(Code for Paper)

DUBLIN INSTITUTE OF TECHNOLOGY
KEVIN STREET, DUBLIN 8

Bachelor of Engineering Technology in Control and Automation Systems

Bachelor of Engineering Technology in Electrical Energy Systems

Year 3

SUMMER EXAMINATIONS 2007

INSTRUMENTATION

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?? May 2007 Time : ?? to ??

Question 1 is compulsory [40 marks]
Attempt any two other questions [30 marks per question]

The following should be available for this examination:

Graph Paper

Q1.

(a) Compare and contrast the electrical strain gauge and the piezoresistor. Give some typical applications for these devices. **[8 marks]**

(b) Explain how you would determine the time constant of a thermometer.

A thermometer has a time constant of 6 seconds and is suddenly moved from ice to boiling water. How long will it take before it will read 100 ºC? **[8 marks]**

(c) Explain the principle of operation of any ONE of the following differential pressure flowmeters:

Venturi Meter
Orifice Plate

Include a sketch of the device clearly identifying the location of pressure tappings used for differential pressure measurement. **[8 marks]**

(d) Compare the thermistor, thermocouple and RTD as methods of measuring temperature.

Illustrate your answer by defining the output from each, stating approximate temperature ranges that can be measured and sketching the relationship between temperature and output for each transducer. **[8 marks]**

(e) Explain the following terms as used in instrumentation:

span
linearity
offset
resolution **[8 marks]**

Q2.

(a) A load cell using electrical strain gauges in a Wheatstone bridge arrangement was tested in the laboratory and the following set of results were obtained:

Mass (g)	Bridge Output (mV)
0	2.7
50	2.8
100	3.0
150	3.4
200	3.9
250	4.4
300	4.9
350	5.2

Plot these results and determine the following:

Sensitivity
Offset
Maximum non linearity **[12 marks]**

(b) A resistance strain gauge has a gauge factor of 2.1 and an unstrained resistance of 120 Ω.

What would the resistance of the gauge be if it experienced a strain of 1000 μstrain? **[6 marks]**

(c) Determine the output voltage from the Wheatstone bridge in figure Q2 below when the gauge is subjected to a strain that results in it's resistance increasing to 120.4 Ω. **[10 marks]**

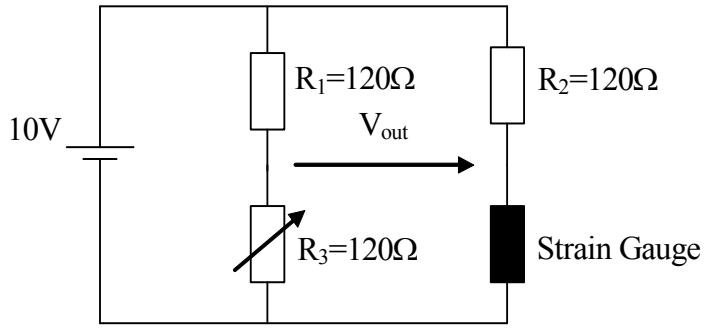

Figure Q2

What is the purpose in making in making R_3 a variable resistor? **[2 marks]**

Q.3

An industrial water storage tank is fitted with a pressure sensor on the side of the tank near it's base. The tank has a diameter of 5 m and height of 4 m. The pressure sensor is installed 0.3 m above the base of the tank. An overflow nozzle is fitted on the side of the tank at a distance of 0.3 m from the top.

(a) What are the gauge and absolute pressures at the pressure sensor when the tank is filled to overflow?

Note: The density of water is 1000 kg/m^3.
Atmospheric pressure = 101,325 Pa

[6 marks]

(b) The pressure sensor contains a diaphragm with 4 piezoresistors connected in a Wheatstone bridge arrangement. It has a sensitivity of 30 mV/bar. This is connected to an instrumentation amplifier as shown in the circuit in Figure Q3 below:

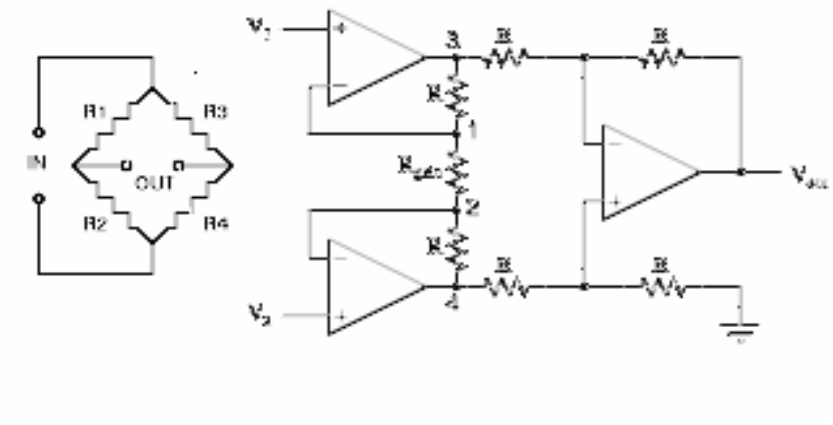

Figure Q3

(i) Explain the operation of the diaphragm type sensor including the circuit diagram. **[8 marks]**

(ii) Calculate the gain required for the instrumentation amplifier if the output from the circuit is to be 10 V when the pressure at the sensor is 0.33 bar. You can assume that the Wheatstone bridge is balanced when the tank is empty. **[6 marks]**

(iii) What size resistors should be used in the instrumentation amplifier to give this gain? **[10 marks]**

Q.4

(a) Derive the following equation that relates velocity to pressure drop for the Pitot Tube. **[8 marks]**

$$v = \sqrt{\frac{2(P_1 - P_2)}{\rho}}$$

Note: Bernoulli's equation for fluid flow is:

$$P_1 + \rho g h_1 + \frac{\rho v_1^2}{2} = P_2 + \rho g h_2 + \frac{\rho v_2^2}{2}$$

(b) Explain with the aid of a sketch the principle of operation of a Pitot tube flow meter. **[8 marks]**

(c) A Pitot tube flowmeter is installed in cooling tower water return pipe that has a diameter of 300 mm. A differential pressure reading of 10 mbar is obtained from the sensor.

Determine the following:

(i) velocity of water in the pipe, **[6 marks]**

(ii) volumetric flowrate of water in the pipe, **[4 marks]**

(iii) and mass flowrate of water in the pipe. **[4 marks]**

Note: The density of water is 1000 kg/m^3.