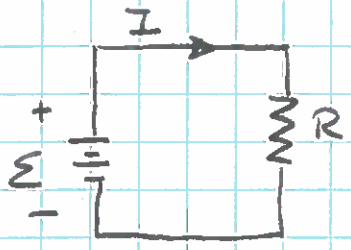
Single Bulb

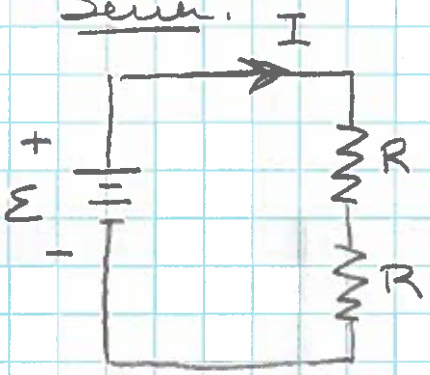


Loop ↻: $-IR + \mathcal{E} = 0 \Rightarrow I = \frac{\mathcal{E}}{R}$

Power of single bulb alone:

$$P_1 = I^2R = \frac{\mathcal{E}^2}{R^2}R = \frac{\mathcal{E}^2}{R}$$

Series:



Loop ↻: $-IR - IR + \mathcal{E} = 0$

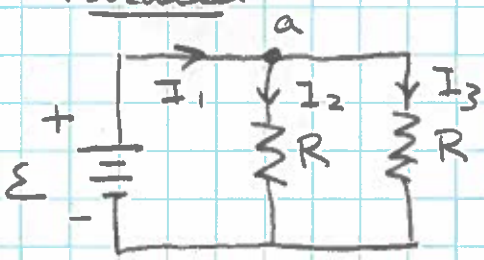
$$\Rightarrow I = \frac{\mathcal{E}}{2R}$$

Power of one bulb in series:

$$P_{series} = I^2R = \frac{\mathcal{E}^2}{4R^2}R = \frac{1}{4}\frac{\mathcal{E}^2}{R} = \frac{P_1}{4}$$

So, bulb in 1/4 are bright.

Parallel:



left loop ↻ from a: $-I_2R + \mathcal{E} = 0$

$$\Rightarrow I_2 = \frac{\mathcal{E}}{R}$$

right loop ↻ a: $-I_3R + I_2R = 0$

$$\Rightarrow I_3 = I_2 = \mathcal{E}/R$$

So, power on either bulb is:

$$P_{par} = I_2^2R = \frac{\mathcal{E}^2}{R^2}R = \frac{\mathcal{E}^2}{R} = P_1$$

same as for one bulb alone.

But, total current, $I = I_2 + I_3 = 2\mathcal{E}/R$