



School of Mechanical Engineering  
Iran University of Science and Technology

# Measurement Systems, Winter 2011

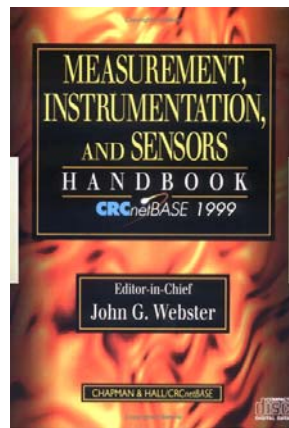
**Instructor:** Dr. Hamid Ahmadian, Wednesdays 13:30-15 pm. Room 225

**Office Hours:** It is best to make an appointment and use email [ahmadian@iust.ac.ir](mailto:ahmadian@iust.ac.ir) to ask questions.

**Text:**

Measurement,  
Instrumentation and  
Sensors

by John G. Webster



## Course Objectives:

Measurement is an essential activity in every branch of technology and science. We need to know the speed of a car, the temperature of our working environment, the flow rate of liquid in a pipe, the amount of oxygen dissolved in river water. It is important, therefore, that the study of measurement forms part of engineering and science courses in further and higher education. The aim of this course is to provide the fundamental principles of measurement which underlie these studies.

## Course Management:

- 35% - Mid- term Exam (Date: 90/02/07)
- 20% - Course Project and Seminar (The project report due is 90/03/16 and the presentation session is scheduled for 90/03/18)
- 45% - Final Exam (Date: 90/04/08)
- $\pm 10\%$  - My opinion of you as a test and measurement engineer

## COURSE OUTLINE

1. **Characteristics of Instrumentation** : Simple Instrument Model • Passive and Active Sensors • Calibration • Modifying and Interfering Inputs • Accuracy and Error • Sensor Fusion • Estimation

2. **Operational Modes of Instrumentation:** Null Instrument • Deflection Instrument • Analog and Digital Sensors • Analog and Digital Readout Instruments • Input Impedance
3. **Static and Dynamic Characteristics of Instrumentation:** Static Characteristics of Instrument Systems: Output/Input Relationship • Drift • Hysteresis and Backlash • Saturation • Bias • Error of Nonlinearity, Dynamic Characteristics of Instrument Systems: Dealing with Dynamic States • Forcing Functions • Characteristic Equation Development • Response of the Different Linear Systems Types • Zero-Order Blocks • First-Order Blocks • Second-Order Blocks, Calibration of Measurements
4. **Measurement Accuracy Error:** The Normal Distribution and the Uniform Distribution Uncertainty (Accuracy), Measurement Uncertainty Model Purpose • Classifying Error and Uncertainty Sources • ISO Classifications • Engineering Classification • Random • Systematic • Symmetrical Systematic Uncertainties, Calculation of Total Uncertainty ISO Total (Expanded) Uncertainty • Engineering System Total Uncertainty • High Degrees of Freedom Approximation
5. **Measurement Standards:** A Historical Perspective, What Are Standards? Standards of Practice (Protocol Standards) • Legal Metrology • Forensic Metrology • Standard Reference Materials, A Conceptual Basis of Measurements, The Need for Standards, Types of Standards, Basic or Fundamental Standards • Derived Standards • The Measurement Assurance System, Numbers, Dimensions, and Units, Multiplication Factors
6. **Acceleration, Vibration, and Shock Measurement:** Accelerometer Dynamics: Frequency Response, Damping, Damping Ratio, and Linearity Periodic Vibrations • Stationary Random Vibrations • Transients and Shocks • Nonstationary Random Vibrations, Electromechanical Force-Balance (Servo) Accelerometers Coil-and-Magnetic Type Accelerometers • Induction Type Accelerometers, Piezoelectric Accelerometers, Piezoresistive Accelerometers, Differential-Capacitance Accelerometers, Strain-Gage Accelerometers, Seismic Accelerometers, Inertial Types, Cantilever, and Suspended-Mass Configuration, Electrostatic Force Feedback Accelerometers, Microaccelerometers, Cross-Axis Sensitivity, Selection, Full-Scale Range, and Overload, Capability, The Frequency Range • The Sensitivity, Mass, and Dynamic Range • The Transient Response • Full-Scale Range and Overload Capability • Environmental Conditions, Signal Conditioning, Signal Conditioning Piezoelectric Accelerometers • Signal, Conditioning of Piezoelectric Transducers • Microaccelerometers
7. **Fundamentals of Signal Analysis:** • Time and Frequency Domains: A matter of Perspective • Understanding Dynamic Signal Analysis • Spectrum Analysis and Correlation • FFT Properties • Sampling and Digitizing • Aliasing • Leakage • Windowing