Unit 2 Particles and Waves
2.4 Answers

Irradiance

(1). $I = 1.4 kWm^{-2}$
$P = ?$
$A = 15 m^2$

$P = IA$
$= 1.4 \times 10^3 \times 15$
$= 21,000 W$

(2) $I = 200 Wm^{-2}$
$A = ?$
$P = 1mW$

$A = \frac{P}{I}$

$A = \frac{1 \times 10^{-3}}{200}$

$A = 5 \times 10^{-6} m^2$

(3)(a) $d_1 = 2m$.
$I_1 = 6.4 Wm^{-2}$

$I_2 = ?$
$d_2 = 1$

$I_1 d_1^2 = I_2 d_2^2$
$6.4 \times 4 = I_2 \times 1$
$I_2 = 25.6 Wm^{-2}$.

(b) $I_1 d_1^2 = I_2 d_2^2$
$I_2 = ?$
$d_2 = 4$
$6.4 \times 4 = I_2 \times 16$
$I_2 = 1.6 Wm^{-2}$.

(4)(a) $I_1 = 4.8 Wm^{-2}$
$d_1 = 2.4m$
$d_2 = 1.5m$

$I_1 d_1^2 = I_2 d_2^2$

$4.8 \times 5.76 = I_2 \times 2.25$

$I_2 = 12.3 Wm^{-2}$

(b) $I_1 = 4.8 Wm^{-2}$
$d_1 = 2.4m$
$d_2 = 3m$

$I_1 d_1^2 = I_2 d_2^2$

$4.8 \times 5.76 = I_2 \times 9$

$I_2 = 3.1 Wm^{-2}$

(5) $d_1 = 1.2m$
$I_1 = 9.0 Wm^{-2}$
$d_2 = ?$
$I_2 = 1 Wm^{-2}$

$I_1 d_1^2 = I_2 d_2^2$

$9 \times 1.44 = 1 \times d_2^2$

$d_2^2 = 12.96$

$d_2 = 3.6m$

(6)(a) $I_1 = 1.5 Wm^{-2}$
$d_1 = 6m$
$d_2 = ?$
$I_2 = 2 Wm^{-2}$

$I_1 d_1^2 = I_2 d_2^2$
$1.5 \times 36 = 2 d_2^2$
$d_2^2 = 27$

$d_2 = 5.2m$

(b) $I_1 = 1.5 Wm^{-2}$
$d_1 = 6$
$d_2 = ?$
$I_2 = 1.2$

$I_1 d_1^2 = I_2 d_2^2$
$1.5 \times 36 = 1.2 \times d_2^2$

$d_2^2 = 45$

(7) $P = 100W$.

$I_1 = 2 Wm^{-2}$

$d_1 = 2m$

$d_2 = 1m$.

$I_2 = ?$

$I_1 d_1^2 = I_2 d_2^2$

$2 \times 4 = I_2 \times 1$

$I_2 = 8 Wm^{-2}$

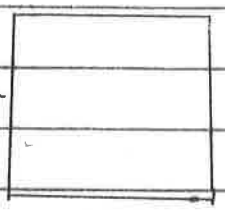
(8a) $I = \frac{P}{A}$

$P = ?$

$I = 20mWm^{-2}$

$A = 0.5 \times 0.5$

$= 0.25m^2$



$P = IA$

$P = 20 \times 10^{-3} \times 0.25$

$P = 5 \times 10^{-3} W$.

(b) $I_1 = 20mWm^{-2}$

$d_1 = 2.25m$

$d_2 = 1.5m$.

$I_2 = ?$

$I_1 d_1^2 = I_2 d_2^2$

$20 \times 10^{-3} \times 5.06 = I_2 \times 2.25$

$0.101 = 2.25 I_2$

$I_2 = 0.05 Wm^{-2}$

$P = IA$.

$= 0.05 \times 0.25$

$= 0.013W$

(9) a)

I	d^2	Id^2
242	0.01	2.42
106	0.0225	2.39
60	0.04	2.40
39	0.0625	2.44

$$Id^2 = \text{constant}$$

$$I = \frac{\text{constant}}{d^2}$$

$$I \propto \frac{1}{d^2}$$

The lamp acts like a point source of light as the irradiance varies inversely with the square of the distance.

b) $I \approx 15$ units.

c) The irradiance of a laser would not vary over distance, so the irradiance would remain the same if a laser replaced the lamp.

(10) $f = 5\times10^{14}$ Hz
$A = 1\,m^2$
$I = ?$
$N = 2\times10^{19}$ photons.

$I = Nhf$.

$I = 2\times10^{19} \times 6.63\times10^{-34} \times 5\times10^{14}$
$I = 6.63\,Wm^{-2}$.

(11) $I = ?$
$N = 5\times10^{20}$ photons
$h = 6.63\times10^{-34}$ Js
$f = 4.5\times10^{14}$ Hz.

$I = Nhf$.

$I = 5\times10^{20} \times 6.63\times10^{-34} \times 4.5\times10^{14}$
$I = 149\,Wm^{-2}$.

(12) $N = ?$
$f = 6.5\times10^{14}$ Hz
$I = 2.4\,Wm^{-2}$
$h = 6.63\times10^{-34}$.

$N = \frac{I}{hf}$.

$N = \frac{2.4}{6.63\times10^{-34}\times6.5\times10^{14}}$

$N = 5.6\times10^{18}$ photons.

(13) $N = ?$
$\lambda = 450\times10^{-9}$ m

$I = 4\,Wm^{-2}$
$f = v/\lambda$

$= \frac{3\times10^8}{450\times10^{-9}} = 6.67\times10^{14}$ Hz.

on $1m^2$ $N = \frac{I}{hf}$.

$= \frac{4}{6.63\times10^{-34}\times6.67\times10^{14}}$

$= 9.05\times10^{18}$ photons.

on $1cm^2$ $= 9.05\times10^{18} \div 10{,}000 = 9.05\times10^{14}$ photons

(14) $\lambda = 650nm$

$I = 0.24 Wm^{-2}$

$f = \frac{V}{\lambda}$

$= \frac{3 \times 10^8}{650 \times 10^{-9}}$

$= 4.62 \times 10^{14} Hz$.

on $1m^2$, $N = \frac{I}{hf}$

$= \frac{0.24}{6.63 \times 10^{-34} \times 4.62 \times 10^{14}}$

$= 7.84 \times 10^{17}$ photons.

on $0.05m^2$, $7.84 \times 10^{17} \times 0.05 = 3.92 \times 10^{16}$ photons