

Photometry**Exercise Solutions****Question 1:****Solution:**

Radiant flux of the source = [total energy emitted]/time

$$= 45/15 = 3 \text{ W}$$

Question 2:**Solution:**

To record the sufficiently intense lines, energy should be same.

$$\Rightarrow \text{Energy} = \text{time} \times \text{radiant flux}$$

$$\Rightarrow 10\text{W} \times 12\text{sec} = 12 \text{ W} \times t$$

$$\Rightarrow t = 10 \text{ sec}$$

The photographic plate should be exposed for 10 s to get equally intense lines.

Question 3:

Solution:

From the graph,

- (a) The relative luminosity of wavelength 480 nm = 0.14.
- (b) The relative luminosity of wavelength 520 nm = 0.68.
- (c) The relative luminosity of wavelength 580 nm = 0.92.
- (d) The relative luminosity of wavelength 600 nm = 0.66.

Question 4:**Solution:**

Relative luminosity is the ratio of "luminous flux of source of given wavelength" to the "luminous flux of source of 555 nm of same power"

Relative luminosity = 0.6 (given)

Let "P" be the radiant flux of the source.

So, Luminous flux = 685P

$$\Rightarrow 0.6 = [\text{luminous flux of source of } P \text{ watt}] / 685 P$$

$$\Rightarrow 685 P \times 0.6 = 120 \times 685$$

$$\Rightarrow P = 200 \text{ W}$$

Question 5:**Solution:**

Relative luminosity is the ratio of "luminous flux of source of given wavelength" to the "luminous flux of source of 555 nm of same power"

$$\Rightarrow \text{Relative luminosity} = 450/685 = 66\%$$

Question 6:**Solution:**

(a) the total radiant flux = radiant flux of 555 nm part of light + radiant flux of 600 nm part of light = 40 W + 30 W = 70 W

(b) Total luminous flux = luminous flux of 555 nm part of light + luminous flux of 600 nm part of light = $1 \times 40 \times 685 + 0.6 \times 30 \times 685 = 39730$ lumen

(c) the luminous efficiency.

We know, Luminous efficiency = $[\text{total luminous flux}]/[\text{total radiant flux}]$

$$= 39730/70 = 567.6 \text{ lumen/W}$$

Question 7:**Solution:**

We know, overall luminous efficiency = $[\text{total luminous flux}]/[\text{power input}]$

$$= [35 \times 685]/100$$

$$= 239.75 \text{ lumen/W}$$

Question 8:

Solution:

Luminous intensity = [luminous flux]/[solid angle] ...(1)

From question, Radiant flux = 31.4, since the radiant flux is distributed uniformly in all directions, the solid angle will be Luminous efficiency = 60 lumen/W

luminous flux = luminous efficiency × radiant flux = 60 × 31.4 lumen

(1) => Luminous intensity = $[60 \times 31.4] / 4\pi$

= 150 candela

Question 9:**Solution:**

We know, Luminous intensity = [luminous flux]/[solid angle] ...(1)

Given: Luminous flux = 628 lumen

Distance of point, $r = 1$ m

Angle made by the normal with x-axis = 37 degrees

Since the radiant flux is distributed uniformly in all directions, the solid angle will be 4π .

(1) => Luminous intensity = $628 / 4\pi = 50$ candela

So, Illuminance, $E = I \cos(\theta / r^2)$

=> $E = 50 \times [\cos 37^\circ] / 1^2$

= 40 lux

Question 10:**Solution:**

Let I be Luminous intensity of source.

Let E_A = Initial illuminance = 900 lm/m^2 and

E_B = Final illuminance = 400 lumen/m^2

Now,

Illuminance on the initial position = $E_A = [I \cos\theta]/x^2 \dots(1)$

Illuminance at final position = $E_B = [I \cos\theta]/(x+10)^2 \dots(2)$

Now, (1) = (2)

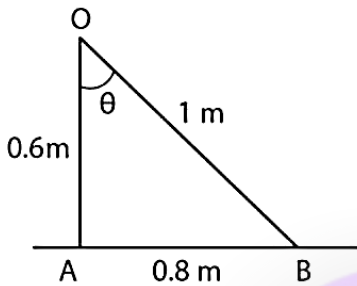
$$\Rightarrow I = [E_A x^2]/\cos\theta = [E_B (x+10)^2]/\cos\theta$$

$$\Rightarrow 900 x^2 = 400(x + 10)^2$$

$$\Rightarrow x = 20 \text{ cm}$$

The distance between the source and the area at the initial position is 20 cm.

