

# DUBLIN CITY UNIVERSITY

Semester Two Examinations 2002

COURSE:            B.Sc. in APPLIED PHYSICS  
                      B.Sc. in PHYSICS/LANGUAGE

YEAR:             4

EXAMINATION:    PS410 Sensors

EXAMINERS:       Prof. R. W. McCullough  
                      Dr. G.O'Sullivan  
                      Dr V. Ruddy  
                      Dr B. Lawless

DURATION:        3 hours

INSTRUCTIONS:    Attempt THREE questions

- Question 1.**
- (a) Discuss the design of the Platinum One Hundred (Pt-100) thermometer. give details of a method by which the resistance of such a sensor might be measured accurately.
  - (b) What properties of the device determine:
    - i. its useful temperature range
    - ii. its response time
  - (c) Pt-100 thermometers are said to have a resolution of 1 part in  $10^5$  Kelvin. To what resistance resolution does this correspond? The resistance of a Pt-100 increases linearly from 100 to 137 Ohms over the temperature range of 0 to 100<sup>circ</sup> C.

- Question 2.** Explain clearly, with the aid of a diagram, the design of a gas analyser for a chemical which has an absorption band in the mid infrared. What photoconductive devices are suitable to detect such absorption?

What factors determine the minimum detectable concentration MDC of such an analyser? Derive an expression for the MDC in terms of the parameters listed.

**Question 3.** Discuss Noise in sensors and its effect on Signal to Noise ratio under the following headings:

- (a) Thermal noise
- (b) Shot noise
- (c) Flicker noise (1/f noise)
- (d) Quantisation noise

Explain, with the aid of circuit diagrams, the operation of the 3 op-amp Instrumentation Amplifier.

Why is the instrumentation amplifier used in situations where common mode signals must be rejected?

Explain the operation of a Sigma Delta analog to digital converter. What is meant by "Bit stream output"?

**Question 4.** Discuss the use of Neural Networks with sensor arrays under the following headings;

- (a) Non-invertability of sensor response matrix
- (b) The neuron
- (c) Thresholding and squashing functions
- (d) Weighted summation in networks
- (e) The need for multilayer networks and hidden layers
- (f) Feed forward, feedback and competition
- (g) Supervised and unsupervised learning

**Question 5.** Explain the principles of operation of:

- (a) Hall effect magnetic field sensors
- (b) Anisotropic Magneto Resistive sensors

Your discussion should pay particular attention to the structure of the sensors, the range of magnetic fields which are sensed by the two types of sensor and the methods used to obtain linear outputs from the sensors.