PHYS 235

(A) In-class exercise, Tuesday 1/22/19

I. Design a circuit to light a CEC 1432 miniature lamp as intended by the manufacturer. Use D-Cells (1.5 V) & resistors.

From the spec sheet we want

$I_{bulb} = 0.160\ A$

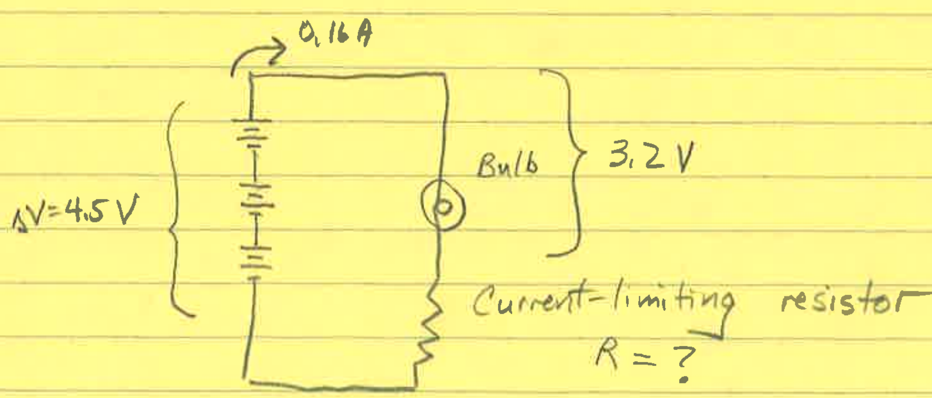
$P = 0.512\ W$

[$\Delta V_{bulb} = 3.2\ V$] ← blocked out

Can determine ΔV from power & current:

$$P = I\,\Delta V \longrightarrow \Delta V = \frac{P}{I} = \frac{0.512}{0.16} = 3.2\ V$$

Thus we need at least 3-D cells in series to get a potential difference greater than 3.2 V.



If we choose the right current limiting resistor to get $I = 0.16\,A$, the voltage drop across the resistor will be

$$\Delta V_R = 4.5 - 3.2 = 1.3\,V$$

We can get the value of the resistance from Ohm's Law:

$$R = \frac{\Delta V_R}{I} = \frac{1.3}{0.16} = 8.125\,\Omega$$

$8\,\Omega$ will be "close enough."

II How long will the bulb stay lit under these conditions?

The Wikipedia page for "D Battery" gives a typical "capacity" for a Zinc-carbon D-cell as 8000 mA-h or equivalently 12 W-h

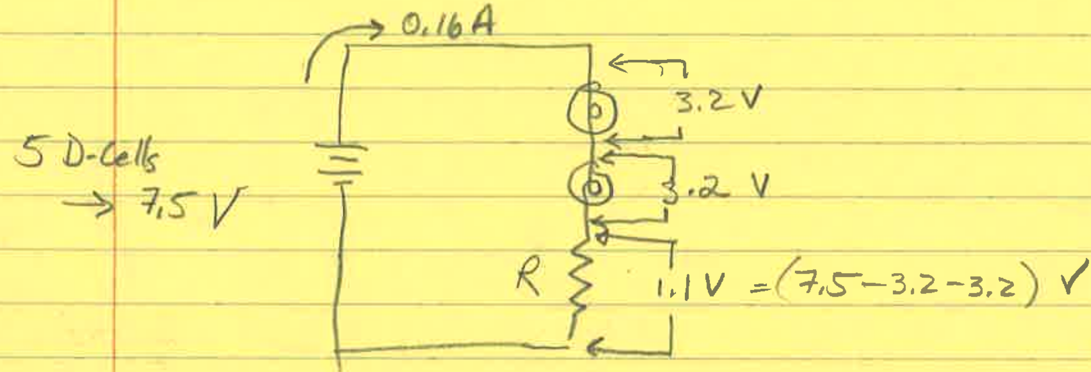
$$\hookrightarrow t = \frac{8000\,mA\cdot h}{0.16\,mA} = 50\,h \qquad \hookrightarrow t = \frac{12\,W\cdot h}{1.5\,V \times 0.16\,A} = 50\,h$$

(This is shorter than the listed lifetime of the bulb; ~ 3,000 h.)

