Biomedical Instrumentation Spring, 2003

Solutions to Problem Set 4

1. The output voltage of the circuit is

$$v = \frac{R_s}{1{,}000\Omega + R_s} 1.5V$$ where R_s is the resistance of the strain gauge

We can find the change in R_s by using the definition of the gauge factor, γ

$$\gamma = \frac{\Delta R / R}{\Delta L / L} \quad \Rightarrow \quad \Delta R = \frac{R\gamma\Delta L}{L} = \frac{50\Omega \bullet 2 \bullet \Delta L}{30cm} = 3.33\frac{\Omega}{cm}\Delta L$$

Then, we get R_s as $R_s = 50\ \Omega + 3.33\ \Delta L\ \Omega/cm$. Now to find the output voltage we get

$$v = \frac{50\Omega + 3.33\Delta L \,\Omega/cm}{1{,}050\Omega + 3.33\Delta L\,\Omega/cm} 1.5V \qquad (1)$$

For zero strain, $\Delta L=0$, so v becomes

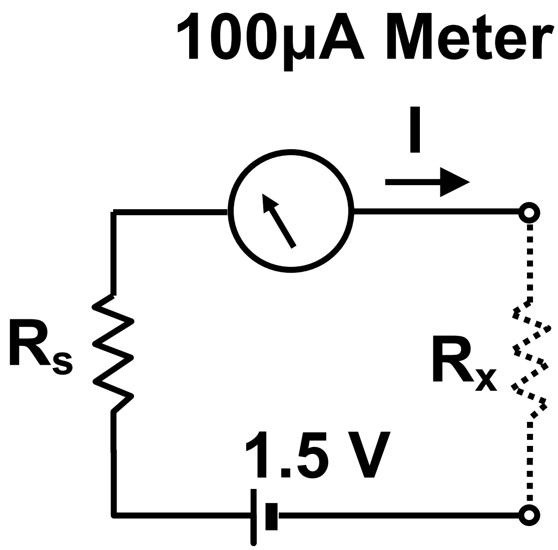
$$v = \frac{50\Omega}{1{,}050\Omega} 1.5V = 0.0714V$$

This is the offset voltage. We can get the voltages at other strains by following the same procedure and plugging in different displacements for ΔL in the range of 0 – 10 cm. and plotting the results. This is best done with a spreadsheet program such as Excel. The slope of the curve can be found by taking the derivative of v with respect to ΔL for equation (1) above. This equation shows that the slope will be a function of ΔL, but we can approximate it by neglecting the ΔL term in the denominator, since it is small with respect to the 1,050 Ω resistance in the denominator. Thus equation (1) can simplify to

$$v = \frac{50\Omega + 3.33\Delta.}{1{,}050\Omega} 1.5V = 0.0714V + 0.00476\Delta L \,V/cm$$

2. Do not answer this problem for it is the same as problem 3 of problem set 3, sorry.

3. The circuit for the series ohmmeter is shown. When R_x is zero, I=100 µA, so we can find the total resistance in the circuit from Ohm's Law



$$R = \frac{E}{I} = \frac{1.5V}{100\mu 0} = 15{,}000\Omega$$

This resistance is the series combination of the meter resistance and R_s, so we can find R_s by

$R = R_{meter} + R_s$

Therefore

$R_s = 15{,}000\ \Omega - 150\ \Omega = 14{,}850\ \Omega$ or in other words, the meter resistance is not very important in this case.

To find the meter reading (current) as a function of R_x we again apply Ohm's Law

$$I = \frac{E}{R_{total}} = \frac{1.5V}{15{,}000\Omega + R_x}$$

Then we can create a spread sheet with several selected resistance values and the resulting current in the meter. We can then use the spread sheet to plot the results. It is seen that the relationship between meter reading and resistance is non-linear.