By shaking one end of a stretched string, a single pulse is generated. The traveling pulse carries

A. energy

B. momentum

C. both energy and momentum

D. neither energy nor momentum

Text ‘PHYSJC’ and your answer to 22333

Announcements

- Homework 13 (next week) is extra credit
- Lab 9 this week (in your lab manual)
- Lab B next week (handout)
- Final Exam: Friday, May 13, 10:15am-12:15pm **CR 306**

Ch 15.1-3
Mechanical Waves

PHYS 1210 -- Prof. Jang-Condell

Chapter 15

Mechanical Waves

PowerPoint® Lectures for
University Physics, Thirteenth Edition
– Hugh D. Young and Roger A. Freedman

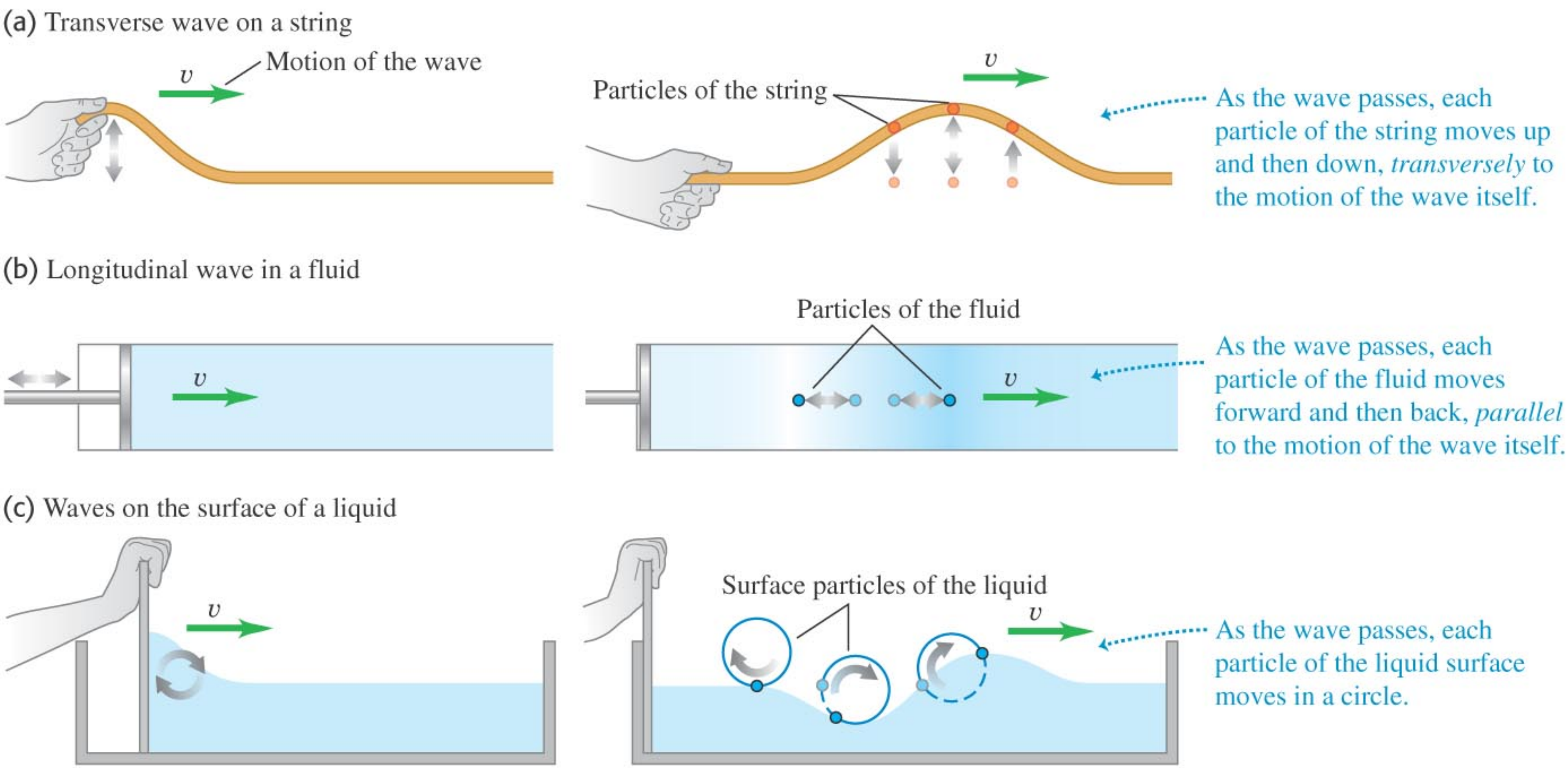
Lectures by Wayne Anderson

