INSTRUMENTATION AND SENSORS

ENME 252

Lecture : 3 **Year : II**
Tutorial : 1 **Part : II**
Practical : 3/2

Course Objectives:
The objective of this course is to introduce students to the methods for instrumentation and sensing in the engineering industry and research. Students will learn about the principle and application of intrusive and non-intrusive techniques and will gain first-hand experience in the development and application of sensors that are important across engineering fields.

1 Measurement System (6 hours)

1.1 Definition and types
1.2 Intrusive and non-intrusive techniques
1.3 Analog and digital instruments
1.4 Performance terms: Reliability, linearity, saturation, hysteresis, response time
1.5 Calibration techniques
1.6 Safety considerations
1.7 Data acquisition: Methods, devices and features

2 Signal Conditioning and Processing (12 hours)

2.1 Signal: Concept, types, acquisition, and properties of digital signal
2.2 Resistance to voltage conversion: Wheatstone bridge
2.3 Noise: Types, signal-to-noise ratio
2.4 Digital signal processing
2.5 Fourier transform: Discrete Fourier transform; Fast Fourier transform
2.6 Inverse Fourier transform
2.7 Data presentation

3 Dynamic Response of Measurement System (8 hours)

3.1 Amplitude and frequency response
3.2 Mathematical modelling of systems
  3.2.1 Zero order system with examples
  3.2.2 First order system with examples
  3.2.3 Second order system with examples
3.3 Characteristics and response of zero, first and second order systems

4 Sensors and Transducers (17 hours)

- 4.1 Classification: Resistive; Capacitive; Inductive; Piezoelectric sensors
- 4.2 Position and motion measurement
  - 4.2.1 Potentiometer: Linear; Rotary
  - 4.2.2 Strain gauge: Construction; Gauge factor
  - 4.2.3 Linear variable differential transformer (LVDT)
  - 4.2.4 Proximity sensors: Optical; Capacitive; Inductive
  - 4.2.5 Ultrasonic, infrared, radar, and laser sensors
- 4.3 Force, moment and torque measurement
  - 4.3.1 Load cells: Types and data acquisition examples
  - 4.3.2 Multi-axis measurement for combined force and moment measurements
  - 4.3.3 Torque measurement systems: Strain gauge and torque meters
- 4.4 Fluid pressure sensor
  - 4.4.1 Manometers
  - 4.4.2 Bourdon tube
  - 4.4.3 Diaphragm sensor
  - 4.4.4 Piezoelectric sensor
- 4.5 Temperature sensor
  - 4.5.1 Expansion thermometer: Liquid-in-glass; Bimetallic
  - 4.5.2 Resistance Temperature Detectors (RTD)
  - 4.5.3 Thermocouple: Types and temperature compensation
  - 4.5.4 Pyrometer
- 4.6 Flow measurement
  - 4.6.1 Flow meter and pitot probes
  - 4.6.2 Flow visualization: Particle image velocimetry (PIV), Schlieren imaging, and BOS
- 4.7 Hydraulic and pneumatic system
  - 4.7.1 Working principle
  - 4.7.2 Actuation system
  - 4.7.3 Control valves
- 4.8 Vibration measurement: Vibration sensors and accelerometer
- 4.9 Image sensor

5 Smart Systems (2 hours)

- 5.1 Micro-electromechanical systems (MEMS)
- 5.2 Smart and intelligent sensors

Tutorial (15 hours)

1. Fourier transform, FFT analysis on arbitrary signals
2. Response of zero, first and second order systems
3. Strain gauge; Wheatstone bridge circuit
4. Sensors and transducers

Practical **(22.5 hours)**

1. Modelling first and second order systems in Simulink
2. Raspberry Pi, and Arduino programming and operation
3. Loadcell calibration and measurement
4. Digital signal processing: FFT and filtering
5. Group project on using sensors with Arduino and/or Raspberry Pi

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapters	Hours	Marks distribution*
1 and 5	8	10
2	12	15
3	8	10
4	17	25
Total	**45**	**60**

* There may be minor deviation in marks distribution.

Reference

1. Webster, J. G., Eren, H. (2018). Measurement, Instrumentation, and Sensors Handbook: Two-Volume Set. CRC press.
2. Northrop, R. B. (2018). Introduction to instrumentation and measurements. CRC press.
3. Bolton, W. (1998). Measurement and Instrumentation System. Butterworth-Heinemann.
4. De Silva, C. W. (2015). Sensors and actuators: Engineering system instrumentation. CRC press.