

## Correction Series 2.

### Exercise 1

- (a) We have seen during the lecture that the surface intensity of a tungsten filament ( $T = 2500$  K and  $\varepsilon = 0.35$ ) is

$$I_{\text{fila.}} \simeq 0.77 \text{ W/mm}^2. \quad (1)$$

Since the emitting surface is the lateral surface of a cylinder:  $S_{\text{fila.}} = 2\pi rh$ , the numerical data give:

$$S_{\text{fila.}} \simeq 2 \times 3.14 \times 0.5 \times 20 \simeq 62.8 \text{ mm}^2,$$

and we conclude that the electro-magnetic power of the bulb is:

$$P_{\text{bulb}} = I_{\text{fila.}} S_{\text{fila.}} \simeq 0.77 \times 62.8 \simeq 48.4 \text{ W}. \quad (2)$$

- (b) We have seen during the lecture that the image intensity can be estimated by the formula:

$$I_{\text{image}} = \frac{1}{4} I_{\text{fila.}} \left( \frac{R_1}{f} \right)^2$$

where  $R_1$  is the radius of the lens and  $f$  its focus. With the numerical data for  $R_1$  and  $f$  and using the value (1) of the source intensity, we get that

$$I_{\text{image}} = \frac{1}{4} \times 0.77 \times \left( \frac{25}{150} \right)^2 \simeq 0.00534 \text{ W/mm}^2. \quad (3)$$

- (c) At a large distance  $R$ , the bulb emission can be approached by a spherical wave. The value of the intensity depends on the power through the formula:

$$I_0(R) = \frac{P_{\text{bulb}}}{4\pi R^2}.$$

Therefore we will have  $I_0(R) = I_{\text{image}}$  if

$$R = \sqrt{\frac{P_{\text{bulb}}}{4\pi I_{\text{image}}}}.$$

Using the value (2) of the power and the value (3) of the image intensity, we get that

$$R \simeq \sqrt{\frac{48.4}{4 \times 3.14 \times 0.00534}} \simeq 26.85 \text{ mm}.$$

Which means that focusing, in the case of a bulb, is not the only solution to increase intensity. Approaching the bulb might be more efficient.

## Exercise 2

(a) We have seen during the lecture that the surface intensity on the sun is

$$I_{\text{sun}} \simeq 63 \text{ W/mm}^2. \quad (4)$$

Since the sun surface  $S_{\text{sun}} = 4\pi R_{\text{sun}}^2 \simeq 6.084 \times 10^{24} \text{ mm}^2$ , we conclude that its electro-magnetic power is:

$$P_{\text{sun}} = 63 \times 6.084 \times 10^{24} \simeq 3.833 \times 10^{26} \text{ W}. \quad (5)$$

(b) We have seen during the lecture that the image intensity can be estimated by the formula:

$$I_{\text{image}} = \frac{1}{4} I_{\text{sun}} \left( \frac{R_1}{f} \right)^2$$

where  $R_1$  is the radius of the lens and  $f$  its focus. With the numerical data for  $R_1$  and  $f$  and using the value (4) of the surface intensity, we get that

$$I_{\text{image}} = \frac{1}{4} \times 63 \times \left( \frac{25}{150} \right)^2 \simeq 0.438 \text{ W/mm}^2. \quad (6)$$

(c) At a large distance  $R$  from its center:  $R \gg R_{\text{sun}}$ , the sun emission can be approached by a spherical wave. The value of the intensity depends on the power through the formula:

$$I_0(R) = \frac{P_{\text{sun}}}{4\pi R^2}.$$

Therefore we will have  $I_0(R) = I_{\text{image}}$  if

$$R = \sqrt{\frac{P_{\text{sun}}}{4\pi I_{\text{image}}}}.$$

Using the value (5) of the power and the value (6) of the image intensity, we get that

$$R \simeq \sqrt{\frac{3.833 \times 10^{26}}{4 \times 3.14 \times 0.438}} \simeq 8.345 \times 10^{12} \text{ mm} = 8.345 \times 10^6 \text{ km}.$$

Since the intensity collected at the image is probably able to burn paper, we expect the location  $R$  to be far away from earth. It is the case, because the distance earth to sun is of about  $228 \times 10^6 \text{ km}$ .

In the case of the sun, focusing is certainly a good solution to increase intensity. Getting closer to the sun is also a possibility to increase intensity in the same proportion, but a spacecraft would be needed to travel millions of km.