Goals for Chapter 15

- To study the properties and varieties of mechanical waves
- To relate the speed, frequency, and wavelength of periodic waves
- To interpret periodic waves mathematically
- To calculate the speed of a wave on a string
- To calculate the energy of mechanical waves
- To understand the interference of mechanical waves
- To analyze standing waves on a string
- To investigate the sound produced by stringed instruments

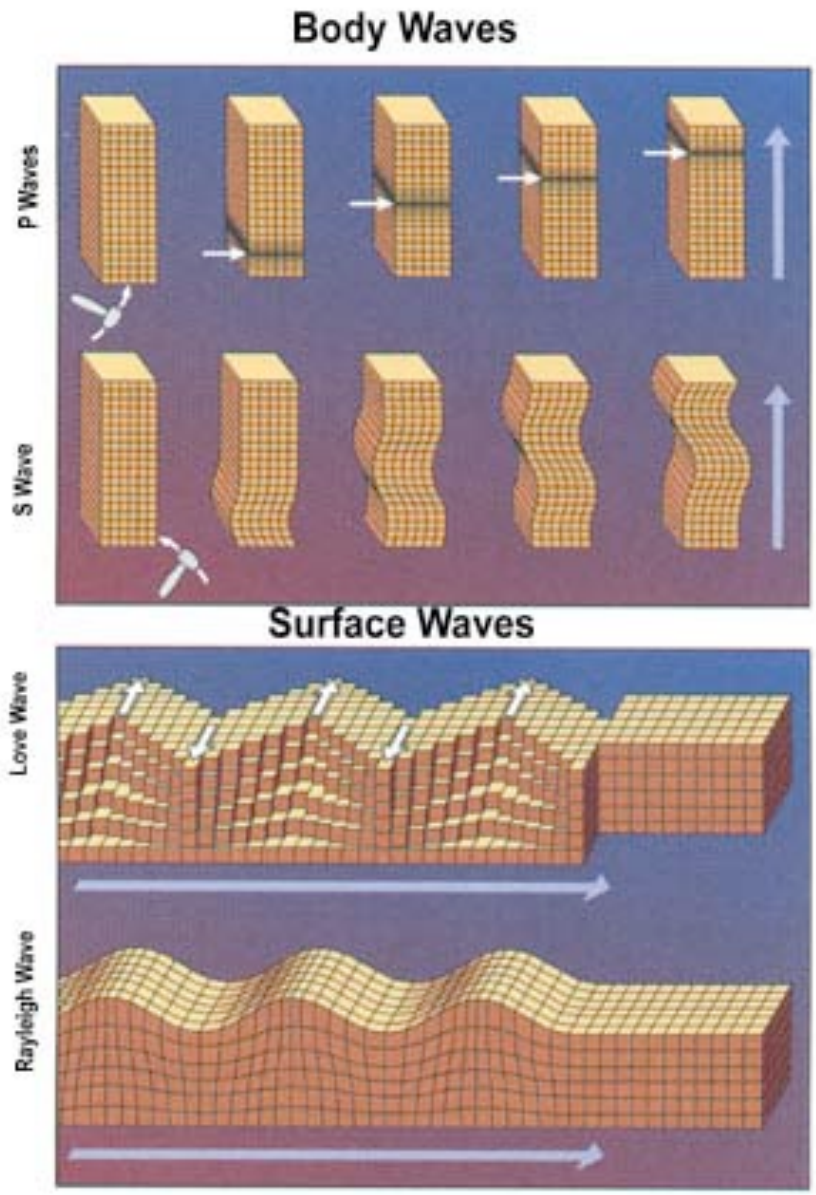
Types of mechanical waves

- A *mechanical wave* is a disturbance traveling through a *medium*.
- Figure 15.1 below illustrates *transverse waves* and *longitudinal waves*.



