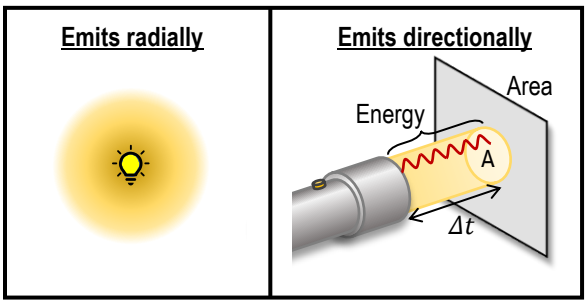
CONCEPT: ELECTROMAGNETIC WAVE INTENSITY

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

- The Intensity of EM waves is related to the magnitudes of $\boldsymbol{E}$ & $\boldsymbol{B}$:



$$I = \frac{P}{A} = \_\_\_\_\_ = \_\_\_\_\_ \left[\frac{\mathrm{W}}{\mathrm{m}^2}\right]$$

- IF you can assume the source emits equally in all directions, then $\boldsymbol{A} =$ _____. Otherwise, you must determine $\boldsymbol{A}$.

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

E_{rms} = ____ B_{rms} = ____

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

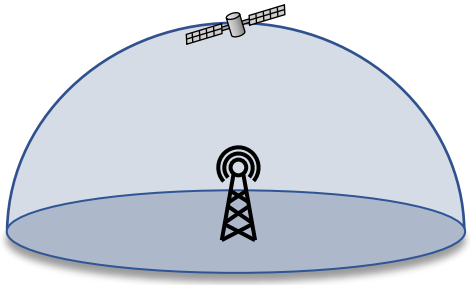
a) Calculate the intensity of light at a distance of 5m from the lightbulb.
b) What is the maximum value of the electric field at this distance?
c) What is the rms value of magnetic field at this distance?

CONSTANTS
$\mu_0 = 1.257\times10^{-6}\left[\frac{N}{A^2}\right]$
$\varepsilon_0 = 8.854\times10^{-12}\left[\frac{C^2}{N\cdot m^2}\right]$

PROBLEM**:** The average intensity of sunlight at Earth's surface is approximately 1400 W/m^2**. 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 1.5×10^{11} m, what is the average power output of the Sun?

E.M. WAVES EQUATIONS
$I = \frac{P}{A} = \frac{1}{2} c\varepsilon_0 E_{max}^2 = \frac{1}{2}\frac{c}{\mu_0} B_{max}^2$
$E_{rms} = \frac{E_{max}}{\sqrt{2}}$; $B_{rms} = \frac{B_{max}}{\sqrt{2}}$
$E_{max} = cB_{max}$
CONSTANTS
$c = 3.0\times10^8 \frac{m}{s}$
$\mu_0 = 1.26\times10^{-6} \frac{N}{A^2}$
$\varepsilon_0 = 8.85\times10^{-12} \frac{C^2}{N\cdot m^2}$

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

$$I = \frac{P}{A} = \frac{1}{2} c\varepsilon_0 E_{max}^2 = \frac{1}{2}\frac{c}{\mu_0} B_{max}^2$$

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

$$E_{max} = cB_{max}$$

CONSTANTS

$c = 3.0\times10^{8}\ \frac{m}{s}$

$\mu_0 = 1.26\times10^{-6}\ \frac{N}{A^2}$

$\varepsilon_0 = 8.85\times10^{-12}\ \frac{C^2}{N\cdot m^2}$