Homework # 1

Physics 397

1. $$P_{Eur} = \frac{V_{Eur}^2}{R}$$

$$P_{us} = \frac{V_{us}^2}{R} \Rightarrow R = \frac{V_{us}^2}{P_{us}}$$

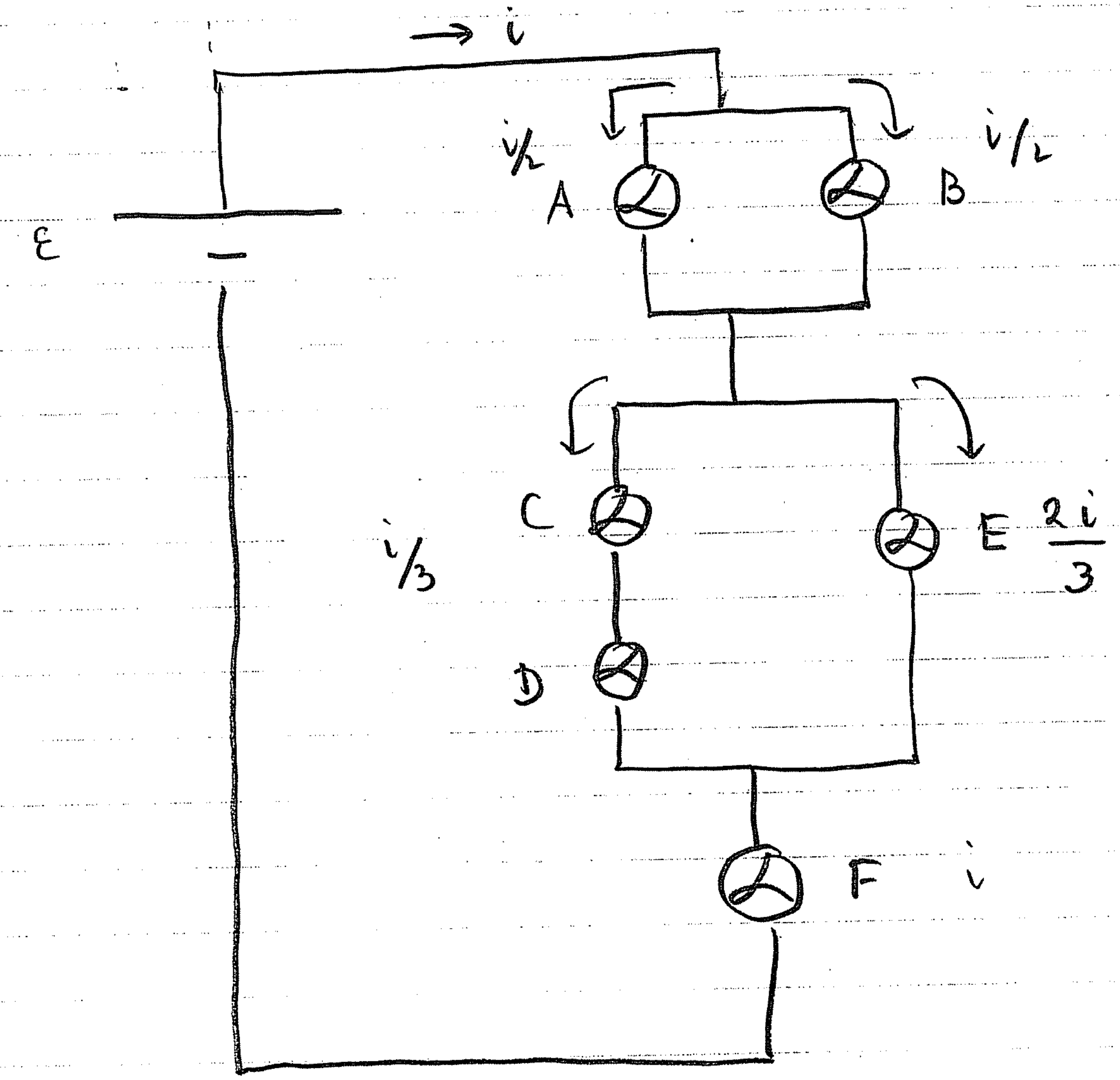
$$P_{Eur} = \frac{V_{Eur}^2}{R} = \left(\frac{V_{Eur}^2}{V_{us}^2}\right) P_{us}$$

$$= \left(\frac{220}{120}\right)^2 50$$

$$\boxed{P_{Eur} = 168.1 \text{ Watts}}$$

2. 6 Identical Light Bulbs (identical Rs)