Slinky Demo

Seismic Waves



- P Waves = pressure waves
- S Waves = shear waves
- 2 types of surface waves

Image credit: http://earthquake.usgs.gov

Speed of seismic waves

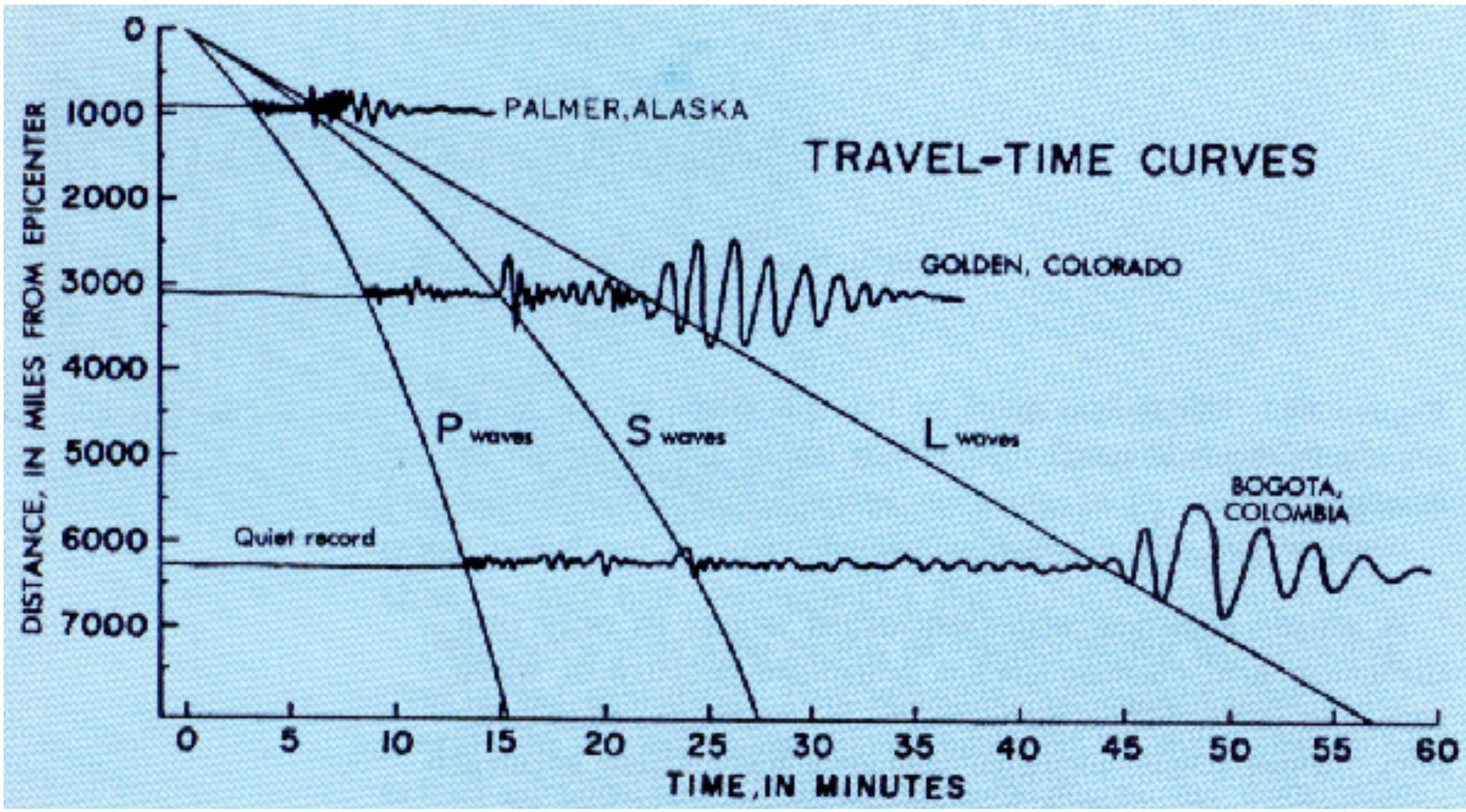


