**Example**

Suppose you detect an EM wave traveling in the **z** direction whose E field component is  (in N/C). What is its magnetic field component at that same point in time?

Well, the magnitude of the component is B = E/c = 100/3×108 = 33×10-8 = 0.33μT. As far as the direction is concerned, it must be the case that **E**×**B** = **z**. You can verify that **y×(-x)** = **z**. And so we must have:



**Example**

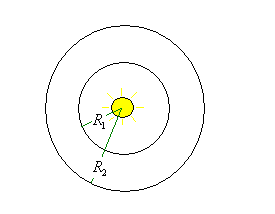
If you listen to the radio station 89.1FM, what is the wavelength of the waves you are picking up?

The standard relationship for waves is: *v* = *f λ*. And so we have,



**Example**

Now consider a point a source of light, or some other EM radiation,



and two concentric spheres surrounding it. The total power passing through the surface of sphere R1, must be equal to the total power passing through the surface of sphere R2 by energy conservation. The relationship between power at one radius and power at another radius – for spherical waves - is the following,

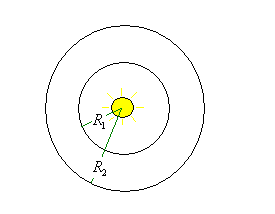


for spherical waves, and A = 4πR2 – the surface area of a sphere of radius R.

**Example**

Since the intensity of radiation near the Earth is 1000 W/m2, and the Earth is ~ 93 million miles from the Sun, what is the intensity of the solar radiation coming from the Sun at a distance of 46.5 million miles?

We can use the picture above,



The source of light in this example is the sun. R2 is where the Earth is (93 million miles) and R1 is 46.5 million miles. Using energy conservation, we have,



Therefore,



**Example**

Solar panels have been installed on the space station to generate electricity. Suppose a solar panel is 10m × 10m. Since the intensity of solar radiation coming from the Sun near the Earth’s surface is ~ 1000 W/m2, what power would be incident on such a solar panel?

The relation between power (P) and I is:



therefore,



If the solar panel were perfectly efficient in converting this radiation energy into electrical energy, then the solar panel could provide 100kW of power, which seems pretty good. Efficiencies though are usually not 100% though.

**Example**

What force does the solar radiation (EM waves) exert on the panel?

The EM wave is bumping into the panel delivering energy, but also momentum, and consequently, a force. The force, F is just Prad.A – we are assuming the panels are perfect absorbers. So we have,



**Example**

Given that the intensity of light is 1000W/m2 near the Earth, what is the strength of **E** and **B** in the incident EM wave?

Well,



and as for B, it is:



**Example**

Suppose the Emperor shoots EM radiation out of his hands with a power of 20 kW. What backward force will be exerted on him?

We know that the radiation pressure will be:



and this comes to:



which isn’t too much.

1. Suppose sunlight just outside Earth's atmosphere has an intensity of 2 kW/m2. Calculatethe magnitude of *E* and*B* for sunlight there, assuming it to be a plane wave.

Can use:



Magnitude of magnetic field is:



2. A small spaceship whose mass is 200 kg (including an astronaut) is drifting in outer space with negligible gravitational forces acting on it. If the astronaut turns on a 15 kW laser beam, what speed will the ship attain in 3 days because of the momentum carried away by the beam?

First let’s calculate the force on the spaceship:



And so:



If this force is applied for 3 days that will result in an impulse of:



and therefore a speed of:



**Problem 2.**

Suppose you aim to suspend in air a perfectly reflecting 4cm×4cm surface, with mass m = 0.00045kg. What intensity of light must you shine on it?

Force on the mirror would be



1. Suppose sunlight just outside Earth's atmosphere has an intensity of 2 kW/m2. Calculatethe magnitude of *E* and*B* for sunlight there, assuming it to be a plane wave.

Can use:



Magnitude of magnetic field is:



13. Suppose that near the Sun, the intensity of radiation is 10 000 W/m2. What is the rms value of the **B** field there?

The rms value of E is related to I via:



and so,



since B = E/c for a magnetic field, we will have for Brms­­,



14. If a comet of cross section 5m2 were in the vicinity, what force would it feel coming from the Sun’s radiation?

The force it would feel would be:



7. Suppose you’re floating out in space 1m away from your space station. If you have a flashlight with a 120 W light bulb and shine it directly away from yourself, how long will it take you to reach the space station? Suppose your mass is 70kg. (Hint: remember F = ma, Δx = υt + (1/2)at2).

Suppose you’re floating out in space 1m away from your space station. If you have a flashlight with a 120 W light bulb and shine it directly away from yourself, how long will it take you to reach the space station? Suppose your mass is 70kg. (Hint: remember Δx = υt + (1/2)at2).

The force exerted by the departing radiation is:



a = F/m, so



The time required then is determined from



so,



**Question 8.** A typical helium-neon laser found in supermarket checkout scanners emits 650-nm-wavelength light in a 1mm diameter beam with a power of 2.5mW. (a) What is the amplitude of the oscillating E field? (b) What is the amplitude of the oscillating B field?

