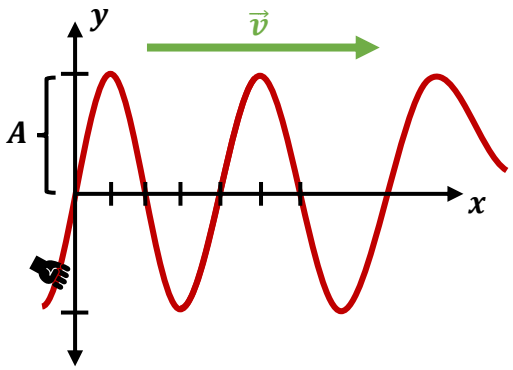
CONCEPT: WAVE FUNCTIONS FOR ELECTROMAGNETIC WAVES

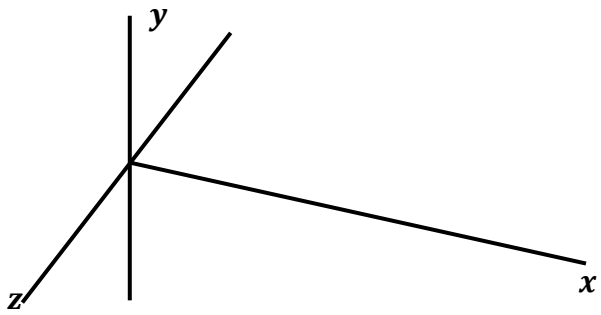
- EM waves are just like other sinusoidal transverse waves, and sometimes you'll have to write their wave functions.
  - Because E.M waves are ____ oscillating waves, you'll need to write ____ wave functions to describe them.

MECHANICAL WAVES



$y(x,t) = A\sin(kx - \omega t)$

ELECTROMAGNETIC WAVES



$E_y(x,t) =$ _____ $\sin(kx - \omega t)$

$B_z(x,t) =$ _____ $\sin(kx - \omega t)$

[**Note**: Your book/class may use $\cos$ instead of $\sin$]

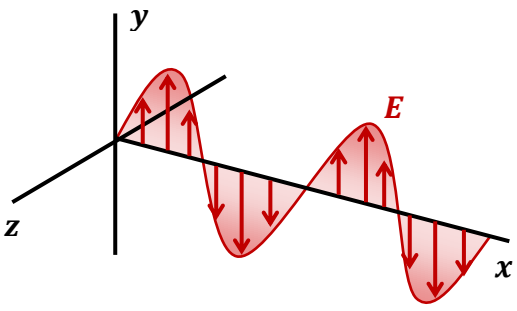
Important Wave Variables/EQs

$k = \frac{2\pi}{\lambda}$ (Wavenumber)

$\omega = 2\pi f = vk$ (Angular Freq.)

- Subscripts below $\boldsymbol{E}$ & $\boldsymbol{B}$ indicate which _____ the field is parallel to
- $\boldsymbol{E}$ & $\boldsymbol{B}$ are ALWAYS "in phase", i.e. they have the same _____
  - They reach min/0/max values _____

EXAMPLE: An infrared laser emits a 10μm wavelength light beam in the z-direction in a vacuum, as shown in the figure below. The $\boldsymbol{E}$-field is parallel to the x-axis and has a max value of 1.5×10^6 V/m, and the $\boldsymbol{B}$-field is parallel to the y-axis. Write the wavefunctions of $\boldsymbol{E}$ and $\boldsymbol{B}$.



- Problems *usually* tell you to use sin or cos, but if they don't show a wave's "start" point with graph/text, choose one!

PROBLEM: Electromagnetic waves produced by X-ray machines typically have a frequency of approximately 3.5×10^{16} Hz. What is the wave number of these waves?

E.M. WAVES EQUATIONS
$k = \frac{2\pi}{\lambda}$
$\omega = 2\pi f = ck$
CONSTANTS
$c = 3.0\times10^{8}$ m/s

PROBLEM: The electric field of an electromagnetic wave is described by the equation $E_y = 54\sin(2\times10^{7}x - \omega t)$.

a) Find the amplitude of the magnetic field.

b) Calculate the frequency of this EM wave.

E.M. WAVES EQUATIONS
$E = E_{max}\, sin(kx - \omega t)$
$B = B_{max}\, sin(kx - \omega t)$
$E_{max} = cB_{max}$
$k = \frac{2\pi}{\lambda}$
$\omega = 2\pi f = ck$
CONSTANTS
$c = 3.0\times10^{8}\ \frac{m}{s}$

PROBLEM: The magnetic field of a travelling electromagnetic wave is described by the wavefunction $B(z,t) = 1.0\times10^{-3} \sin(kz - 1.27\times10^{12}t)$, where k is the wavenumber. Write the *complete* wavefunction for the electric field of this wave.

E.M. WAVES EQUATIONS
$E = E_{max}\, sin(kx - \omega t)$
$B = B_{max}\, sin(kx - \omega t)$
$E_{max} = cB_{max}$
$k = \frac{2\pi}{\lambda}$
$\omega = 2\pi f = ck$
CONSTANTS
$c = 3.0\times10^{8}\ \frac{m}{s}$