☆ Note: Some of power from the battery is dissipated in the resistor.

III Lighting two bulbs in series.

For this we need a voltage difference greater than $2 \times 3.2V$. We can get this from 5 D-cells in seriers.

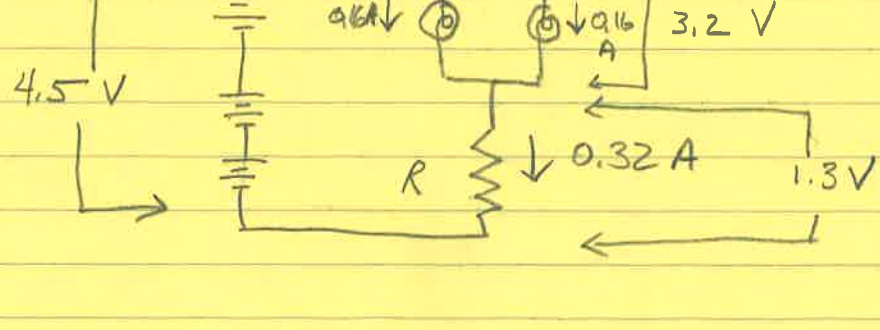


In this case $R = \frac{1.1V}{0.16A} \approx 7\Omega$

Each of batteries still has 0.16A flowing through it, so the lifetime is the same 50 h as before

IV Lighting two bulbs in parallel

We can simply add an additional bulb to the circuit from part I.



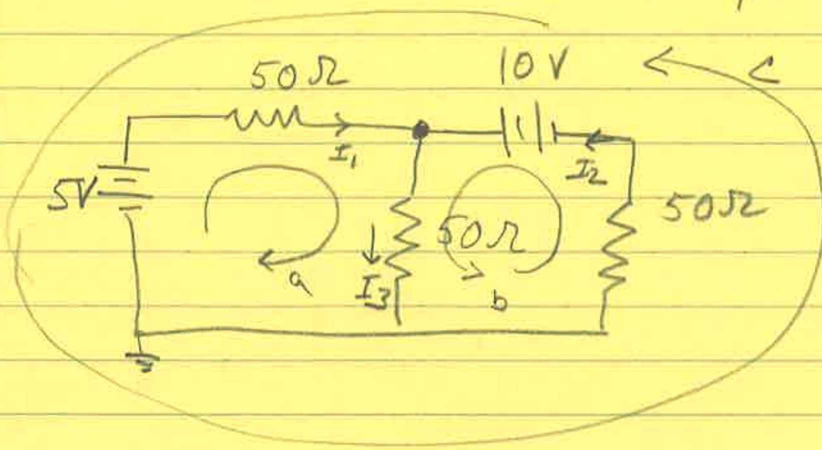
In this circuit

$$R = \frac{\Delta V}{I} = \frac{1.3V}{0.32A}$$

$$\approx 4\Omega$$

The current through each battery is twice as big as in I, so the battery lifetime will be cut in half → 25h.

(B) In-class exercise, Tuesday 1/22/19



KCL at to node:

$$I_1 + I_2 = I_3$$

KVL:

Loop a $\quad 5 - 50I_1 - 50I_3 = 0$

Loop b $\quad 10 - 50I_3 - 50I_2 = 0$

Loop c $\quad 10 + 50I_1 - 5 - 50I_2 = 0$

} Only need 2 of these equations.

One way to solve:

Add "loop a" equation to "loop b" equation

$$\rightarrow \quad 15 - 50(I_1 + I_2) - 100 I_3 = 0$$

Use KCL

$$15 - 50 I_3 - 100 I_3 = 0$$

$$\rightarrow \quad I_3 = \frac{15}{150} = 0.100A = 100mA$$

Use "Loop a" equation

$$\cancel{5} - 50I_1 - \cancel{50} \times 0.1 = 0$$

$$50 I_1 = 0$$

$$\Rightarrow I_1 = 0$$

$$\Rightarrow I_2 = 0.1\,A = 100\,mA$$