

16-WEEK LESSON PLAN & TEACHING NOTES

Course: 5.2 INSTRUMENTATION | Diploma in Electronics & Communication Engineering

Board/State: Haryana State Board of Technical Education

NSQF Level: Level 5

Weekly Scheme: L: 3 Hrs, P: 4 Hrs

Target Audience: Diploma Students

COURSE OUTCOMES (COS)

CO1: Study and perform measurement of basic systems.

CO2: Operate various displacement and strain devices.

CO3: Measure force and torque using various devices.

CO4: Learn and measure flow and pressure.

CO5: Handle temperature and humidity measurement.

16-WEEK COMPREHENSIVE LESSON PLAN

Week	Unit & Topic	Detailed Content Breakdown	Practical / Pedagogical Focus
UNIT I: Measurements & Transducers			
Week 1	Basic Measuring Systems	Importance of measurement, generalized measurement system block diagram (Sensing, Signal Conditioning, Output), advantages and limitations of basic measuring systems.	Identification of basic measuring instruments in lab and mapping their functional block diagrams.
Week 2	Transducers Basics & Resistive Types	Definition, classification (Active vs. Passive, Primary vs. Secondary). Resistance Transducers: Potentiometers, RTDs, and Thermistors — principles, construction, and applications.	Plotting resistance vs. temperature curves for RTD and Thermistor.
Week 3	Inductive & Capacitive Transducers	Inductance Transducers: Variable reluctance, principle of LVDT. Capacitance Transducers: Variable dielectric, variable area, and variable distance principles.	Hands-on experiments with capacitive proximity/displacement setups.
Week 4	Electromagnetic & Piezoelectric Transducers	Working principles and construction of Electromagnetic Transducers. Piezo-electric Transducers: Piezoelectric effect, materials (Quartz, Rochelle Salt), equivalent circuit, frequency response.	Demonstration of piezoelectric sensor response to dynamic stress/impact.
UNIT II: Measurement of Displacement and Strain			

Week	Unit & Topic	Detailed Content Breakdown	Practical / Pedagogical Focus
Week 5	Displacement Measurement	Wire-wound potentiometers & Linear Variable Differential Transformers (LVDT). Construction, primary-secondary coupling, residual null voltage, input-output displacement characteristics.	Characterization of LVDT output voltage vs. linear displacement; null point adjustment.
Week 6	Strain Measurement Principles	Principles of strain gauges; physical mechanisms of resistance variation under mechanical strain. Inductance-type & Resistive-type strain gauges.	Introductory setup for strain measurement using cantilever beam setup.
Week 7	Gauge Factor & Construction	Wire-type, foil-type, and semiconductor strain gauges. Derivation and understanding of Gauge Factor (GF). Selection criteria for strain gauge materials and temperature compensation.	Calculating Gauge Factor (GF) experimentally under step loading conditions.
Week 8	Bridges & Proximity Switches	Electrical strain gauge Wheatstone bridges (Quarter, Half, and Full bridge configurations). Proximity switches: Inductive, capacitive, and photo-electric proximity switches.	Testing Quarter and Full Bridge strain configurations; proximity sensor triggering experiments.
UNIT III: Force, Torque, and Speed Measurement			
Week 9	Force Measuring Devices	Principles of force measurement, elastic transducers (proof rings, diaphragms, cantilever beams) for converting force to displacement/strain.	Calibration of elastic force sensors using known weight standards.
Week 10	Load Cells	Load measurements using elastic transducers and electrical strain gauges. Load cells: Construction, compression load cells, tension load cells, signal conditioning for load cells.	Operation and signal conditioning of a strain gauge load cell setup.
Week 11	Torque Measurement	Torque measurement principles using strain gauges and inductive transducers. Shaft torsion measurement, wireless/slip-ring telemetry setup for rotating shafts.	Demonstration of shaft torque measurement models.
Week 12	Speed Measurement	Different methods of speed measurement: Mechanical, electrical, optical tachometers, and stroboscopic methods. Non-contact vs. contact speed measurements.	RPM measurement using Optical Encoder, Magnetic Pick-up, and Stroboscope.
UNIT IV: Pressure, Flow, Temperature & Humidity Measurement			

Week	Unit & Topic	Detailed Content Breakdown	Practical / Pedagogical Focus
Week 13	Pressure Measurement	Working principles and construction of Bourdon pressure gauges (C-type, spiral, helical), pressure cells, and mechanical pressure calibration methods.	Pressure measurement and calibration using Bourdon tube gauge setup.
Week 14	Electrical Pressure Pickups	Strain gauge pressure transducers, capacitive pressure sensors, LVDT-based pressure transducers. Direct conversion of pressure into proportional electrical signals.	Testing LVDT/Strain gauge based pressure transducer module.
Week 15	Flow Measurement	Basic principles, construction, and applications of Magnetic Flow Meters (Faraday's Law) and Ultrasonic Flow Meters (Doppler shift and transit-time principles).	Demonstration of non-invasive flow rate monitoring techniques.
Week 16	Temperature, Humidity & Revision	Temperature: Thermocouples, Pyrometers. Humidity: Hair, Electrical, and Capacitive Hygrometers. Course review, equipment maintenance, fault diagnosis, and final practical testing.	Fault diagnosis, troubleshooting of instrumentation setups, and end-term practical assessment.

TEACHING NOTES & KEY MATHEMATICAL FORMULATIONS

1. Transducers & Signal Conversion

A transducer converts a non-electrical physical quantity (e.g., pressure, force, displacement) into an electrical signal (voltage, current, resistance, capacitance).

Gauge Factor (GF): Defines the sensitivity of a strain gauge.

$$GF = \Delta R / R / \epsilon = 1 + 2\nu + (\Delta \rho / \rho) / \epsilon$$

Where ν is Poisson's ratio, ϵ is axial strain ($\Delta L / L$), and ρ is resistivity.

LVDT (Linear Variable Differential Transformer):

- Differential output voltage: $V_{out} = E_{s1} - E_{s2}$.
- At core center (null position): $E_{s1} = E_{s2} \Rightarrow V_{out} = 0 \text{ V}$ (ideally).

2. Strain Gauge Bridge Circuits

To measure minute resistance changes (ΔR), strain gauges are connected in Wheatstone bridge circuits.

Bridge Output Voltage (V_O for Full Bridge):

$$V_O = V_{IN} \cdot GF \cdot \epsilon$$

Temperature Compensation: Thermal expansion causes strain-independent resistance changes. Use a *Dummy Gauge* in the adjacent bridge arm subjected to the same temperature but no mechanical strain to cancel out thermal drift.

3. Flow & Pressure Measurement Principles

Magnetic Flow Meter (Faraday's Law of Electromagnetic Induction):

$$e = B \cdot L \cdot v$$

Where e is induced voltage, B is magnetic field strength, L is pipe inner diameter, and v is conductive fluid velocity.

Bourdon Tube Gauges: Elastic sensing elements (C-type, spiral, helical) deflect under fluid pressure. The mechanical movement is magnified via sector and pinion gears to drive a pointer or couple to a potentiometer/LVDT.

4. Pedagogical Guidelines for Practical Sessions (4 Lab Hours / Week)

- **Lab Integration:** Synchronize classroom lectures directly with the 4 weekly laboratory hours.
- **Fault Diagnosis Protocols:** As mandated by course goals, introduce simple hardware faults (e.g., loose ground leads, misaligned LVDT cores, offset bridge zero) to teach systematic fault isolation and calibration.
- **Safety & Maintenance:** Emphasize equipment maintenance, sensor protection, and signal conditioning noise reduction techniques.