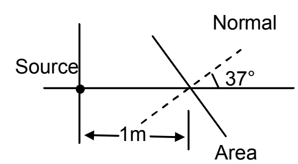
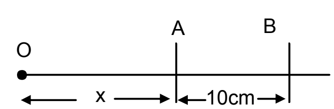
SOLUTIONS TO CONCEPTS
CHAPTER 22

1. Radiant Flux = $\frac{\text{Total energy emitted}}{\text{Time}} = \frac{45}{15s}$ = 3W
2. To get equally intense lines on the photographic plate, the radiant flux (energy) should be same.
   S0, 10W × 12sec = 12W × t
   $\Rightarrow t = \frac{10W \times 12\,sec}{12W}$ = 10 sec.
3. it can be found out from the graph by the student.
4. Relative luminousity = $\frac{\text{Luminous flux of a source of given wavelength}}{\text{Luminous flux of a source of 555 nm of same power}}$
   Let the radiant flux needed be P watt.
   Ao, 0.6 = $\frac{\text{Luminous flux of source 'P' watt}}{685\text{ P}}$
   $\therefore$ Luminous flux of the source = (685 P)× 0.6 = 120 × 685
   $\Rightarrow P = \frac{120}{0.6}$ = 200W
5. The luminous flux of the given source of 1W is 450 lumen/watt
   $\therefore$ 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 = 40W + 30W = 70W
   (b) Luminous flux = $(\text{L.Fllux})_{555nm} + (\text{L.Flux})_{600nm}$
   = 1 × 40× 685 + 0.6 × 30 × 685 = 39730 lumen
   (c) Luminous efficiency = $\frac{\text{Total luminous flux}}{\text{Total radiant flux}} = \frac{39730}{70}$ = 567.6 lumen/W
7. Overall luminous efficiency = $\frac{\text{Total luminous flux}}{\text{Power input}} = \frac{35 \times 685}{100}$ = 239.75 lumen/W
8. Radiant flux = 31.4W, Solid angle = 4π
   Luminous efficiency = 60 lumen/W
   So, Luminous flux = 60 × 31.4 lumen
   And luminous intensity = $\frac{\text{Luminous Flux}}{4\pi} = \frac{60 \times 31.4}{4\pi}$ = 150 candela
9. I = luminous intensity = $\frac{628}{4\pi}$ = 50 Candela
   r = 1m, $\theta = 37°$
   So, illuminance, E = $\frac{I\cos\theta}{r^2} = \frac{50 \times \cos 37°}{1^2}$ = 40 lux



10. Let, I = Luminous intensity of source
    E_A = 900 lumen/m^2
    E_B = 400 lumen/m^2
    Now, $E_a = \frac{I\cos\theta}{x^2}$ and $E_B = \frac{I\cos\theta}{(x+10)^2}$
    So, $I = \frac{E_A x^2}{\cos\theta} = \frac{E_B(x+10)^2}{\cos\theta}$



    $\Rightarrow 900x^2 = 400(x+10)^2 \Rightarrow \frac{x}{x+10} = \frac{2}{3} \Rightarrow 3x = 2x + 20 \Rightarrow x = 20$ cm
    So, The distance between the source and the original position is 20cm.

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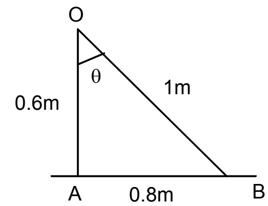


11. Given that, $E_a = 15 \text{ lux} = \frac{I_0}{60^2}$

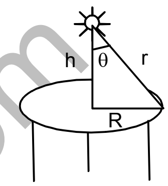
$\Rightarrow I_0 = 15 \times (0.6)^2 = 5.4$ candela

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



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

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

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

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

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