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Home Work # 3

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EET 3120 Sensors & Instruments

**Part - I**

**Pascal to inch of water (Pa to inH2O):**

It is defined as the pressure exerted by a column of water of 1 inch in height at defined conditions. For example, 39 °F (4 °C) at the standard acceleration of gravity; 1 inAq is approximately equal to 249 Pascals at 0 °C.

InH2O Derivation:

The calculation below shows how the pressure unit Inches of Water Column (inH2O) is derived from SI Units.

Formula:

* Pressure = Force / Area
* Force = Mass x Acceleration
* Mass = Density x Volume
* Volume = Area x Height
* Acceleration = Distance / (Second x Second)

SI Units:

* Mass: Kilogram (kg)
* Length: Metre (m)
* Time: Second (s)
* Force: Newton (N)
* Pressure: Pascal (Pa)

Input Values:

* Density = Water Density at 4degC = 1000 kg/m³
* Area = 1 m²
* Height = 1 in = 0.0254 m
* Acceleration = Standard Gravity = 9.80665 m/s²

Calculations:

* 1 inH2O Mass = 1000 kg/m³ x 1 m² x 0.0254 m = 25.4 kg
* 1 inH2O Force = 25.4 kg x 9.80665 m/s² = 249.08891 N

1 inH2O Pressure = 249.08891 N / 1 m² = 249.08891 Pa

References:

* http://www.sensorsone.uk/inh2o-inches-water-column-4-deg-c-pressure-unit/
* http://en.wikipedia.org/wiki/Inch\_of\_water

**Part –II**

1. **A metallic wire embedded in a strain gage is 4.2 cm long with a diameter of 0.07 mm. The gage is mounted on the upper surface of a cantilever beam to sense strain. Before strain is applied, the initial resistance of the wire is 64 Ω. Strain is applied to the beam, stretching the wire 0.1mm, and changing its electrical resistivity by 2 × 10-8 Ωm. If Poisson’s ratio for the wire is 0.342. Find the change in resistance in the wire due to the strain to the nearest hundredth ohm.**

L **=** 4.2cm, d **=** 0.07mm, R **=** 64Ω, dL **=** 0.1mm, dρ **=** 2 \*10-8Ωm,

v **=** 0.342

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1. **A metallic strain gage has a resistance of 350 Ω at zero strain. It is mounted on a 1-m-long column. The column is strained axially by 1 cm. Determine a typical resistance (in Ω) of such a gage under its strained condition.**

R = 350 Ω, Ge = 2, L = 1m or 0.01cm, ΔL = 1cm

1. **A resistive accelerometer is fabricated with an internal mass of 1 gm and 2-mm-long strain gauges, each having a spring constant of 300 N/m. When the gages are strained by 2% in a direction parallel to the strain gages, determine (a) the acceleration (in m/s2) in the direction parallel to the strain gages and (b) the acceleration (in m/s2) in the direction perpendicular to the strain gages.**

m = 1g or 0.001kg, L = 2mm or 0.002m, k = 300N/m

1. ∆L = 0.002 \* 2/100 = m

 = \* 300/0.001 = 12 m/s2

1. ∆L = 0.002 \* 98/100 = 0.00196m

 = 0.00196 \* 300/0.001 = 588 m/s2

1. **A variable-capacitance relative humidity sensor has a capacitance of 10 µF at 10% relative humidity and 35µF at 50% relative humidity. Determent (a) its capacitance at 78% relative humidity, (b) its capacitance at 0% relative humidity, and (c) its sensitivity.**

C = 10 µ F at 10 % RH, C = 35 µ F at 50 % RH

Relative Humidity: C = A + B \* RH

10µF =A + 10% B

35µF =A + 50% B

35-10 = (A+B\*50%) - (A + B \* 10%)

35-10 = A+B\*0.5 – A – B\*0.1

25 = 0.5B – 0.1B

B = 25/0.4= 62.5

10µF = A + B \* 10%

10 = A + (62.5\*.01)

10 = A + 6.25

A = 10 – 6.25

A = 3.75

1. Capacitance at 78% Humidity:

C = A + B \* RH

C = 3.75 + 62.5 \* 78%

C = 52.5 µ F

1. Capacitance at 0% Humidity:

C = A + B \* RH

C = 3.75 + 62.5 \* 0%

C = 3.*75* µ F

1. **The Strouhal number, St , depends only on the Reynolds number, Re .For a cylinder in cross-ﬂow, St is constant and equals 0.21 for 6000 ≤ Re ≤ 60 000. For a vortex shedding ﬂowmeter using a 1-cm-diameter cylindrical element placed in water under standard conditions in this Re range, determine the range of shedding frequencies (in Hz).**

µ = 8.94\*10-4N/m2, ρ = 1Kg/m3

The range of shedding frequency is : 1792Hz ≤ fs ≤ 17927.85Hz