Pre-Lab 2

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1. Using the equation:

$$i = I_s\left(e^{v/(nV_T)} - 1\right)$$

and the given measurements, we may write:

$$10^{-3} = I_s\left(e^{.62/(n.025)} - 1\right)$$
$$10^{-2} = I_s\left(e^{.69/(n.025)} - 1\right)$$

Since the exponential is greater than 1, we may simplify to:

$$\frac{10^{-3}}{e^{24.8/n}} = I_s$$
$$\frac{10^{-2}}{e^{27.6/n}} = I_s$$

$$I_s = .001e^{-\frac{24.8}{n}}$$
$$I_s = .01e^{-\frac{27.6}{n}}$$

We can combine the two equations to solve for n and I_s:

$$.001e^{-\frac{24.8}{n}} = .01e^{-\frac{27.6}{n}}$$
$$e^{-\frac{24.8}{n}} = 10e^{-\frac{27.6}{n}}$$
$$e^{\frac{27.6-24.8}{n}} = 10$$
$$\frac{27.6-24.8}{n} = \ln(10)$$
$$n = \frac{2.8}{\ln(10)}$$

$$\boxed{n = 1.216}$$

We then plug this into the earlier equations to find I_s:

$$I_s = .001e^{-24.8/1.216}$$
$$\boxed{I_s = 1.3889 \cdot 10^{-12}[\text{A}]}$$

We can verify by using the second equation for I_s:

$$I_s = .01e^{-27.6/1.216}$$
$$\boxed{I_s = 1.3889 \cdot 10^{-12}[\text{A}]}$$

It is difficult to measure the current in a reverse bias mode, however, because the diode may reach breakdown voltage by increasing the reverse voltage.

2. Read through, no questions ✓

3. Taking the forward voltage of the LEDs as 2[V], we can make some relevant calculations, assuming each LED will form a "branch" consisting of a resistor, optional Zener diode, and the LED itself. First, using the maximum power, we can calculate the maximum current, starting with the first (red) LED to turn on, per the power specifications:

$$I_{max} = \frac{6 \cdot 10^{-2}}{.2} = .3[\text{A}]$$

Now, we find the resistance value, assuming the maximum input (24[V]):

$$R_{red} = \frac{24 - 2}{.3} = 73.33[\Omega]$$

We then cascade this with the next LED to turn on (yellow), and add in a Zener diode so that the LED turns on only after 8[V]. Using a Zener diode, we can calculate current using the maximum voltage input and power rating:

$$I^2_{max} = \frac{1}{6} = .1667[\text{A}]$$

We then find the resistor value:

$$R_{yel} = \frac{24 - 8}{.1667} = 96[\Omega]$$

Repeating the same process for green, but with a 15[V] Zener:

$$I^3_{max} = \frac{1}{15} = .0667[\text{A}]$$

$$R_{grn} = \frac{24 - 17}{.0667} = 105[\Omega]$$

Combining this together, we get:

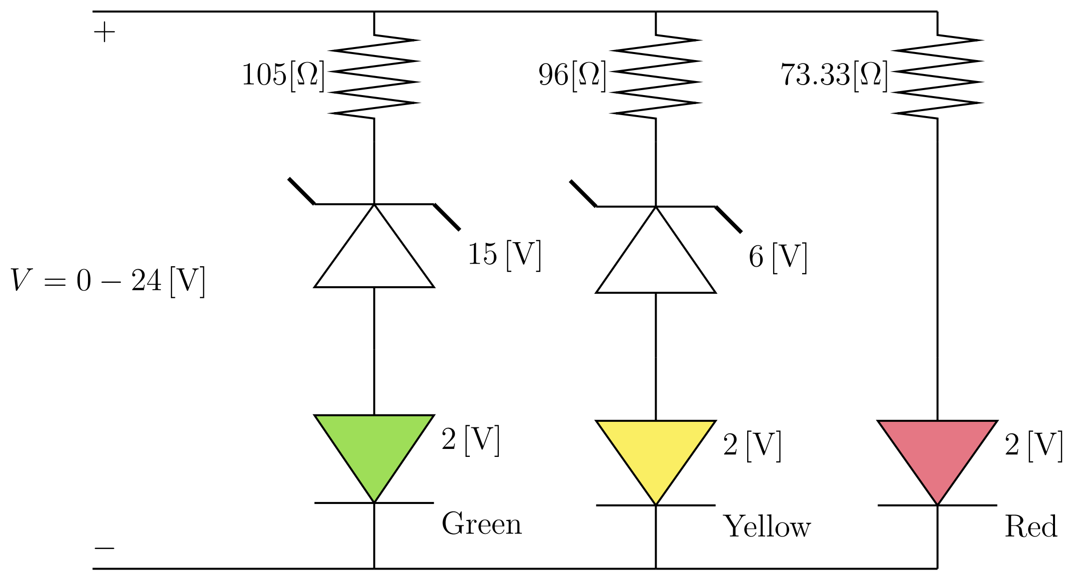

Figure 1: Final Configuration

Hypothetically, the circuit should be able to operate up to an input voltage of 24[V] before the LEDs or Zeners are at threat of burning out or being overloaded.