1. For elongation measurement, we want to achieve the accuracy of $10^{-6}$. For instance, for a 1-cm-long specimen, we need to detect its length change as small as $10^{-6}$ cm, i.e. 10 nm. Assume the gauge factor (GF) of a strain gauge is 2. By using a Wheatstone bridge, we measure the resistance change of the strain gauge ($dR/R$) to calculate the strain ($dL/L$). The smallest electrical resistance change that we can measure is $2 \times 10^{-4}$ Ohm. (a) How large does the initial resistance of strain gauge ($R$) need to be, so that our resistance measurement resolution ($2 \times 10^{-4}$ Ohm) is sufficient for the strain measurement? (b) If the strain gauge is made of constantan and the wire thickness is 0.025 mm, how long should the wire be? Hint: the resistivity of constantan is $49 \times 10^{-8}$ Ωm. (c) How can this wire be arranged to measure the average strain of a 1×1 cm small area?

2. List two common factors that may cause failure in strain measurement using strain gauges.

3. A Wheatstone bridge is formed by 1 strain gauge ($R_1$) and three resistors ($R_2$, $R_3$, and $R_4$). The initial resistance of all of them are the same 120 Ohm. The gauge factor of the strain gauge is 1.5. The applied voltage ($E_i$) on the Wheatstone bridge is 10 V. Initially, the bridge is balanced. After the strain gauge deforms, the bridge output ($E_0$) is measured as 10 mV. What is the strain?