

SOLUTIONS TO CONCEPTS CHAPTER 22

1. Radiant Flux = $\frac{\text{Total energy emitted}}{\text{Time}} = \frac{45}{15\text{s}} = 3\text{W}$
2. To get equally intense lines on the photographic plate, the radiant flux (energy) should be same.
So, $10\text{W} \times 12\text{sec} = 12\text{W} \times t$
 $\Rightarrow t = \frac{10\text{W} \times 12\text{sec}}{12\text{W}} = 10\text{ sec.}$

3. it can be found out from the graph by the student.

4. Relative luminosity = $\frac{\text{Luminous flux of a source of given wavelength}}{\text{Luminous flux of a source of 555 nm of same power}}$

Let the radiant flux needed be P watt.

$$A_0, 0.6 = \frac{\text{Luminous flux of source 'P' watt}}{685 P}$$

$$\therefore \text{Luminous flux of the source} = (685 P) \times 0.6 = 120 \times 685$$

$$\Rightarrow P = \frac{120}{0.6} = 200\text{W}$$

5. The luminous flux of the given source of 1W is 450 lumen/watt

$$\therefore \text{Relative luminosity} = \frac{\text{Luminous flux of the source of given wavelength}}{\text{Luminous flux of 555 nm source of same power}} = \frac{450}{685} = 66\%$$

[\therefore Since, luminous flux of 555nm source of 1W = 685 lumen]

6. The radiant flux of 555nm part is 40W and of the 600nm part is 30W

(a) Total radiant flux = $40\text{W} + 30\text{W} = 70\text{W}$

(b) Luminous flux = $(L.\text{Flux})_{555\text{nm}} + (L.\text{Flux})_{600\text{nm}}$
 $= 1 \times 40 \times 685 + 0.6 \times 30 \times 685 = 39730\text{ lumen}$

(c) Luminous efficiency = $\frac{\text{Total luminous flux}}{\text{Total radiant flux}} = \frac{39730}{70} = 567.6\text{ lumen/W}$

7. Overall luminous efficiency = $\frac{\text{Total luminous flux}}{\text{Power input}} = \frac{35 \times 685}{100} = 239.75\text{ lumen/W}$

8. Radiant flux = 31.4W, Solid angle = 4π

Luminous efficiency = 60 lumen/W

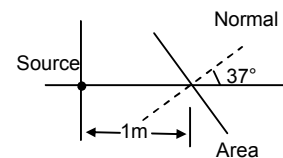
So, Luminous flux = $60 \times 31.4\text{ lumen}$

And luminous intensity = $\frac{\text{Luminous Flux}}{4\pi} = \frac{60 \times 31.4}{4\pi} = 150\text{ candela}$

9. $I = \text{luminous intensity} = \frac{628}{4\pi} = 50\text{ Candela}$

$r = 1\text{m}, \quad \theta = 37^\circ$

So, illuminance, $E = \frac{I \cos \theta}{r^2} = \frac{50 \times \cos 37^\circ}{1^2} = 40\text{ lux}$



10. Let, $I = \text{Luminous intensity of source}$

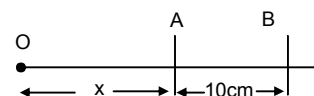
$E_A = 900\text{ lumen/m}^2$

$E_B = 400\text{ lumen/m}^2$

Now, $E_a = \frac{I \cos \theta}{x^2}$ and $E_B = \frac{I \cos \theta}{(x+10)^2}$

So, $I = \frac{E_A x^2}{\cos \theta} = \frac{E_B (x+10)^2}{\cos \theta}$

$\Rightarrow 900x^2 = 400(x+10)^2 \Rightarrow \frac{x}{x+10} = \frac{2}{3} \Rightarrow 3x = 2x + 20 \Rightarrow x = 20\text{ cm}$

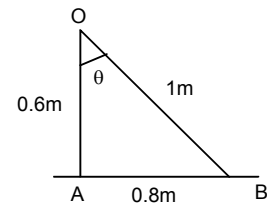


So, The distance between the source and the original position is 20cm.

11. Given that, $E_a = 15 \text{ lux} = \frac{I_0}{60^2}$

$$\Rightarrow I_0 = 15 \times (0.6)^2 = 5.4 \text{ candela}$$

$$\text{So, } E_B = \frac{I_0 \cos \theta}{(OB)^2} = \frac{5.4 \times \left(\frac{3}{5}\right)}{1^2} = 3.24 \text{ lux}$$



12. The illuminance will not change.

13. Let the height of the source is 'h' and the luminous intensity in the normal direction is I_0 .

So, illuminance at the book is given by,

$$E = \frac{I_0 \cos \theta}{r^2} = \frac{I_0 h}{r^3} = \frac{I_0 h}{(r^2 + h^2)^{3/2}}$$

$$\text{For maximum } E, \frac{dE}{dh} = 0 \Rightarrow \frac{I_0 \left[(R^2 + h^2)^{3/2} - \frac{3}{2} h \times (R^2 + h^2)^{1/2} \times 2h \right]}{(R^2 + h^2)^3}$$

$$\Rightarrow (R^2 + h^2)^{1/2} [R^2 + h^2 - 3h^2] = 0$$

$$\Rightarrow R^2 - 2h^2 = 0 \Rightarrow h = \frac{R}{\sqrt{2}}$$

