

NEW YORK City College of Technology

Electrical and Telecommunication Engineering Technology Department

Assignment # 3

EET 3120 Sensors and Instruments

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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.

Length of wire (L): 4.2cm = 42mm; Diameter (d): 0.07mm

Resistance (R): 64Ω; $∆$L = 0.1mm

Resistivity (dρ): = $2\*10^{-8}$ Poissons Ratio (v): 0.342

$$\frac{dR}{R}=\left(1+2v\right)εL+\frac{dρ}{ρ}$$

$$εL=\frac{∆L}{L}=\frac{0.1mm}{42mm}=0.00238$$

$$A=πr^{2}=0.035mm^{2}\*π=0.0038mm$$

$ρ=\frac{RA}{L}=\frac{64Ω\*\left(0.0038mm^{2}\right)}{42mm}=5.79\*10^{-3}Ωmm$.

$$\frac{dR}{R}=\left(1+2\left(0.342\right)\right)\*0.00238+\left(\frac{2\*10^{-8}Ωm}{5.79\*10^{-3}Ωm}\right)=0.004007m=4.007\*10^{-3}Ωm$$

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= 350Ω at no strain L = 1m = 1000mm (ΔL) = 1cm = 10mm

Ge =2 $Ge=\frac{∆R/R}{∆L/L}$ $R=Ge\*\frac{ΔL}{L}\*R=2\*\frac{10mm}{1000mm}\*350Ω=7Ω$.

Total Resistance = 350 + 7 = 357Ω

1. A resistive accelerometer is fabricated with an internal mass of 1 gm and 2-mm-long strain gages, 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/s 2) in the direction perpendicular to the strain gages.

(m): 1g (L): 2mm (k): 300N/m

$$a=ΔL\*\frac{k}{m}$$

$∆L=\left(\frac{m}{k}\right)a, a=∆L\*\frac{k}{m}$ =$ε\*L=\frac{2}{100}\*2mm=0.04mm$ = 0.00004mm

$$a=0.00004mm\*\frac{300\frac{N}{m}}{0.001kgm}=12\frac{m}{s^{2}}$$

$$ΔL=ε\*L=\frac{98}{100}\*2mm=1.96mm /0.00196m$$

$$a= ΔL\*\frac{k}{m}=0.00196m\*\frac{300\frac{N}{m}}{0.001Kgm}=588\frac{m}{s^{2}}$$

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

$10\%$ = $10=A+0.1B$………………… (1)

$50\%$ = $35=A+0.5B$………………… (2) Subtract equation 1 from equation 2

$ =25=0.4B$…………………....... (3)

Divide both sides by 0.4 to get B in equation 3 = $ B=\frac{25}{0.4}=62.5$

Substitute B into equation [2] and solve for A

$$35=A-62.5(0.5)$$

$$35=A-31.25$$

35-31.25 = 3.75 = A

Capacitance at 78% = 0.78

$$C=A+B\*RH=3.75μF+62.5μF\*0.78=52.5μF$$

Capacitance at 0%:

$$C=A+B\*RH=3.75μF+62.5μF\*0\%=3.75μF$$

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).

Density of water (ρ): $1\frac{kg}{m^{3}}$ Water viscosity (u): $8.94\*10^{-4}\frac{N}{m^{2}}$

dc= 1cm = 0.01m St= 0.21 for 6000≤ Re ≤60000

Re = $\frac{ρUdc}{u}$ U = $\frac{Re\*U}{p\*dc}$ = $\frac{6000\*8.94\*10^{-4}}{0.01m}$ **= 536.4 m/s**

St = $\frac{2πfsD}{u}$ fs = $\frac{St\*u}{2π\*D}$ = $\frac{0.21\*536.4}{2\*3.14\*0.01}$ = **1793.69 Hz**