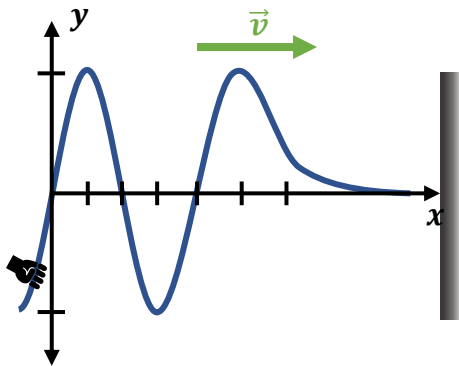


CONCEPT: INTRO TO ELECTROMAGNETIC (EM) WAVES

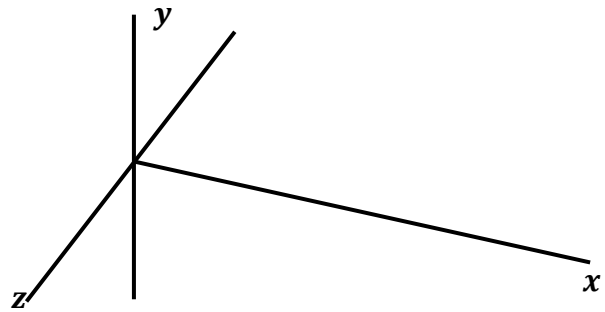
- Remember: Waves are travelling “disturbances” through space.
- Electromagnetic (EM) Waves: Oscillating _____ & _____ fields that are _____.
 - The fields oscillate by constantly changing _____ & _____.

MECHANICAL WAVES



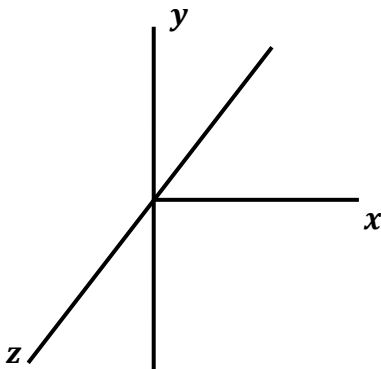
- Direction [**PARALLEL** | **PERPENDICULAR**] to oscillation

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.



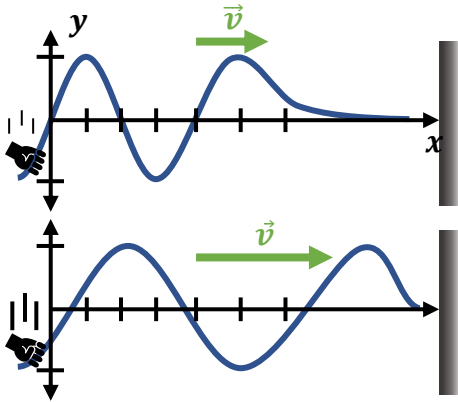
PROBLEM: You measure the electric field of an electromagnetic wave at a particular moment and find it points in the $+z$ direction. The magnetic field points in the $+y$ direction. In which direction is this wave traveling?

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)

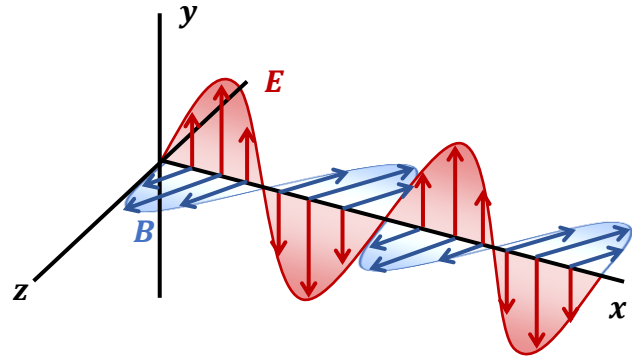


- [DOES | DOES NOT] require a medium (material)
- Speed [DOES | DOES NOT] depend on medium

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

ELECTROMAGNETIC WAVES

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



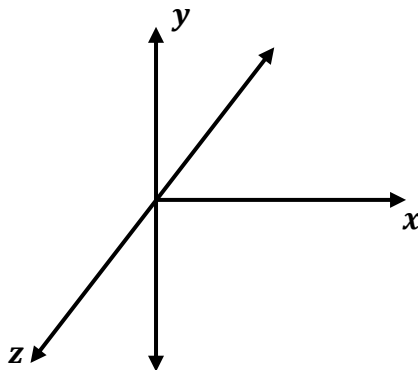
- [DOES | DOES NOT] require a medium (material)
- Speed [DOES* | DOES NOT] depend on medium

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

$$\text{---} = \text{---} = \text{---} = \frac{1}{\sqrt{\mu_0 \epsilon_0}} \quad (\text{speed of light in vacuum})$$

- 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

$$\mu_0 = 1.257 \times 10^{-6} \left[\frac{N}{A^2} \right]$$

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

PROBLEM: You measure the magnetic field strength of a travelling electromagnetic wave to be $8.0 \times 10^{-7} \text{ T}$, 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
$E = cB$
CONSTANTS
$c = 3.0 \times 10^8 \text{ m/s}$

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
$E = cB$
CONSTANTS
$c = 3.0 \times 10^8 \text{ m/s}$