

## **WARNING**

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# Charles Darwin University

Final Examination

Family Name					
Given Name/s					
Student Number					
Teaching Period	Semester 2, 2018				

<b>ENG342 – Instrumentation and Control</b>	<b>DURATION</b>	
	Reading Time:	<b>10 minutes</b>
	Writing Time:	<b>180 minutes</b>
<b>INSTRUCTIONS TO CANDIDATES</b>		
<p>Please ensure that your name and student number are clearly indicated on your Answer Sheet and at the top of this examination paper.</p> <p>Answer ALL 5 questions.          Each Question carries 20 marks. Marks for each sub-question are indicated.          All questions should be answered in the Answer Booklet provided.</p>		
<b>EXAM CONDITIONS</b>		
<p><u>You may begin writing from the commencement of the examination session.</u> The reading time indicated above is provided as a guide only.</p>		
This is a RESTRICTED OPEN BOOK examination		
Any non-programmable calculator is permitted		
One A4 sheet of handwritten double-sided notes permitted		
No dictionaries are permitted		
<b>ADDITIONAL AUTHORISED MATERIALS</b>	<b>EXAMINATION MATERIALS TO BE SUPPLIED</b>	
No additional printed material is permitted	1 x 16 Page Book Formula Sheet/s	

**THIS EXAMINATION IS PRINTED  
DOUBLE-SIDED.**

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LEFT BLANK.**

**Total No of Marks: 100**

All questions should be answered in the Answer Booklet provided.  
ANSWER ALL 5 QUESTIONS.

Each Question carries 20 marks. Marks for each sub-question are indicated.

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**Question 1**

- (a) Describe the operating principle on which piezoelectric pressure sensors are based. With the aid of a diagram, also explain how the piezoelectric material in the sensor can be protected from the material in the process stream when measuring the pressure.

(Marks: 10)

- (b) An orifice plate DP flowmeter was originally used for measuring the volumetric flowrate  $Q$  of an incompressible liquid flowing through a pipe of 10 cm diameter. The volumetric flow rate is measured through the use of the following equation:

$$Q = Ch^{\frac{1}{2}}$$

where  $C = 200 \text{ cm}^{5/2}\text{s}^{-1}$  and  $h$  is the pressure head in cm  $\text{H}_2\text{O}$ . The diameter of the orifice plate is 4 cm. If the original pipe was replaced with a 12 cm diameter pipe and the same orifice plate DP flowmeter was installed onto this pipe, determine the value of  $C$  that should be used for measuring the flowrate through the new pipe.

(Marks: 10)

**Question 2**

- (a) What are the possible sources of error if a wet leg design is used for measuring level with a DP cell? Suggest ways to account for or minimise this error.

(Marks: 5)

- (b) A displacer level gauge consisting of a cylindrical steel rod is to be designed for measuring the level of a liquid in a process vessel. 100% level corresponds to a liquid height of 2 m in the vessel. At 100% level the displacer will be fully submerged in the liquid generating a buoyancy force of 196 N. Determine:

- (i) The diameter of the displacer  
(ii) Apparent weight of the displacer when the liquid level is 50%

Density of steel is  $8000 \text{ kg/m}^3$ , density of water is  $1000 \text{ kg/m}^3$  and specific gravity of liquid is 0.78.

(Marks: 15)

### Question 3

- (a) A DP cell transmitter is installed as shown in the figure below. Determine the calibration span points for this system for which the output current signal range is 4 – 20 mA.

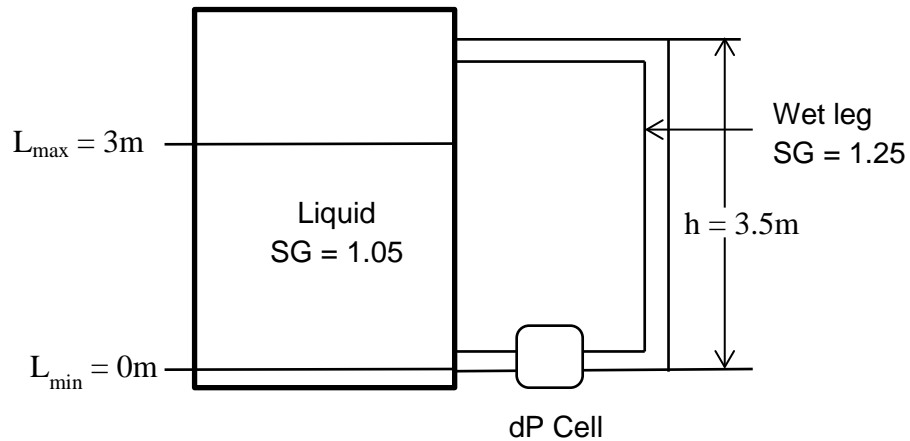


Figure 1. Wet leg dP cell configuration for measuring liquid pressure head.

(Marks: 10)

- (b) A strain gauge with a nominal wire resistance of  $150 \Omega$  is used to measure the gauge pressure of a gas in a vessel. The strain gauge is calibrated so that the gain  $\frac{\Delta R}{\Delta P} = 0.01 \Omega/kPa$ . Calculate the change in wire resistance of the gauge and the change in vessel pressure when the strain is  $800 \mu m/m$ .

(Marks: 10)

### Question 4

- (a) A differential pressure flowmeter is installed in a pipe to measure the volumetric flowrate of a liquid with an accuracy of 2%. The flowmeter has a turn down ratio of 3:1. The DP cell used for this purpose has a 3 cm measurement error. Determine the turndown ratio of the DP cell that would be needed for the flowmeter to achieve the stated requirements.

(Marks: 10)

- (b) An ultrasonic flowmeter is used to measure the flowrate of a liquid flowing through a cylindrical pipe 0.1 m in diameter. The density of the liquid is  $950 \text{ kg/m}^3$ . The beat frequency is 40 cps, the angle between transmitters and receivers is  $45^\circ$  and the sound path is 15 cm. Calculate the fluid velocity, volumetric flowrate and mass flowrate.

(Marks: 10)

### Question 5

(a) Describe the operating principle of a pH meter. Draw a schematic diagram and label the various components.

(Marks: 10)

(b) List the advantages and limitations of turbine flowmeters.

(Marks: 10)