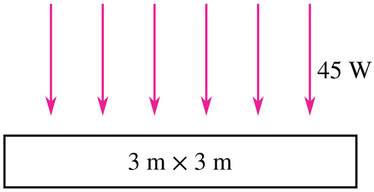
50 Intensity and Radiation ♡

The intensity of light, sound or other radiation depends on the

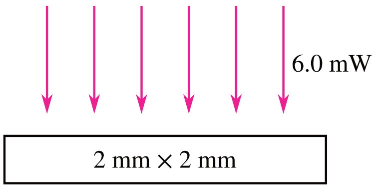
- power of the wave, and
- the size of the area in which the waves are focused.

Formula:

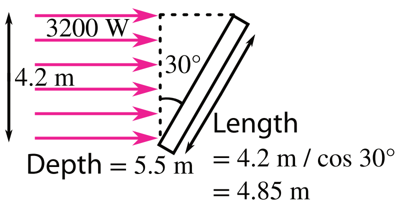
$$\text{intensity (W/m}^2) = \text{power (W)} / \text{area (m}^2) \qquad I = P/A$$



Example 1
Intensity $= P/A = 45\text{ W} \div 9\text{ m}^2$
$= 5\text{ W/m}^2$

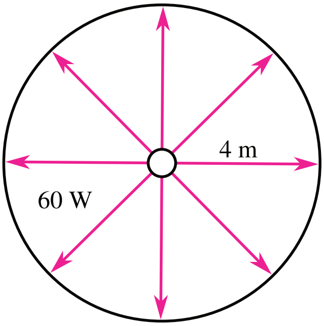


Example 2
Area $= 2\text{ mm} \times 2\text{ mm} = 0.002\text{ m} \times 0.002\text{ m} = 4 \times 10^{-6}\text{ m}^2$
Intensity $= P/A$
$= (6 \times 10^{-3}\text{ W}) \div (4 \times 10^{-6}\text{ m}^2)$
$= 1.5 \times 10^3\text{ W/m}^2$
$= 1\,500\text{ W/m}^2$



Example 3
Area lit $= 5.5\text{ m} \times 4.85\text{ m} = 26.7\text{ m}^2$
Intensity $= P/A$
$= 3\,100\text{ W} \div 26.7\text{ m}^2 = 120\text{ W/m}^2$

Point Sources
To work out the intensity at a distance from a point source, we imagine it shining light in all directions, making the shape of a sphere.



Intensity 4 m from the source
$= $ power / area illuminated
$= $ power / surface area of a 4 m sphere
$= P/(4\pi r^2)$
$= 60/(4\pi \times 4^2) = 60/201 = 0.30$ W/m^2.

50.1 A light bulb radiates at 60 W (thermal and light) evenly in all directions. What is the intensity if

(a) this light all falls in a 5.0 m^2 area?

(b) the light all falls on a 10 m^2 area?

How much area would the bulb light if it were placed

(c) in the middle of a spherical room of radius 3.0 m?

(d) in the middle of a spherical room of radius 6.0 m?

What would the intensity be at the walls of

(e) the spherical room in question (c)?

(f) the spherical room in question (d)?

50.2 A car has 50 W headlamps on it.

(a) Calculate the intensity you would expect from a single headlamp bulb at a distance of 400 m if it shone light in all directions equally.

(b) In practice the intensity 400 m from a headlamp is much higher. Why?

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50.3 Calculate the intensity you would expect from a 1.0 W torch bulb at a distance of 3.0 m.

50.4 ***PLEASE <u>DON'T</u> DO THIS AT HOME*** – you might damage your eyes. If you hold a 100 W bulb about 7.0 cm from your eye, it looks as bright as the Sun. We shall use this fact to calculate the power of the Sun.

(a) What is the intensity of the light 7.0 cm from a 100 W bulb?

(b) What is the intensity of sunlight at the surface of the Earth? [no calculation needed]

(c) The Sun is 1.5×10^{11} m from the Earth. Calculate the surface area of a sphere with this radius.

(d) Use your answers to (b) and (c) to determine the power output (luminosity) of the Sun in watts.

50.5 You want to make a solar power station giving an output of 2 GW (2×10^9 W). Use your answer to Q50.4b to calculate:

(a) The ground area needed for solar cells if they are 100% efficient.

(b) The ground area needed for solar cells if they are 20% efficient.

50.6 Fill in the blanks using the words at the end.
Any energy given off in the form of waves can be called _________. In this sense, _________, radio masts and oven _________ all give off radiation. However, none of these have the ability to _________ atoms - to temporarily change the number of _________ they carry, and thus cause them to act strangely in _________ reactions. Ionizing radiation is either conventional _________ radiation of very high _________ (UV light, X-rays or gamma rays) or a stream of charged particles (like alpha or beta). If your cells receive too much ionizing radiation, a _________ may occur. This may be harmless, it might cause the cell to die, it might prevent the cell _________, or it could cause the cell to reproduce uncontrollably. This last possibility is the root of many _________. Other effects of exposure to ionizing radiation include skin burns, nausea, destruction of _________, hair loss, and sterility. At exceptionally high doses, the thermal energy given to the cells by the ionizing radiation can prove instantly fatal.
Words: *cancers, grills, bone marrow, frequency, electrons, electromagnetic, mutation, radiation, ionize, mobile phones, chemical, reproducing*.