

CONCEPT: WAVE FUNCTIONS

- A **wave function** is a _____ equation describing an oscillating wave.

- It gives **DISPLACEMENT** (y) when you *plug in* 2 values, **POSITION** (x) and **TIME** (t).

$$y(x, t) = \underline{\hspace{2cm}}$$

(Use when wave starts at $y = \underline{\hspace{1cm}}$)

OR

$$y(x, t) = \underline{\hspace{2cm}}$$

(Use when wave starts at $y = \underline{\hspace{1cm}}$)

- A = Amplitude

- k = Wavenumber →

$$k = \frac{2\pi}{\lambda}$$

(Units: —)

- ω = Angular frequency →

$$\omega = \frac{2\pi}{T} = 2\pi f$$

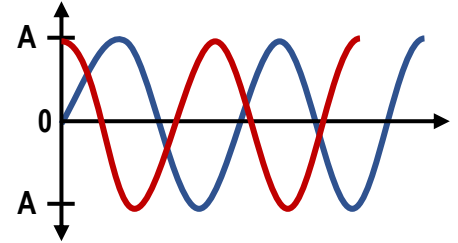
(Units: $\frac{rad}{s}$)

- The **DIRECTION** of the wave determines the **SIGN** of $(kx \pm \omega t)$. The direction is *opposite* to the sign:

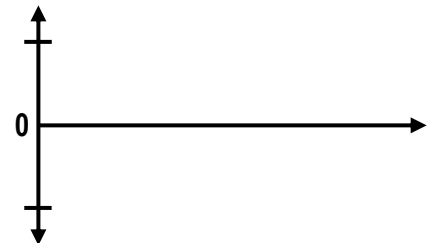
If wave moves **RIGHT** ($+x$), the SIGN is $[+ | -] \Rightarrow (kx \ \omega t)$

If wave moves **LEFT** ($-x$), the SIGN is $[+ | -] \Rightarrow (kx \ \omega t)$

(* make sure calculator is in **RADIANS** mode)



EXAMPLE: You whip a rope up & down to create a transverse wave moving to the right. The amplitude is 0.5m, the wave speed is 8m/s, and the wavelength is 0.32m. At $t=0$, the end of the rope you're holding is at the maximum upward displacement. **a)** Write the wave function for this wave. **b)** Calculate the displacement of a particle at $x = 0.4\text{m}$ at $t = 0.75\text{s}$.



- When asked to just write the wave function, you only plug in values for A , k , & ω , but NOT for x & t .

PROBLEM: A transverse harmonic wave moving to the left has a wavelength of 2.5m and a wave speed of 12 m/s. The amplitude of the wave is 0.1m. At $x=0$ and $t=0$, the displacement of the wave is $y = 0$. Write the wave function for this wave.

- A) $y(x, t) = 0.1\sin(2.51x + 30.2t)$
- B) $y(x, t) = 0.1\cos(2.51x - 30.2t)$
- C) $y(x, t) = 0.1\sin(2.5x + 15.7t)$
- D) $y(x, t) = 0.1\sin(15.7x + 188.5t)$

WAVES
$v = \lambda f$ $v = \sqrt{\frac{F_T}{\mu}}$ (for strings only) $y(x, t) = A \sin(kx \pm \omega t)$ $y(x, t) = A \cos(kx \pm \omega t)$ $k = \frac{2\pi}{\lambda}$ $\omega = \frac{2\pi}{T} = 2\pi f$

PROBLEM: A certain wave is modeled by the wavefunction $y(x, t) = 6.5\cos\left(\frac{2\pi}{28}x + \frac{2\pi}{0.36}t\right)$? Calculate the a) wavelength; b) frequency of the wave. c) What direction does this wave travel?

WAVES
$v = \lambda f$ $v = \sqrt{\frac{F_T}{\mu}}$ (for strings only) $y(x, t) = A \sin(kx \pm \omega t)$ $y(x, t) = A \cos(kx \pm \omega t)$ $k = \frac{2\pi}{\lambda}$ $\omega = \frac{2\pi}{T} = 2\pi f$

CONCEPT: CALCULATING WAVE SPEED USING THE WAVEFUNCTION

- Sometimes given $y(x, t)$ of a transverse wave, you'll have to calculate v .
 - We can calculate v directly from ___ & ___

$$v_{\text{wave}} = \lambda f = \text{---}$$

- This speed is also sometimes called the Propagation Velocity.

WAVES

$$v = \lambda f$$

$$v = \sqrt{\frac{F_T}{\mu}} \text{ (for strings only)}$$

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

$$y(x, t) = A \cos(kx \pm \omega t)$$

$$k = \frac{2\pi}{\lambda}$$

$$\omega = \frac{2\pi}{T} = 2\pi f$$

EXAMPLE: A traveling transverse wave on a string can be modeled by the equation $y(x, t) = 3\cos(0.4x - 6t)$. Calculate the wave speed.

PROBLEM: A wave given by the wave function $y(x, t) = (6\text{mm}) \sin \left[\left(5 \frac{\text{rad}}{\text{mm}} \right) x - \left(600 \frac{\text{rad}}{\text{s}} \right) t \right]$ travels along a string. How long does it take for any given particle on the string to travel between $y = +6\text{mm}$ and $y = -6\text{mm}$?

WAVES

$$v = \lambda f$$

$$v = \sqrt{\frac{F_T}{\mu}} \quad (\text{for strings only})$$

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

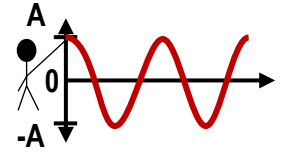
$$y(x, t) = A \cos(kx \pm \omega t)$$

$$k = \frac{2\pi}{\lambda}$$

$$\omega = \frac{2\pi}{T} = 2\pi f$$

CONCEPT: TRANSVERSE VELOCITY OF WAVES

- “Velocity of transverse waves” & “transverse velocity of waves” sound similar, but are different.



VELOCITY OF TRANSVERSE WAVES

(a.k.a. PROPAGATION VELOCITY)

(Velocity of WAVE PATTERN moving left/right)

$$v = \lambda f = \frac{\omega}{k}$$

- Constant at all points on the wave

TRANSVERSE VELOCITY OF WAVES

(*Perpendicular* Velocity of the _____ on the wave moving _____)

If using

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

, use

$$v_T(x, t) = \underline{\hspace{2cm}}$$

If using

$$y(x, t) = A \cos(kx \pm \omega t)$$

, use

$$v_T(x, t) = \underline{\hspace{2cm}}$$

- Changes with position (**x**) and time (**t**) on the wave

- The *maximum* transverse velocity:

$$v_{T,max} = \underline{\hspace{2cm}}$$

EXAMPLE: A traveling transverse wave on a string can be modeled by the equation $y(x, t) = 3\cos(0.4x - 6t)$.

a) Calculate the velocity of the wave (i.e. propagation velocity).

b) Calculate the transverse velocity of a particle at $x = 0.75\text{m}$ when $t = 0.2\text{s}$.

c) Calculate the maximum transverse velocity of particles on the string.