Image credit: http://earthquake.usgs.gov

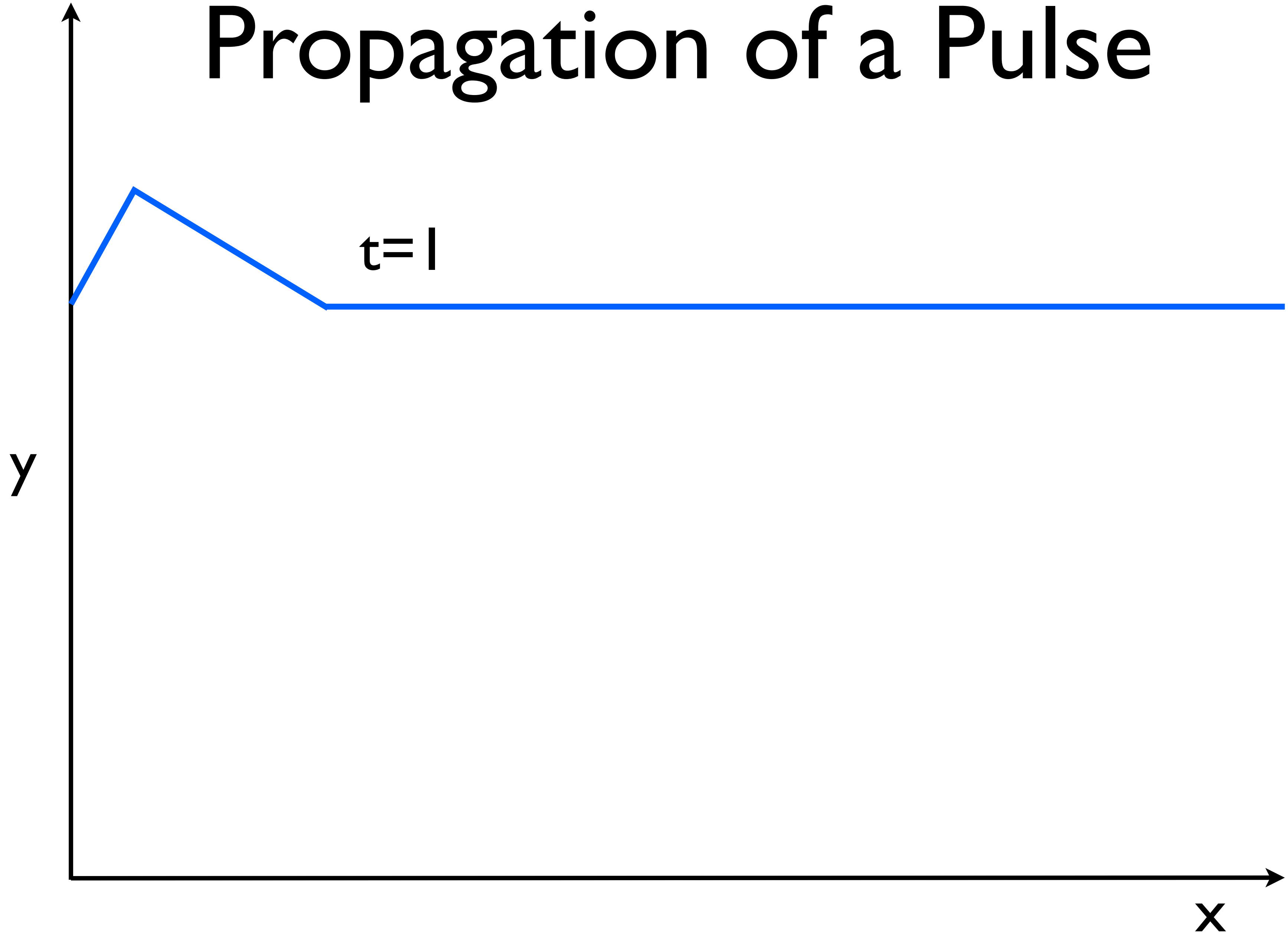
In a mechanical wave, the particles move and then go back to where they started. The wave travels, or **propagates**, through the medium, the particles don't.

