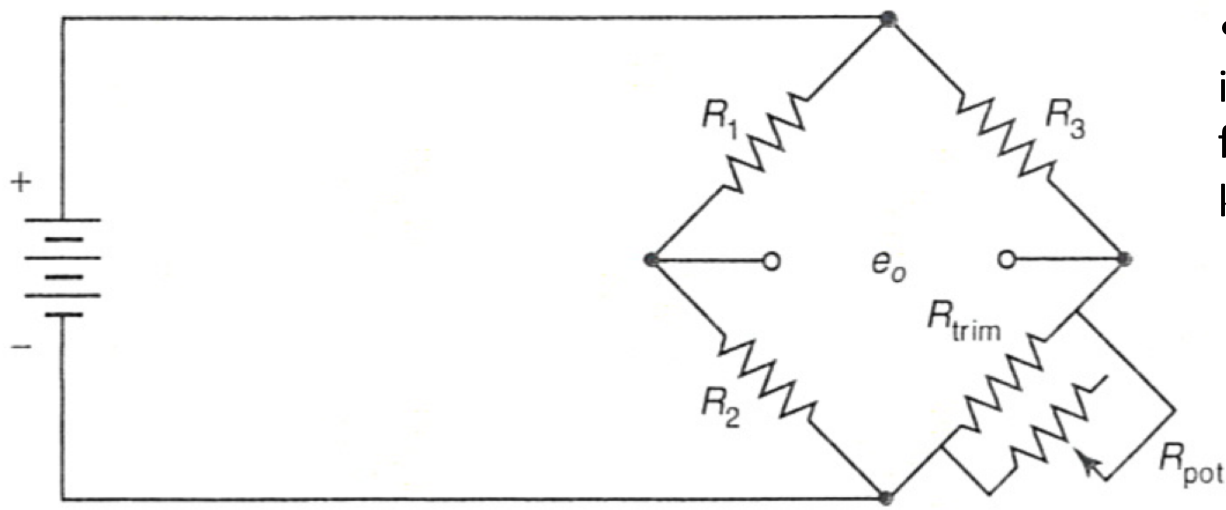
Homework ~~5~~ 6

Figure below shows a shunt balance arrangement for nulling a Wheatstone bridge. Suppose

1) that $R_1 = R_3 = 120\ \Omega$, $R_{trim} = 127\ \Omega$, and $R_{pot} = 10\ k\Omega$. What is the maximum value of R_2 for which the bridge can be brought into balance by adjusting R_{pot}? What would be the maximum value if $R_1 = 119\ \Omega$ and $R_3 = 121\ \Omega$?



- Assume Pot is fully variable from 0 to 10 kΩ

Circuit for Problem

Part 1 Solution

Let $R_4 = R_{trim}$ $\quad R_{pot} = \left(\frac{1}{R_{trim}} + \frac{1}{R_{pot}}\right)^{-1}$

At balance (Eqn 7.14a)

$$\frac{R_1}{R_3} = \frac{R_2}{R_4} = R_2\left(\frac{1}{R_{trim}} + \frac{1}{R_{pot}}\right) \qquad R_1 = R_3$$

$$R_2 = \left(\frac{1}{R_{trim}} + \frac{1}{R_{pot}}\right)^{-1}$$

$$R_2 \leq \left(\frac{1}{127} + \frac{1}{10{,}000}\right)^{-1} = 125.4\ \Omega$$

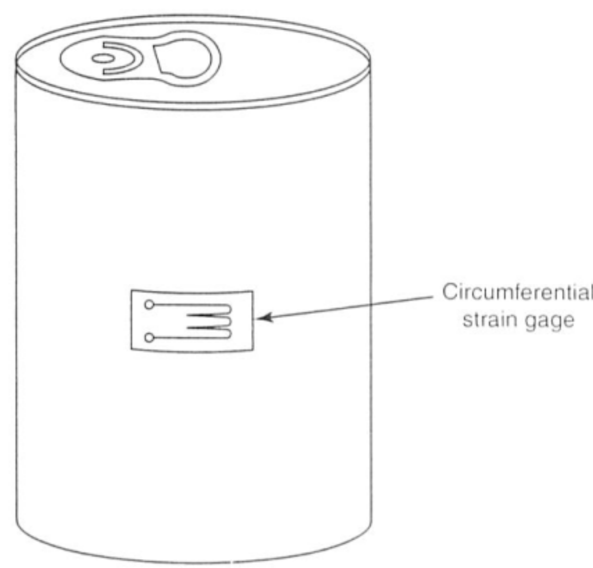
If $R_1 = 119\ \Omega$ and $R_3 = 121\ \Omega$

$$R_2 \leq \frac{119}{121}\left(\frac{1}{127} + \frac{1}{10{,}000}\right)^{-1} = 123.3\ \Omega$$

Homework 5

2) . A mechanical engineering student wishes to determine the internal pressure existing in a diet soda can. She proceeds by carefully mounting a single-element strain gage aligned in circumferential direction on the center of the soda can, as shown in Figure Below After wiring the gage properly to a commercial strain indicator, she "pops" the flip-top lid, which relieves the internal pressure. She notes that the strain indicator reads $-400\ \mu$-strain. If the can body is made of aluminum with a thickness of 0.010 in. and a diameter of 2.25 in., what was the original internal pressure of the sealed can?