An example circuit:



$P = iV = i^2 R$ (assuming light bulb = ohmic resistor)

Brightest bulb draws the most current
Dimmest bulb draws the least current

$i \uparrow$ = Power $\uparrow$ = Brightness $\uparrow$
$(P = i^2 R)$

$$i = \frac{\varepsilon}{R_{eff}}$$

Brightest bulb (F)

$$i_F = i = \frac{\varepsilon}{R_{eff}}$$

$$P_F = i_F^2 R = \frac{\varepsilon^2}{R_{eff}^2} R$$

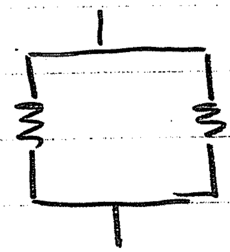
Dimmest bulbs (C) (D)

$$i_C = i_D = \frac{i}{3} = \frac{\varepsilon}{3 R_{eff}}$$

$$P_C = P_D = \frac{\varepsilon^2}{9 R_{eff}^2} R$$

Now we need to calculate R_{eff}

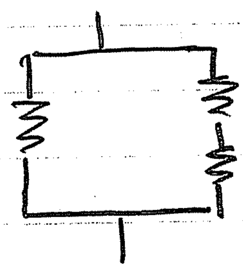
(1)



$$\frac{1}{R_1} = \frac{1}{R} + \frac{1}{R} = \frac{2}{R}$$

$$R_1 = \frac{R}{2}$$

(2)



$$\frac{1}{R_2} = \frac{1}{R} + \frac{1}{2R}$$

$$= \frac{3}{2R}$$

$$R_2 = \frac{2R}{3}$$

$$R_{eff} = \frac{R}{2} + \frac{2R}{3} + R$$

$$= \frac{3R + 4R + 6R}{6} = \frac{13R}{6}.$$

Then

$$P_F = \frac{\varepsilon^2}{R_{eff}^2} R = \left(\frac{6\varepsilon}{13}\right)^2 \frac{1}{R}$$

$$\boxed{P_F = \frac{36\,\varepsilon^2}{(169)\,R}}$$

Brightest

$$P_C = P_D = \frac{\varepsilon^2}{9R_{eff}^2} R = \frac{1}{9R}\left(\frac{6\varepsilon}{13}\right)^2$$

$$\boxed{P_C = P_D = \frac{4\varepsilon^2}{(169)\,R}}$$

Dimmest

3. Astronomers assume the star is a "blackbody" and use Wien's Displacement Law

$$\lambda_{max} T = 2.9 \times 10^{-3} \text{ K-m}$$

to determine the star's temperature.

Assumptions: Star is blackbody with a single defining effective temperature

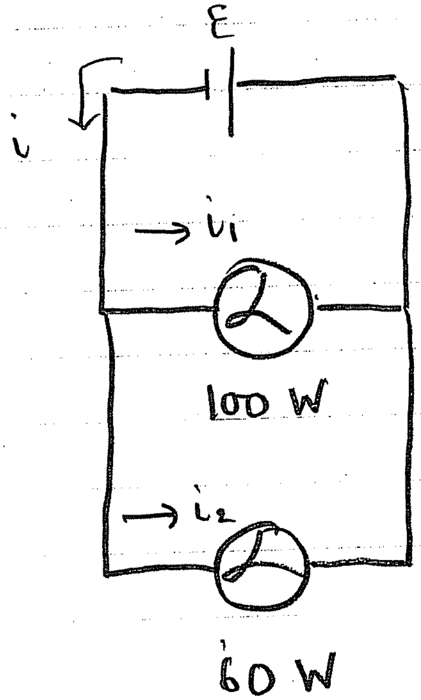
Possible Complications: The stellar volume could have a temperature gradient so that the star's $I(\lambda)$ is not characteristic of a single T.

