working, Applications **III. Float Type Level Indications:** Float level switch, Level measurement using float – rope method, float operated spring loaded level switch, magnetic float device, applications **IV. Level Measurement Using Displacer and Torque Tube:** Construction, material of construction, principle, working, applications **V. Air–purge System/Bubbler System:** Principle, construction, operation, operating considerations, applications. **VI. Hydrostatic Pressure Method:** Principle, Hydrostatic Pressure Measurement in Open Tank, Hydrostatic Pressure Measurement in Closed Tank, Applications, Calibration **VII. Differential Pressure Method for Open and Closed Tank**, Use of Electronic DP Transmitter, Practical consideration, Location Correction for Hydrostatic Pressure Level Measurement, Calibration of receiving instrument **VIII. Level Measurement by Electrical Methods:** Resistance Type: Resistance Tapes, Pressure effect, temperature and other effects; Capacitance Level Detection and Measurement: Principle, bare capacitance probe, Teflon coated capacitance probe, selection of probe configuration, capacitance measurement techniques, applications. Radiometric Level Detection and Measurement: Principle; Radiation type instruments; Components of nucleonic level measurement system; mounting; applications Ultrasonic Level Measurement: Principle; Ultrasonic level switches and Transmitters; Applications. Microwave Level Measurement: Principle; construction; applications Optical Level Measurement: Principle; non-conducting optical level sensor; optical sludge level detector; light refraction type level switch; level detection using fiber optic; practical considerations; applications Radar Level Transmitter: Principle; Radar Antenna Types; Time of Flight Determination; Construction; Installation method; application. Laser Level switch: Principle; Time of reflection measurement; Construction; Installation; Applications **IX. Level Switches:** Rotating Paddle switch; Vibration Damping Method; Microwave Level Switch; Field Effect Level Switch; Conductivity Level Switch **X. Interface Measurement:** Principle; Interface Level Switch	12

5.	**FLOW MEASUREMENT** I. **Types of flow;** Units of flow – volumetric and mass; Importance of flow measurement **II. Mechanical Flow Meters:** Theory of fixed restriction variable head type flow meters: Flow of incompressible fluids in pipes; β ratio; Reynolds Number; Discharge Coefficient; Flow Coefficient; Flow of compressed fluid in pipes Orifice Flow Meter: Principle of operation; types of orifice plates; machining methods of orifice; material for orifice; position of tapes in orifice; Orifice Plate selection and Designing Venturi Tubes: Classical (long form) Venturi; Short form Venturi; Types of Ventru Tubes; Installation Flow Nozzle: Flange type flow nozzle; Design of flow nozzle; applications Dall Tube: Construction and working; applications Installation of Head Flow Meters: Pressure pipe layout; Installation of condensation pots; Installation of sealing pots; piping arrangement practical considerations Pitot Tube: Principle; Averaging Pitot Tube (Annubar); Apllications Positive Displacement Meters: Nutating Disc Type; Reciprocating Piston Type; Oval Gear Type; Helix Type; Their working principles; application; selections Inferential Flow Meters: Principle; Variable Area Flow Meters: Rotameters and Piston Type Meters; Construction; Target Flow Meters: principle of working; construction, applications Mass Flow Meters: Angular – Momentum Mass Flow Meter; Constant Torque Hysteresis Clutch Mass Flow Meter; Impeller Turbine Mass Flow Meter; Twin Turbine Mass Flow Meter; Gyroscopic Mass Flow Meter; Coriolis Mass Flow Meter; Thermal Mass Flow Meter; Volume Flow Meter plus Density Measurement (Radiation type Mass Flow Meter) **III. Electrical Flow Meters: Electromagnetic Flow Meter:** Principle; Excitation schemes (AC, DC, and Dual Frequency); Construction Ultrasonic Flow Meter: Principle; Types of Ultrasonic Flow Meters; Construction; Doppler Flow Meters; Applications Laser Doppler Anemometer Systems: Principle of operation; working; applications **IV. Other Types of Flow Meters: Purge Flow Regulators:** Rotameter types purge meter; applications Cross Correlation Flow Meter: Principle of working; applications	12

	Solid Flow Measurement: Need; Belt Type Gravimetric Feeder; Belt Type Electromechanical Gravimetric Feeder; applications Vortex Shedding Flow Meter: Vortex shedding phenomenon; Vortex Flow Meter Detection; Features; Selections Anemometers: Hot Wire Filament; Principle; Types of Hot Wire Anemometers (constant current type and constant temperature type), principle, construction, and comparison; Mechanical Anemometers, vane anemometer, three cup anemometer, and impeller anemometer Flow Switch: Designs **V. Flow Meter Calibration:** Methods of Calibration of Flow Meter with Liquids: Dynamic Weighing (Gravimetric) Method; Pipe Prover Method; Master Meter Method Methods of Calibration of Flow Meter with Gases: Soap Film Burettes; Bell Prover System; Sonic Venturi Nozzles; Gravimetric System for Gas – Meter Calibration; PVT System **VI. Flow Meter Selection and Designs:** Factors to be considered; Desirable characteristics;	

Learning Outcomes

- Understand fundamental transduction and sensing principles
- Have a broad understanding of the applications of various sensors and transducers available for industrial measurements
- Develop and apply engineering concepts for a range of problems after studying this course.

Books Recommended

1. Instrument Engineers' Handbook: Process Measurement and Analysis by B. G. Liptak.
2. Industrial Instrumentation by K. Krishnaswamy and S. Vijayachitra, New Age International Publication.
3. Industrial Instrumentation and Control by S. K. Singh, Tata McGraw Hill Publication.
4. Sensors and Transducers by D. Patranabis, PHI Learning Pvt. Ltd.
5. Handbook of Applied Instrumentation by D. M. Considine and Sidney David Ross, McGraw – Hill Publicaiton.
6. Encyclopedia of Instrumentation and Control by D. M. Considine, Krieger Publication Co.
7. Instrumentation Reference Book by Walt Boyes, Butterworth – Heinemann Publisher.
8. Measurement Systems: Application and Design by E. D. Doeblin, McGraw – Hill Publication.