MONITORING AND INSTRUMENTATION

ENAS 251

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

Course Objectives:
The objective of this course is to introduce students to condition and fault monitoring techniques, non-destructive techniques, and the methods for instrumentation and sensing in the aerospace 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 in aerospace engineering.

1 Fundamentals of Measurement Systems (2 hours)

- 1.1 Types of measurement systems
- 1.2 Properties of measurement systems
- 1.3 Methods of measurement
- 1.4 Measurements in experiments
- 1.5 Condition monitoring

2 Digital Signal Processing (10 hours)

- 2.1 Acquisition and properties of digital signals
- 2.2 Signal conditioning
- 2.3 Signal processing techniques
- 2.4 Fourier transform
- 2.5 Discrete Fourier transform
- 2.6 Fast Fourier transform
- 2.7 Inverse Fourier transform
- 2.8 Processing and presentation of data

3 Dynamic Response of Measurement System (4 hours)

- 3.1 Mathematical modelling of systems
  - 3.1.1 Zero order system, and its examples
  - 3.1.2 First order system, and its examples
  - 3.1.3 Second order system, and its examples
- 3.2 Characteristics and response of zero, first and second order systems
- 3.3 Natural frequency, damping and harmonic response of second order systems

4 Measurement Systems (8 hours)

- 4.1 Sensors and transducers
- 4.2 Force, moment and torque measurement
  - 4.2.1 Load cells, their types and data acquisition examples
  - 4.2.2 Strain gauge, their construction and application
  - 4.2.3 Multi-axis measurement for combined force and moment measurements
  - 4.2.4 Torque measurement systems: Strain gauge and torque meters
- 4.3 Flow measurement
  - 4.3.1 Flow meter and pitot probes
  - 4.3.2 Pressure gauge/sensors: Manometer, bourdon tube, digital sensors
  - 4.3.3 Flow visualization: PIV, Schlieren imaging, and BOS
  - 4.3.4 Hydraulic and pneumatic systems
- 4.4 Thermal measurement: Thermometer, thermocouple and optical techniques
- 4.5 Pyrometry and infrared measurements
- 4.6 Distance and speed sensors: Ultrasound, radar, and laser sensors
- 4.7 Vibration sensors and accelerometer

5 Condition Monitoring (6 hours)

- 5.1 Concept of structural health monitoring
- 5.2 Sensors for condition monitoring
- 5.3 Processing of condition monitoring data
- 5.4 Fault monitoring and prediction
- 5.5 Vibration monitoring and Campbell diagram

6 Non-Destructive Testing (10 hours)

- 6.1 Fault detection techniques
- 6.2 NDT methods and applications
- 6.3 Ultrasonic non-destructive testing, working principle and applications
- 6.4 Eddy-current testing, working principle and applications
- 6.5 Boroscopy techniques
- 6.6 NDT methods in aviation
  - 6.6.1 NDT levels, certifications and requirements
  - 6.6.2 NDT techniques currently used in Nepali aviation

7 Optical Techniques (5 hours)

- 7.1 Imaging systems
- 7.2 Optical methods for fault monitoring
- 7.3 Digital image processing
- 7.4 Laser-based techniques: Types and applications
- 7.5 Synchronizing, processing and correlating data from multiple sources

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. Raspberry Pi, and Arduino programming and operation
2. Loadcell calibration and measurement
3. Digital signal processing: FFT and filtering
4. Ultrasonic NDT practice
5. Eddy-current NDT practice

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*
1,3 and 7	11	10
2 and 5	16	15
4	8	15
6	10	20
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.
5. Northrop RB. Introduction to instrumentation and measurements. CRC press; 2018 Sep 3.