X

Unit 9 - Week 8

Week 8 Assignment on Pressure and low-pressure Measurements

1) *2 points*

A well-type manometer, shown in Figure 1, is used to measure differential air pressure ($P_1 - P$ The manometric liquid has density (ρ_m) of 1000 kg/m^3. The ratio of well diameter (α_w) to tu diameter (α_t) is 10. If a scale of simple U-tube manometer is used for this system, then find o magnitude of percentage error in measurement. (Assume, density of the fluid over manomet fluid << ρ_m)

(In well-type manometer, change in liquid height ('h', as in Figure 1) due to pressure differen in the tube is only measured. That will be the source of error.)

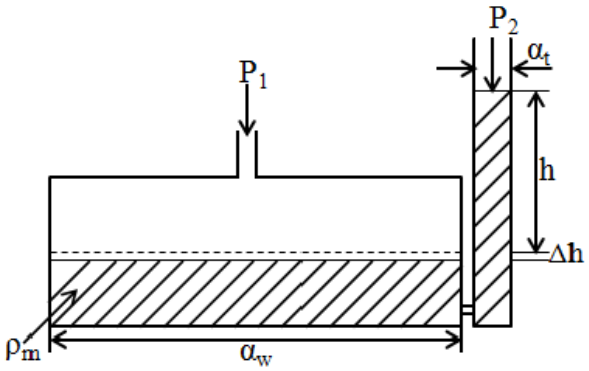

Figure 1

(**Hint:** For a U-tube manometer, $P_1 - P_2 = h \times \rho m \times g$. Find out the expression of ($P_1 - P_2$) for we type manometer based on α_w and α_t. Then find the error.)

- a) 0.1 %
- b) 1 %
- c) 10 %
- d) None of these

Accepted Answers:
b) 1 %

2) *3 points*

The tube of the above well-type manometer is inclined at an angle 30° with vertical axis. Fin out the percentage change (increase or decrease) in 'h' (length of liquid in the tube) compare to a well-type manometer for measuring same differential pressure.

a) 13.4 %
b) 14.3 %
c) 15.5 %
d) 16.3 %

Accepted Answers:
c) 15.5 %

3) **3 points**

A pressure gauge is designed using a diaphragm and LVDT arrangement. The LVDT core i connected to the centre point of deflection of the diaphragm. The diaphragm has the followin characteristics: Poisson's ratio (v): 0.25, density of diaphragm material: 7000 kg/m^3, Modulus c elasticity for the diaphragm material (E) = 2×10^{11} Pa, radius of diaphragm (R) 10 cm. Calculat diaphragm thickness 't' such that non-linearity is 1 %. Assume, maximum pressure is 1 MPa.

a) 4.2 mm
b) 8.5 mm
c) 4.97 mm
d) None of these

Accepted Answers:
c) 4.97 mm

4) **3 points**

In problem 3, calculate the resolution of the system, if the LVDT has sensitivity of 0.5 V/mm an the output is measured using a millivoltmeter, capable of measuring minimum of 0.1 mV.

a) 1385.4 N/m^2
b) 385.1 N/m^2
c) 168.9 N/m^2
d) 281.8 N/m^2

Accepted Answers:
d) 281.8 N/m^2

5) **5 points**

In the Figure 2, four strain gauges are placed over a diaphragm. The diaphragm has t following specifications:

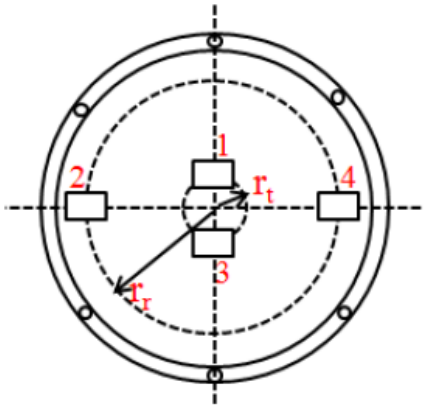

Figure 2

r_t = 0.02 m, r_r = 0.08 m, D = 0.2 m, Poisson's ratio 0.3, E_{ex} = 10 V, Gauge resistance = 100 Ω, Gau factor (λ) = 2, diaphragm density = 7000 kg/r Modulus of elasticity for the diaphragm material = 2×10^{11} Pa, sensitivity = 10^{-4} mV/Pa.

Find diaphragm thickness 't'.

(**Hint:** (i) Evaluate expression for radial stress tangential stress S_t for both r_r and r_t. (ii) Evalua expression for radial strain (ε_r) and tangential str (ε_t). (iii) Evaluate expression for resistances of t four strain gauges. (iv) Finally calculate 't' from output voltage e_o of Wheatstone bridge, if t strain gauges are connected in the bridge.)

a) 12.7 mm
b) 1.27 mm

c) 2.54 mm
d) 1.79 mm

Accepted Answers:
d) 1.79 mm

6) **2 points**

A McLeod gauge has a bulb of volume 100 cm^3. The diameter of the capillary is 1 mm. Calculat the gauge pressure indicated by the capillary tube when a pressure of 100 µm of Hg is applied.

a) 0.08 m
b) 0.113 m
c) 0.183 m
d) None of these

Accepted Answers:
b) 0.113 m

7) **2 points**

For an Ionization gauge, pressure of the gas in the vessel is 10^{-11} torr and sensitivity is 50/torr. 0.01 µA ion current is generated in the vessel, calculate the electron current.

a) 20 A
b) 20 mA
c) 2 A
d) 200 mA

Accepted Answers:
a) 20 A

8) **4 points**

The following bridge circuit is used for measurement of low pressure by Pirani gaug Resistance of the filament (R_P) changes with applied pressure, following the relation, R_P $R_O \times (1-k \times P)$, where k is a sensitivity constant, P is applied pressure, R_O is nominal resistan under no pressure. (Null-deflection measurement done using deflection-galvanometer 'D')

Assume range of P is 10^{-3} to 1 torr. Find (i) maximum value of k, if allowable nonlinearity in R' P relation is 1 %. Also find (ii) value of R' for measuring maximum pressure, using the abo value of k (Assume, R_O = 1 kΩ).

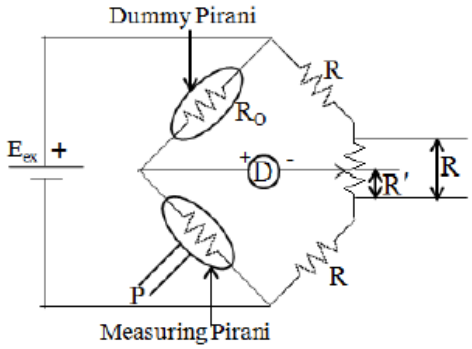

Figure 3

a) (i) 0.02/Torr; (ii) 485 Ω
b) (i) 0.01/Torr; (ii) 4850 Ω
c) (i) 0.01/Torr; (ii) 485 Ω
d) None of these

Accepted Answers:
a) (i) 0.02/Torr; (ii) 485 Ω

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