The stellar atmosphere could affect some λ's more than others, effectively altering $I(\lambda)$.

4. The power ratings for the two light bulbs, 60 W and 100 W, refer to conventional parallel wiring schemes.

(a) 100 W bulb is brighter

Bulbs in parallel



$$V = \mathcal{E} = i_1 R_1 = i_2 R_2$$

↓

same for each bulb

$$P = iV = i\mathcal{E}$$

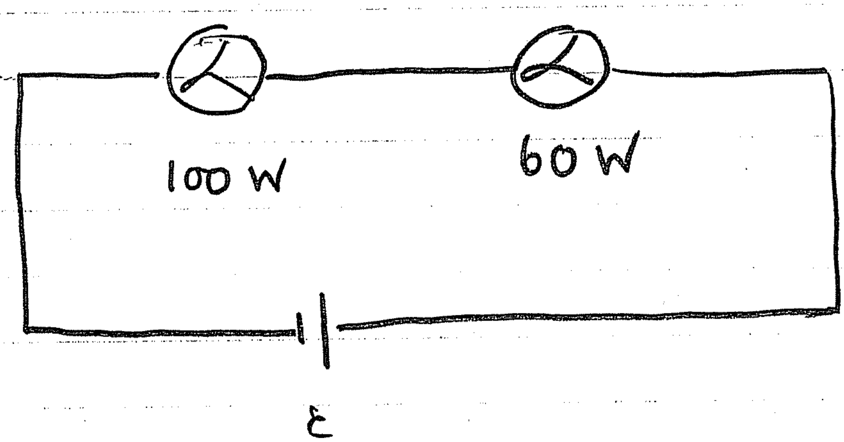
$$i_1 > i_2$$

$$R_1 < R_2$$

Therefore we see that

$$R_{100\,W} < R_{60\,W}$$

(b) 60 W bulb is brighter



$P = i^2 R \Rightarrow$ i same for each bulb

$$R_{60\,W} > R_{100\,W}$$

$$\Downarrow$$

$$P_{60\,W} > P_{100\,W}$$

5. Red paint absorbs all colors of visible light except red.

6. Mercury is very well-suited for fluorescent lighting due to the following properties:

(a) Its vapor pressure is close to room temperature which is good for electric discharge

(b) It converts electric energy into UV violet with good efficiency

(c) It is not damaged or consumed as the lamp operates

7. These atoms have radiative transitions such that the light emitted emulates natural sunlight

8. $$E = hf = \frac{hc}{\lambda}$$

$$\lambda f = c$$

$$f = \frac{E}{h} = \frac{3.8 \times 10^{-19}\ J}{6.63 \times 10^{-34}\ J.s} = 5.73 \times 10^{14}\ H$$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8 \ m/s}{5.73 \times 10^{14} \ /s}$$

$$= 5.23 \times 10^{-7} \ m$$

$$= 523 \text{ nanometers}$$

According to Figure 14.1.1 in HTW, the associated color is <u>green</u>.

9. Why researchers are looking for replacements for incandescent lighting

- Would like better energy efficiency
- Increased longevity (average bulb lasts only 1000 hours)

10. Research and developments towards the "ultimate lamp".

- key developments – research in light-emitting diodes (LED's)
- Better conversion of electricity to light

than light bulbs, particularly in red

- Mass production so that cost / LED declines

- LEDS in blue and green ⇒ necessary to make in all colors so that white-light sources can be made.

- New materials that are inhomogeneous ⇒ improved energy efficiency

- New manufacturing techniques ⇒ smoother crystals, less defects ⇒ better quality of radiation produced.

- Production of white light via colored LED + phosphor (similar to fluorescent lights). Less efficient than color-mixing but simpler.