The Wave

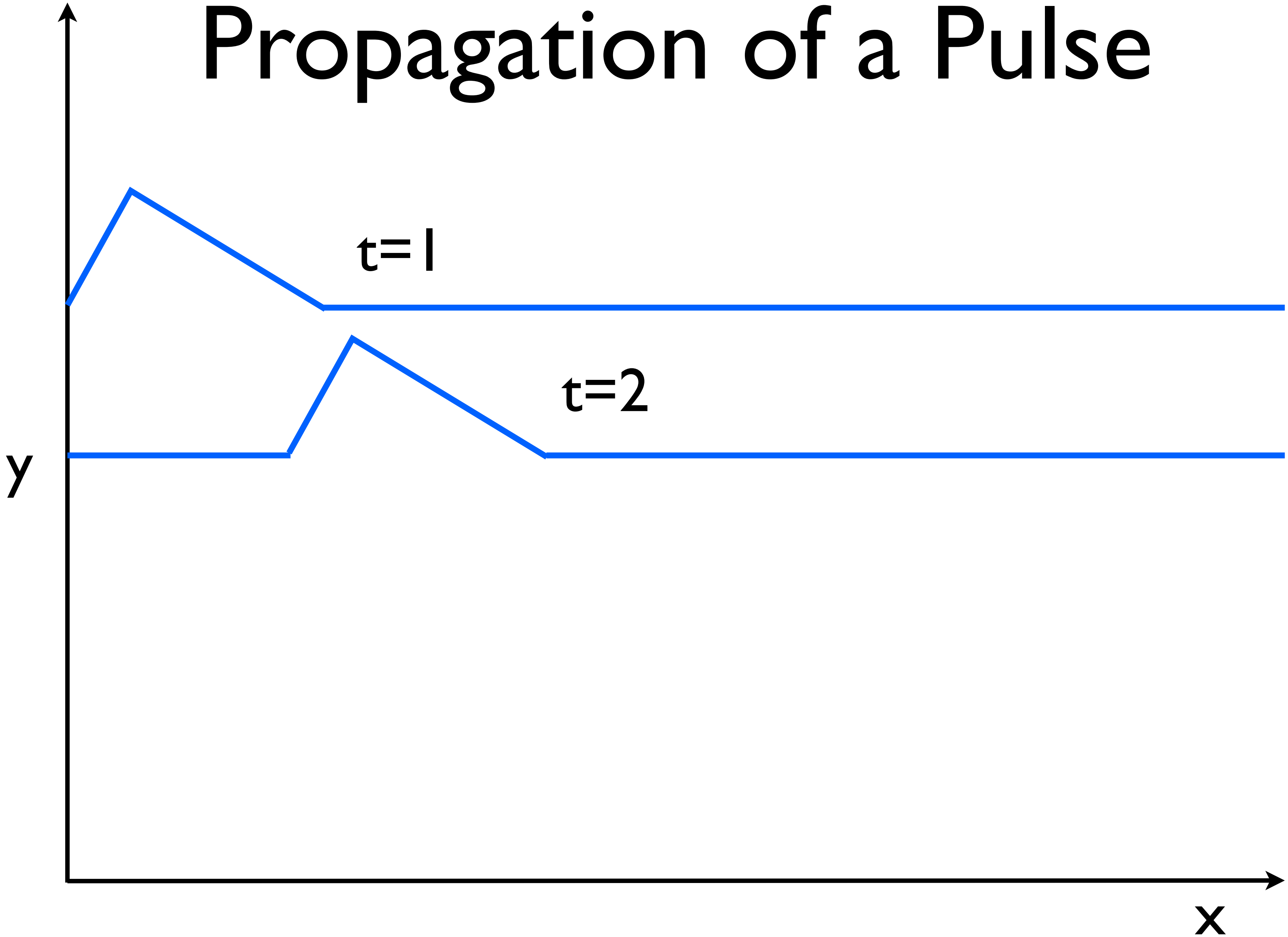
- A **pulse** is a wave created by a perturbation of short duration

