Problem 5:

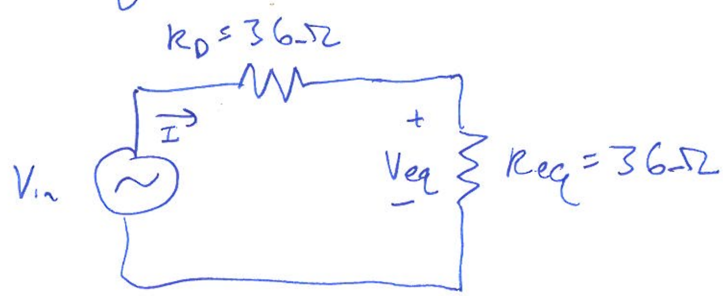
$$P = \frac{V^2}{R}$$

$$\rightarrow R_1 = R_2 = R_3 = R_4 = \frac{V^2}{P} = \frac{(120V)^2}{100W} = \boxed{144\,\Omega}$$

$$\rightarrow R_{eq} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4}} = \frac{1}{\frac{4}{144}} = \frac{144}{4} = \boxed{36\,\Omega}$$

Aside: BTW, when wiring resistors of equal value in parallel, the total equivalent resistance is the resistance of each resistor divided by the number of resistors in parallel.

$\rightarrow$ eq. circuit



$$I = \frac{V_{in}}{R_D + R_{eq}} = \frac{120V}{72\Omega} = 1.67A$$

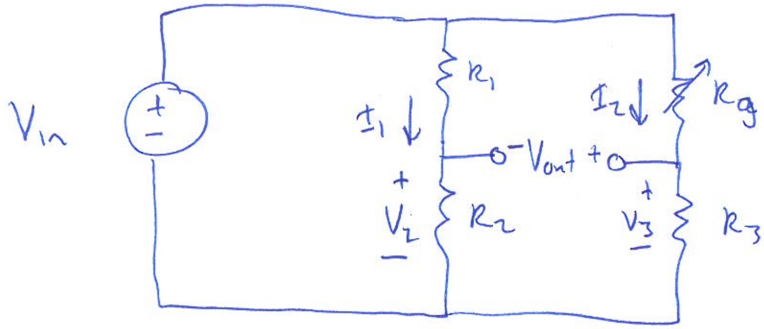
V_{eq} is the voltage applied to each light bulb:

$$V_{eq} = I \cdot R_{eq} = 1.67A \cdot 36\Omega = \boxed{60V}$$

$$\rightarrow P_{D_{max}} = I^2 R_D = (1.67A)^2 \cdot 36\,\Omega = \boxed{100W}$$

Problem 6:

→ To make less confusing (scary), redraw circuit with vertical branches:



→ Label currents through each branch as I_1 and I_2, and voltages across R_2 and R_3 as V_2 and V_3, respectively.

→ Similar to problem 3 now as the input voltage is applied across both branches.

→ The total resistance in each branch is,

$$R_{eq_1} = R_1 + R_2 \quad \text{and} \quad R_{eq_2} = R_g + R_3$$

→ Then the current in each branch is,

$$I_1 = \frac{V_{in}}{R_{eq_1}} = \frac{V_{in}}{R_1 + R_2}, \quad I_2 = \frac{V_{in}}{R_{eq_2}} = \frac{V_{in}}{R_g + R_3}$$

→ The voltage across R_2 is then:

$$V_2 = I_1 R_2 \qquad V_3 = I_2 R_3$$

→ Sub in equations for I_1 and I_2:

$$V_2 = \frac{R_2}{R_1 + R_2} V_{in} \qquad V_3 = \frac{R_3}{R_g + R_3} V_{in}$$

Problem 6 con't:

→ From the circuit, it is seen that Vout is the ~~voltage~~ differential voltage V_3 minus V_2:

$$V_{out} = V_3 - V_2$$

→ Sub in for V_3 and V_2:

$$V_{out} = \frac{R_3}{R_g + R_3} V_{in} - \frac{R_2}{R_1 + R_2} V_{in}$$ and combining terms

$$\boxed{V_{out} = \left(\frac{R_3}{R_g + R_3} - \frac{R_2}{R_1 + R_2} \right) V_{in}}$$

→ Now if $R_1 = R_2 = R_3 = R_g = R$ (all same resistance value)

then

$$\boxed{V_{out} = \left(\frac{R}{R+R} - \frac{R}{R+R} \right) V_{in} = 0 \cdot V_{in} = 0.}$$

Simple, but important. This means that when ~~bridge~~ the Wheatstone bridge (circuit) is balanced, i.e. all resistor values are the same, the output voltage will be 0. Thus, ~~by choosing~~ any fluctuations or offsets in V_{in} won't be ~~treated as~~ interpreted as strain on the material being measured.

→ If under stress $R_g = 3R$ then

$$V_{out} = \left(\frac{R}{3R+R} - \frac{R}{R+R} \right) V_{in} = \left(\frac{R}{4R} - \frac{R}{2R} \right) V_{in} \Rightarrow$$

$$\boxed{V_{out} = -\frac{1}{4} V_{in}}$$

So through circuit, strain is translated into a ~~[illegible]~~ voltage reading!