DUBLIN CITY UNIVERSITY

SEMESTER TWO EXAMINATIONS 1999

COURSE: B.Sc. in Applied Physics

B.Sc. in Physics with a Language

YEAR: 4

MODULE: Electronics 1 - Sensors

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TIME ALLOWED: 2½ Hours

INSTRUCTIONS: Attempt THREE questions.

PLEASE DO NOT TURN OVER THIS PAGE UNTIL YOU ARE TOLD TO DO SO

This booklet contains 4 pages, including cover sheet

Question 1.

EITHER

(i) Compare and contrast the **wire** strain gauge and **semiconductor** strain gauge in terms of their gauge factors and sensitivity to temperature.

(ii) Show how an electrical bridge circuit containing four active gauges in insensitive to small temperature variations provided all four elements are of comparable unstrained resistance, are of the same composition and all experience the same temperatures.

(iii) Discuss the design of a LOAD CELL for measuring weight indicating clearly the location of all four gauges and the wiring configuration.

OR

(i) Discuss the design of the **Platinum One Hundred (PT - 100)** resistance thermometer. Give details of a method by which the resistance of such a sensor might be measured accurately.

(ii) What properties of the device determine

(a) its useful temperature range

(b) its response time.

(iii) Pt-100 thermometers are said to have a resolution of 1 part in 10^5 Kelvin. What resistance resolution does this correspond to ? The resistance of a Pt-100 increases linearly from 100 to 137 ohms over the temperature range of 0 to 100 C.

Question 2.

EITHER

(i) Outline the principle of operation of the Total Radiation Pyrometer. Discuss briefly the nature of a detector suitable for use in such an instrument.

(ii) Why do Total Radiation Pyrometers require an emissivity correction ? Will the transparency of the atmosphere between the target and the objective lens of the pyrometer affect the indicated temperature. If so explain.

(iii) Express the magnitude of the emissivity correction to a measurement in which a Total Radiation Pyrometer indicates a blackbody temperature of 1290C if the emissivity is 0.71. Take the wavelength of the effective bandpass filter in the pyrometer as 680 nm.

The second radiation constant C_2 has a value of 1.439×10^4 μm.K ($C_2 = hc/k$)

OR

(i) What is the principle of operation of the photoconductive infrared detector ? What parameters determine the region of spectral sensitivity of such devices ?

(ii) If a 2-dimensional array of such devices is used inn thermal imaging, explain, **preferably without mathematical detail,** why the minimum detectable temperature difference (MDTD) of such a camera depends upon: the area of each pixel, the total number of pixels and the array scanning frequency.

Question 3.

EITHER

(i) Describe a measurement system based upon the transmission of nuclear radiation (γ rays) for the determination of the density of a fluid in a pipe. Details of suitable source and detector should be included.

(ii) Show how the random nature of the decay of a radiation source places a limit on the maximum flowrate of the fluid in the pipe if a particular minimum density radiation is to be allocated.

A partially collimated beam of gamma rays from a Cs-137 source is incident on a scintillation counter of active surface diameter 100mm, having crossed a steel pipe in which a fluid flows. When the fluid of density 1340 kg/m^3 is at rest in the pipe the detector registers 5.1 x 10^4 counts per second. With no fluid in the pipe the detector signal is 4.2 times longer. At what fluid flowrate will a 2 % variation in fluid density be undetectable ?

OR

Give an account of the determination of the Vapour Pressure - dewpoint/frost point temperature relationship.

i. by experimental measurement and curve fitting in standards laboratories.
ii. By theoretical thermodynamical modelling in the form of the Clausius-Clapeyron equation.

Describe two experimental configurations used to generate reference humidities for the calibration of humidity sensors.

Describe how the water absorption mechanisms in Aluminium Oxide type humidity sensors have been identified.

Question 4.

EITHER

Discuss, with the aid of circuit diagrams where appropriate, the following sensor interfacing problems:

i. How can a voltage proportional to *t* be obtained from a resistive sensor having a response of the form $R = R_o(1 + \alpha t)$.
ii. How can sensor capacitances such as those associated with polyamide humidity sensors be measured?
iii. How can the capacity of a diode be measured as a function of bias voltage?
iv. What are the relative advantages and disadvantages of constant current and constant voltage drives for hot wire anemometer sensors?
v. Describe how you would fit parameters A, B and C for an Aluminium Oxide humidity sensor having a response to dew point temperature given by:

$$\frac{1}{|Z|} = A\exp^{BT} + C$$

OR

Derive the equation which relates the flow of an incompressible fluid through an orifice plate to the differential pressure and the dimensions of the orifice plate and pipe.

Explain the significance of Reynolds Number in flow measurement.

Explain the significance of Discharge Coefficient.

Why are the discharge coefficients for an orifice plate, a Venturi tube and a Pitot tube different?

Discuss the errors in flow measurement which occur as a result of pulsating flow.

Question 5.

EITHER

Give an account of the principle of:

i. Analog feedback control systems
ii. Fuzzy logic control systems

Discuss the differences in performance between these two types of control system.

OR

Give an account of the methods used to establish a Caesium beam atomic frequency standard. Your answer should include a discussion of the physical principles of the operation of the system together with schematic diagrams of the equipment used.

Give an account of the relationship between International Atomic Time (TAI) and Co-ordinated University Time (UTC).