- A **periodic wave** is created by periodic motion, such as simple harmonic motion

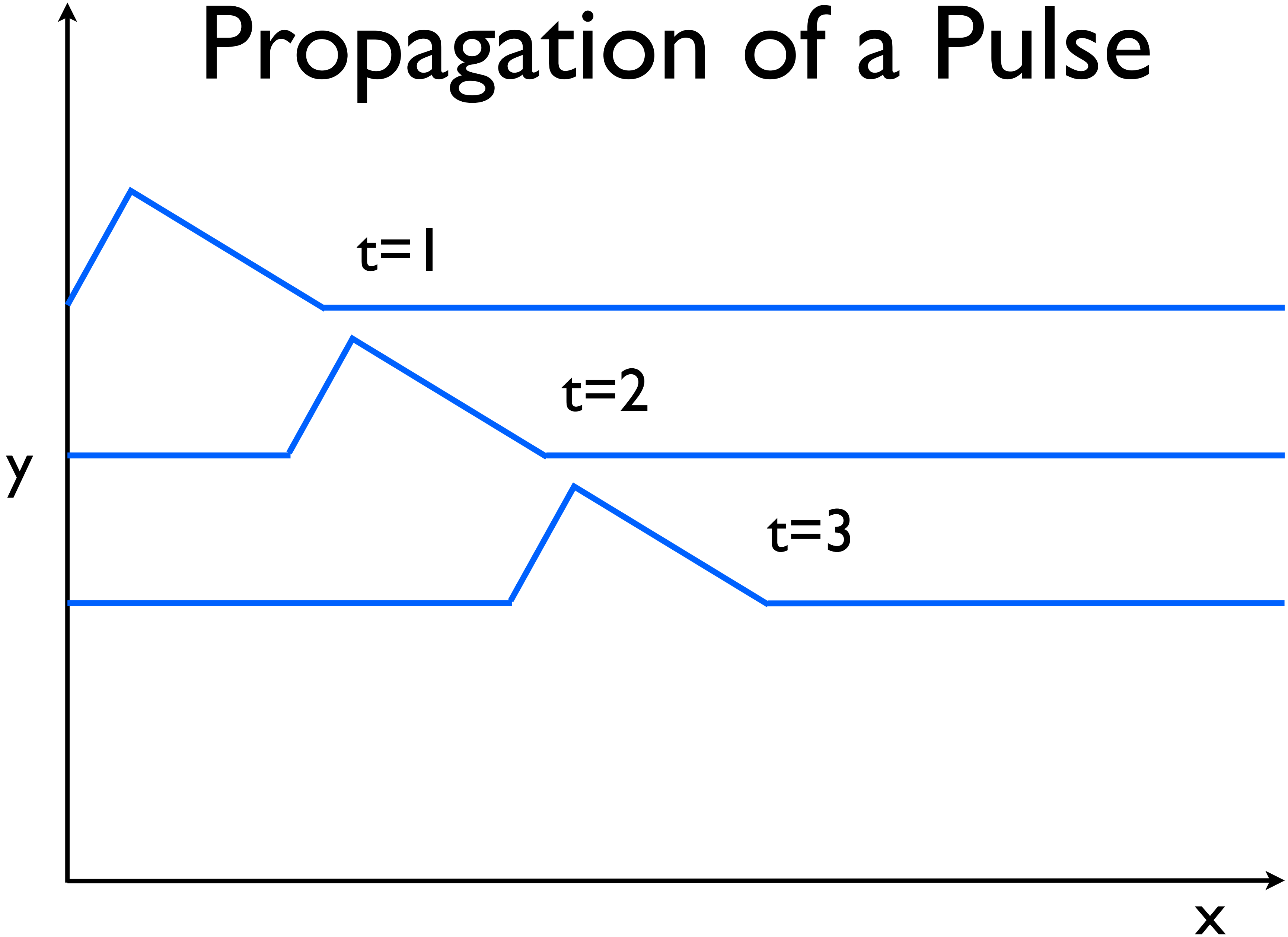