Assume $E = 10\ ksi\ (6.89\ GPa)$
assume $v = 0.5$



Part 2 Solution

σ_h = circumferential

σ_L = longitudinal

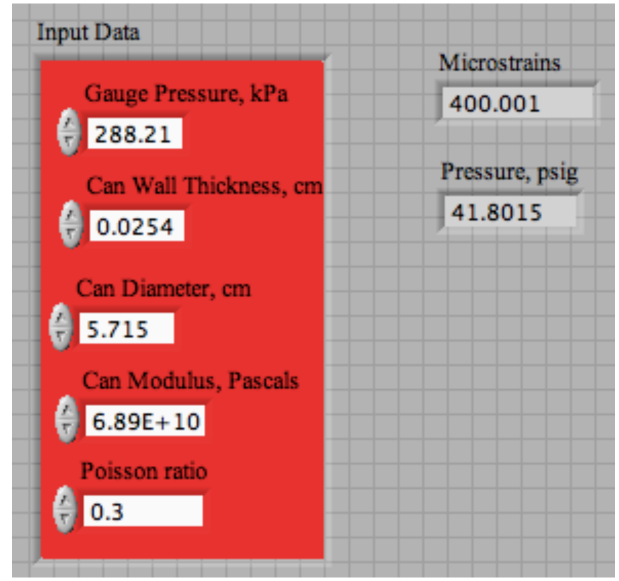
Assume $\sigma_h = 2\sigma_L$

$$\epsilon_h = \frac{1}{E}(\sigma_h - \nu\sigma_L) = \frac{\sigma_h}{E}(1 - .5\nu)$$

$$\sigma_h = \frac{E\epsilon_h}{1-.5\nu} = \frac{10\times10^6 \times 400\times10^{-6}}{1-.5(.3)} = \underline{4706}\ \text{psi}$$

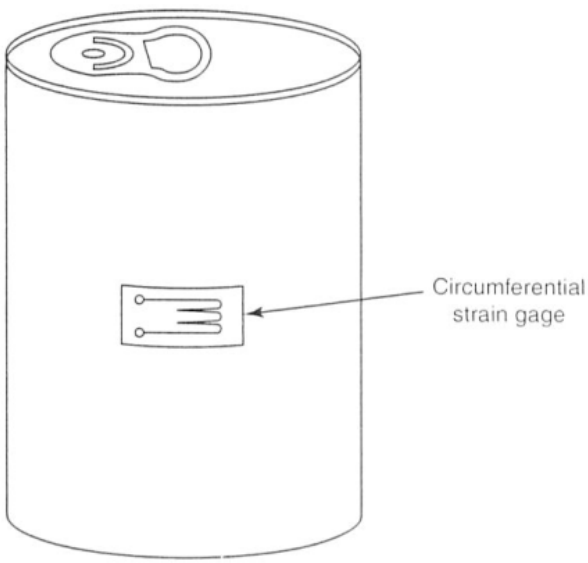
$$\sigma_h = \frac{PD}{2t} \qquad P = \frac{2t\sigma_h}{D} = \frac{4706\times2\times.01}{2.25}$$

$$\underline{P = 42}\ \text{psi}$$ **(289 kPa)**



Homework 5

3) Another student also performed the experiment described in Previous problem Unfortunately, he did not have access to the commercial strain indicator, and instead he had to construct his own Wheatstone bridge circuit. His strain gage had an initial resistance of 120 Ω and a gage factor of 2.05. He used the single gage as one leg of the bridge, which he powered with a 6-V battery. The bridge output was fed to an amplifier (gain = 1000), and the amp's output was read by a voltmeter. The student balanced the bridge circuit before he opened the can. After the can was opened, the voltmeter indicated a voltage of −1.57 V. What was the measured strain for his can?



Part 3 Solution

$$V_{out} = G_{amplifier} \cdot \frac{V_{ex} \cdot G_F \cdot \varepsilon}{4 + 2 \cdot G_F \cdot \varepsilon}$$

$$\rightarrow \left(4 + 2 \cdot G_F \cdot \varepsilon\right) \cdot V_{out} = G_{amplifier} \cdot V_{ex} \cdot G_F \cdot \varepsilon$$

$$\left(G_{amplifier} \cdot V_{ex} \cdot G_F - 2 \cdot G_F \cdot V_{out}\right) \cdot \varepsilon = 4 \cdot V_{out}$$

$$\boxed{\rightarrow \varepsilon = \frac{4 \cdot V_{out}}{\left(G_{amplifier} \cdot V_{ex} \cdot G_F - 2 \cdot G_F \cdot V_{out}\right)}}$$

$$\frac{4\,(-1.57)}{1000 \cdot 6 \cdot 2.05 - 2 \cdot 2.05\,(-1.57)}\,10^6 = -510.302$$ **Microstrains**