

(Code for Paper) S009/

DUBLIN INSTITUTE OF TECHNOLOGY  
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**Bachelor of Engineering Technology in Control  
and Automation Systems**

**Bachelor of Engineering Technology in Electrical  
Energy Systems**

Year 2

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**SEMESTER II EXAMINATIONS 2009-2010**

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**INSTRUMENTATION**

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**DAY / May 2010      TIME**

Question 1 is compulsory (40 marks)  
Attempt any two other questions (30 marks per question)

<b>The following should be available for this examination:</b>
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Motorola MPX4115A pressure sensor datasheet Honeywell 24PCEFA2G pressure sensor datasheet
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**Q1.** (a) Compare any THREE of the following temperature transducers:

Thermistor  
Thermocouple  
Pt100 resistance temperature detector  
LM35 (from National Semiconductor)

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. Also, list one advantage and disadvantage for each device.

**(10 Marks)**

(b) A mercury in glass thermometer has a time constant of 10 seconds. It is placed in a beaker of water at a temperature of 25 °C and allowed to reach steady state before it is suddenly moved to a bath of boiling water at 100 °C.

What temperature will it read 10 seconds after the change is made and how long will it take to reach its new steady state temperature of 100 °C?

Use a sketch to illustrate how the height of mercury in the thermometer changes over time until steady state is reached.

**(10 Marks)**

(c) In terms of instrumentation, explain what is meant by each of the following terms:

Span,  
Offset,  
Resolution,  
Accuracy,  
Drift

**(10 Marks)**

(d) A weather station is fitted with a MPX4115A pressure sensor to measure air pressure. The data sheet for this sensor is supplied.

(i) What are the input and output ranges of this sensor?

**(4 Marks)**

(ii) Calculate the voltage outputs that will be produced by the MPX4115A for input air pressures of 940 and 1060 hPa.

**(6 Marks)**

**Q2.** A temperature measurement system, consisting of a Pt100 connected into a Wheatstone bridge is required to measure a temperature range of -10 to +50 °C and produce a corresponding voltage output range of 0 to 200 mV. The Wheatstone bridge is connected to a 10V DC power supply.

(i) Draw a fully labelled circuit diagram of the Wheatstone bridge. Choose a location for the Pt100 and identify the location and sign of output voltage points. Explain and justify your choice of locations.  
**(10 Marks)**

(ii) Calculate the sizes of the remaining three resistors in the bridge to satisfy the design requirements listed above.  
**(16 Marks)**

(iii) Briefly discuss how you would modify the design of the Wheatstone bridge to increase its sensitivity and explain the effect this will have on linearity.  
**(4 Marks)**

The relationship between resistance and temperature for the Pt100 is given by the following equation:

$$R = R_0(1 + \alpha T)$$

Where  $R$  is the resistance of the thermometer at any temperature  $T$ .

$R_0 = 100 \Omega$ , is its resistance at 0 °C

$\alpha = 0.00385 \text{ } ^\circ\text{C}^{-1}$ , is the temperature coefficient of resistance of the thermometer.

### Q.3

An industrial water storage tank is fitted with a Honeywell 24PC series pressure sensor on the side of the tank at its base. The tank has a diameter of 6 m and has a maximum height of water of 5 m. The pressure sensor contains a diaphragm with 4 piezoresistors connected in a Wheatstone bridge arrangement with a sensitivity of 10 mV/psi. An amplifier is used to amplify this signal to give a 0 to 5 V output range corresponding to an input level range of 0 to 5 m.

The datasheet for this range of pressure sensors is provided.

(a) Describe a piezoresistor. **[4 marks]**

(b) What are the gauge and absolute pressures in Pa and psi at the base of the tank when it is full of water?

Note: The density of water is  $1000 \text{ kg/m}^3$ ,  
Atmospheric pressure = 101,325 Pa or 14.7 psi,  
1 psi = 6895 Pa = 0.70 m H<sub>2</sub>O.

**[6 marks]**

(c) Select an appropriate sensor from the 24PC range for this application. **[4 marks]**

(c) Select a suitable amplifier for this application and draw a circuit diagram of the amplifier. Include the Wheatstone bridge arrangement in the pressure sensor and clearly indicate how it is connected to the amplifier.

Determine the values of the amplifier resistors to give an output range of 0 to 5 V for a water level input range of 0 to 5 m. **[16 marks]**

**Q.4**

- (a) Explain the principle of operation of a cup anemometer connected to a direct current generator to measure wind speed and describe how the output changes with a change in input.
- (b) The voltage output signal from a wind speed sensor is connected to the analogue input card on a programmable logic controller (PLC) that gives converts a 0 to 10 V input to 0 to 2000 Counts. The signal is passed through to a web page where the wind speed is displayed in engineering units. The range of the wind speed measurement system is 0 to 55 m/s.

**[6 marks]**

The wind speed sensor was tested and the following data were obtained:

Wind speed (m/s)	Vout (V)
0	0.00
2	0.35
4	0.65
6	1.10
8	1.42
10	1.85
12	2.17
14	2.54

- (i) Plot these results and determine the following:

Sensitivity,  
Offset,  
Maximum non linearity.

**[12 marks]**

- (ii) Draw a block diagram of this measurement system showing a block for each component, units and ranges of the input to and output from each block, and the sensitivity of each block.

**[12 marks]**