Propagation of a Pulse



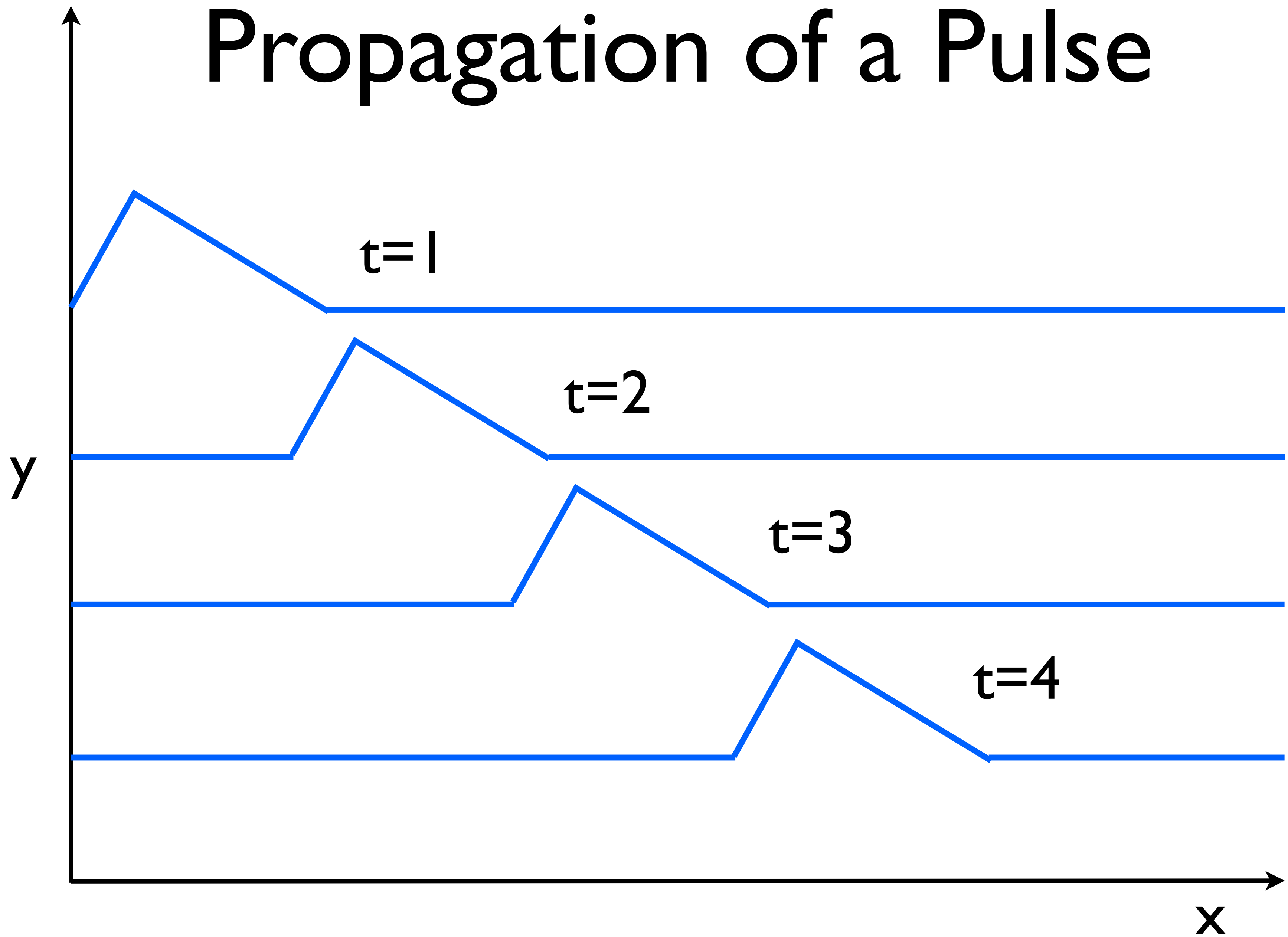
Propagation of a Pulse



