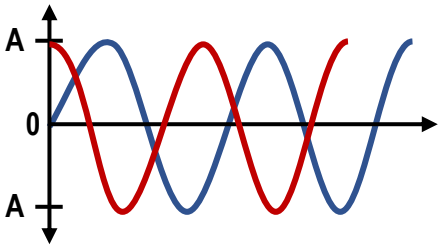
CONCEPT: WAVE FUNCTIONS

● 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).

$y(x,t) =$ _____ **OR** $y(x,t) =$ _____

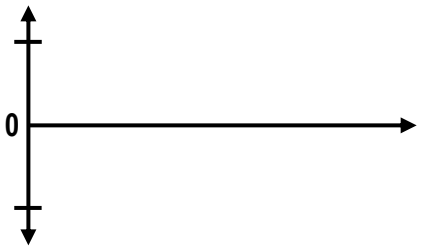
(Use when wave starts at y = __) (Use when wave starts at y = ____)



- **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 ± ωt).** The direction is *opposite* to the sign:
  If wave moves RIGHT (+x), the SIGN is **[+ | –] ⇒ (kx ωt)**
  If wave moves LEFT (–x), the SIGN is **[+ | –] ⇒ (kx ωt)**

(* *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 = 0.4m at t = 0.75s**.**



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

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

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

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

CONCEPT: CALCULATING WAVE SPEED USING THE WAVEFUNCTION

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

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

$$v_{wave} = \lambda f = \text{——}$$

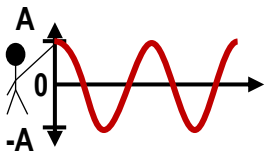
  - This speed is also sometimes called the Propagation Velocity.

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

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

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 $v_T(x,t) =$ _____

If using $y(x,t) = A\cos(kx \pm \omega t)$, use $v_T(x,t) =$ _____

- Changes with position (**x**) and time (**t**) on the wave
- The *maximum* transverse velocity: $v_{T,max} =$ _____

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 = 0.75m when t = 0.2s.

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