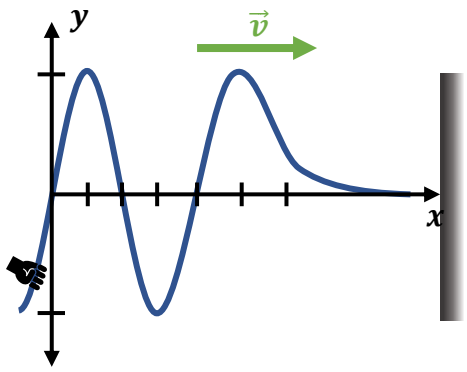
CONCEPT: INTRO TO ELECTROMAGNETIC (EM) WAVES

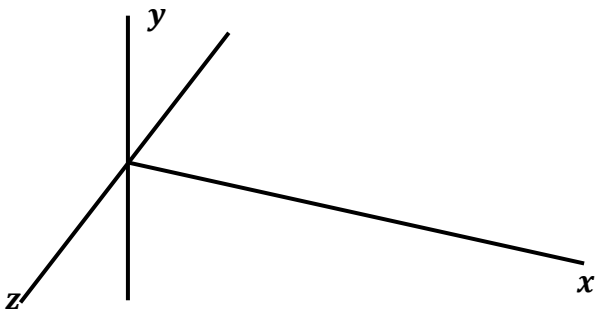
- Remember: Waves are travelling "disturbances" through space.
- Electromagnetic (EM) Waves: Oscillating _____ & _____ fields that are _____.
  - The fields oscillate by constantly changing _____ & _____.

MECHANICAL WAVES



- Direction **[PARALLEL | PERPENDICULAR]** to oscillation

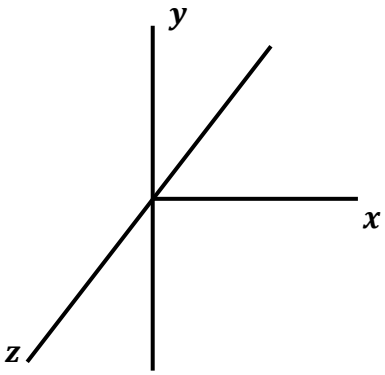
ELECTROMAGNETIC WAVES



- Direction **[PARALLEL | PERPENDICULAR]** to _____ oscillations

- Use Right-Hand-Rule to determine wave direction:
  Point fingers along ___, curl towards ___, thumb points in direction of travel

EXAMPLE: An electromagnetic wave travels in the +z-direction. If the electric field oscillates along the x-axis, draw the magnetic field.



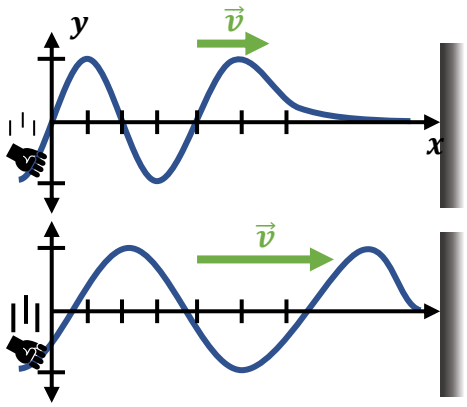
PROBLEM: You measure the electric field of an electromagnetic wave at a particular moment and find it points in the +z direction. The magnetic field points in the +y direction. In which direction is this wave traveling?

CONCEPT: SPEED OF ELECTROMAGNETIC WAVES

- Remember: All waves travel at certain speeds, depending on their type and environment.

MECHANICAL WAVES

(e.g. strings, water, sound)

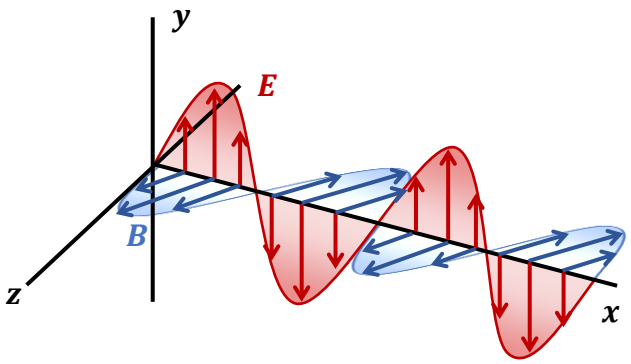


- **[DOES | DOES NOT]** require a medium (material)
- Speed **[DOES | DOES NOT]** depend on medium

$$v_{string} = \sqrt{\frac{F_T}{\left(\frac{m}{L}\right)}} = \lambda f$$

ELECTROMAGNETIC WAVES

(e.g. light, radio waves, x-rays)



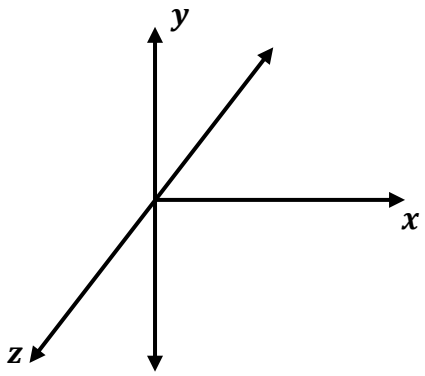
- **[DOES | DOES NOT]** require a medium (material)
- Speed **[DOES* | DOES NOT]** depend on medium

*Unless explicitly stated otherwise, assume waves travel in a vacuum!

$$\_\_\_ = \_\_\_\_\_ = \_\_\_ = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$$ (speed of light in vacuum)

- The _____ of the field magnitudes at any point is ALWAYS equal to c.

EXAMPLE: An electromagnetic wave travels in the –z direction. At a particular point and particular instant, the electric field oscillates along the +x-axis and has a magnitude of 500 V/m. What is the magnitude and direction of the magnetic field at this point and instant?



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**:** You measure the magnetic field strength of a travelling electromagnetic wave to be 8.0×10^{-7} T, oriented along the +x direction**.** If this EM wave moves in the +y direction, what is the magnitude and direction of the wave's electric field at that same exact spot?

E.M. WAVES EQUATIONS
$\boldsymbol{E = cB}$
CONSTANTS
$\boldsymbol{c}$ **=** 3.0×10^{8} m/s

PROBLEM**:** A Martian rover uses radio pulses (electromagnetic waves) to relay data to scientists on Earth**.** If the pulses take 12 minutes to arrive, how far apart are Mars and Earth?

E.M. WAVES EQUATIONS
$\boldsymbol{E = cB}$
CONSTANTS
$\boldsymbol{c}$ **=** 3.0×10^{8} m/s