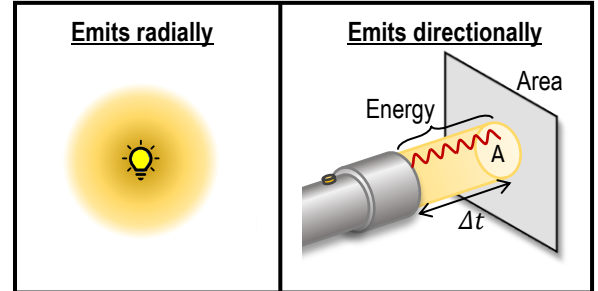


CONCEPT: ELECTROMAGNETIC WAVE INTENSITY

- Remember: ALL waves carry energy, but a more useful measurement is Intensity (I) = $\frac{\text{Energy}}{\text{Time} \cdot \text{Area}}$ **or** $\frac{\text{Power}}{\text{Area}}$.

- The Intensity of EM waves is related to the magnitudes of E & B :

$$I = \frac{P}{A} = \frac{W}{s \cdot m^2} = \frac{J}{s \cdot m^2} \left[\frac{W}{m^2} \right]$$



- IF you can assume the source emits equally in all directions, then $A = 4\pi r^2$. Otherwise, you must determine A .

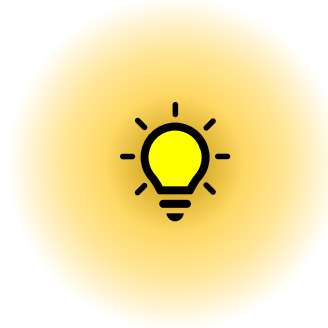
- In some problems, you may be given or asked for “averaged” or root-mean-square (RMS) values instead of maximums.

$$E_{rms} = \frac{E_{max}}{\sqrt{2}} \quad B_{rms} = \frac{B_{max}}{\sqrt{2}}$$

EXAMPLE: An incandescent lightbulb emits 50W of light equally in all directions (with no inefficiencies or energy losses).

- Calculate the intensity of light at a distance of 5m from the lightbulb.
- What is the maximum value of the electric field at this distance?
- What is the rms value of magnetic field at this distance?

CONSTANTS	
$\mu_0 = 1.257 \times 10^{-6}$	$\left[\frac{N}{A^2} \right]$
$\epsilon_0 = 8.854 \times 10^{-12}$	$\left[\frac{C^2}{N \cdot m^2} \right]$



PROBLEM: The average intensity of sunlight at Earth's surface is approximately 1400 W/m². **a)** What are the amplitudes of the electric and magnetic fields for sinusoidal EM waves of this intensity? **b)** If the Earth-Sun distance is approximately 1.5×10¹¹ m, what is the average power output of the Sun?

E.M. WAVES EQUATIONS

$$I = \frac{P}{A} = \frac{1}{2} c \epsilon_0 E_{max}^2 = \frac{1}{2} \frac{c}{\mu_0} B_{max}^2$$

$$E_{rms} = \frac{E_{max}}{\sqrt{2}} \quad ; \quad B_{rms} = \frac{B_{max}}{\sqrt{2}}$$

$$E_{max} = c B_{max}$$

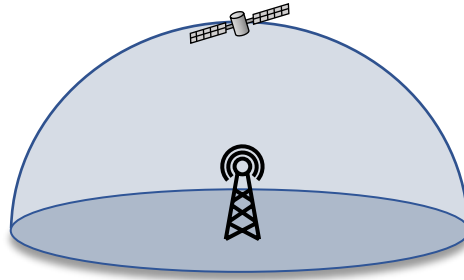
CONSTANTS

$$c = 3.0 \times 10^8 \frac{m}{s}$$

$$\mu_0 = 1.26 \times 10^{-6} \frac{N}{A^2}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{N \cdot m^2}$$

PROBLEM: A radio tower emits a radio wave with an average power output of 50,000W. Assuming the radio tower emits equally in a hemisphere above Earth's surface, calculate **a)** the intensity detected by a satellite passing over at a height of 100km, and **b)** the power received by the satellite's circular radio antenna (radius 0.5m).



E.M. WAVES EQUATIONS

$$I = \frac{P}{A} = \frac{1}{2} c \epsilon_0 E_{max}^2 = \frac{1}{2} \frac{c}{\mu_0} B_{max}^2$$

$$E_{rms} = \frac{E_{max}}{\sqrt{2}} \quad ; \quad B_{rms} = \frac{B_{max}}{\sqrt{2}}$$

$$E_{max} = c B_{max}$$

CONSTANTS

$$c = 3.0 \times 10^8 \frac{m}{s}$$

$$\mu_0 = 1.26 \times 10^{-6} \frac{N}{A^2}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{N \cdot m^2}$$