Question 11 :**Solution:**



$$E_A = 15 \text{ lux} = I_o / 0.6^2$$

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

$$\text{And, } E_B = [I_o \cos\theta] / (OB)^2$$

$$= [5.4 \times 3/5] / 1^2$$

$$= 3.24 \text{ lux}$$

Question 12:

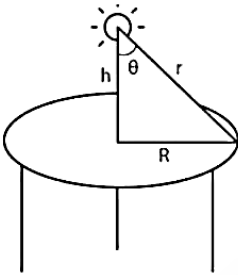
Solution:

The illuminance will not change.

Question 13:

Solution:

Let the height of the source be h and the luminous intensity in the normal direction be I_o .



The illuminance on book, $E = [I_0 \cos\theta] / (r)^2$

From diagram, $\cos\theta = h/r$

$$\Rightarrow E = [I_0 h] / (r)^3$$

But $r = \sqrt{R^2 + h^2}$

$$\Rightarrow E = [I_0 h] / (R^2 + h^2)^{3/2}$$

For maximum illuminance, $dE/dh = 0$

Now,

$$\frac{dE}{dH} = \frac{I_0 \left[(r^2 + h^2)^{\frac{3}{2}} - \frac{3}{2} h \times (R^2 + h^2)^{\frac{1}{2}} \times 2h \right]}{(R^2 + h^2)^3} = 0$$

$$\Rightarrow R^2 - 2h^2 = 0$$

$$\text{Or } h = R/\sqrt{2}$$

Question 14:

Solution:

Given: Illuminance at A = 25 lux.

From figure, AS = 2.4 m and AB = 1.8 m.

$$BS = \sqrt{(2.4)^2 + (1.8)^2} = 3 \text{ m}$$

Let angle ASB is θ

$$\Rightarrow \cos \theta = 2.4/3 = 0.8$$

We know, $E = I \cos\theta/r^2$

$$\Rightarrow 25 = I_0 \cos 0^\circ / (2.4)^2$$

Where I_0 is the intensity along SA

$$\Rightarrow I_0 = 25 \times 5.76 = 144 \text{ cd}$$

Now, from Lambert's cosine law, the intensity along SB:

$$I = I_0 \cos\theta$$

$$= 144 \times 0.8$$

$$= 115.2 \text{ cd}$$

The angle between SB and normal at B is also θ .

$$\text{Illuminance at B is } E = (I \cos\theta)/3^2 = 10.24 \text{ Lux}$$

Question 15:

Solution:

$$I_1/I_2 = (80/20)^2 = 16$$

Here I_1 = Intensity when placed at a distance 80 cm and
 I_2 = Intensity when placed at a distance 20 cm apart from the screen.

Let the new distance between the lamp and the screen be x

$$0.49I_1/I_2 = (x/20)^2$$

$$\Rightarrow 0.49 \times 16 \times 400 = x^2$$

$$\Rightarrow x = 56 \text{ cm}$$

The lamp has to be moved by $80 \text{ cm} - 56 \text{ cm} = 24 \text{ cm}$.

Question 16:**Solution:**

Total intensity of the 8 Cd and the 12 Cd light source is $(8+12) = 20 \text{ Cd}$.
Illuminance due to the 20 Cd source E_1 is:

$$E_1 = 20/(0.4)^2 \dots\dots (1)$$

Illuminance due to the 80 Cd source E_2 is:

$$E_2 = 80/(d)^2 \dots\dots (1)$$

where d is the distance of the 80 Cd source.

Now,

$$E_1 = E_2$$

$$20/(0.4)^2 = 80/(d)^2$$

$$\Rightarrow d = 0.8 \text{ m} = 80 \text{ cm}$$