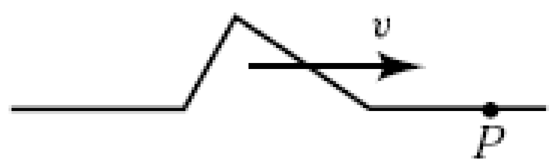
Propagation of a Pulse

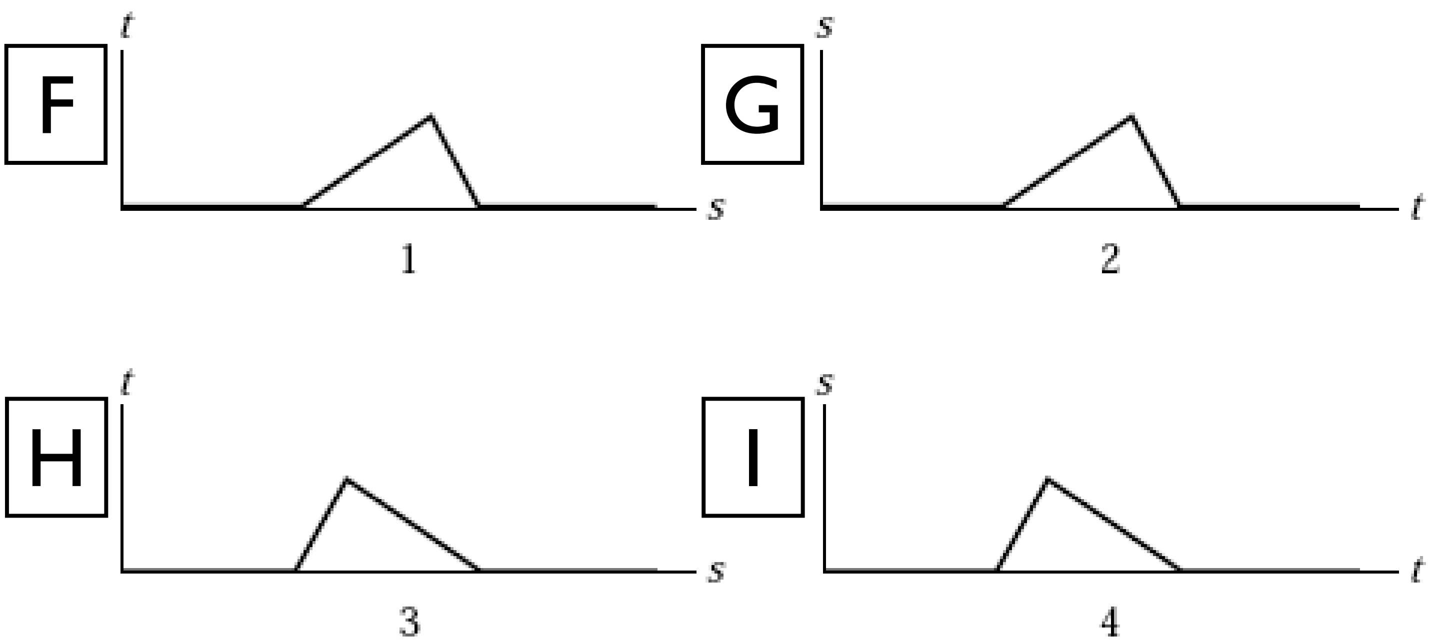


Propagation of a Pulse

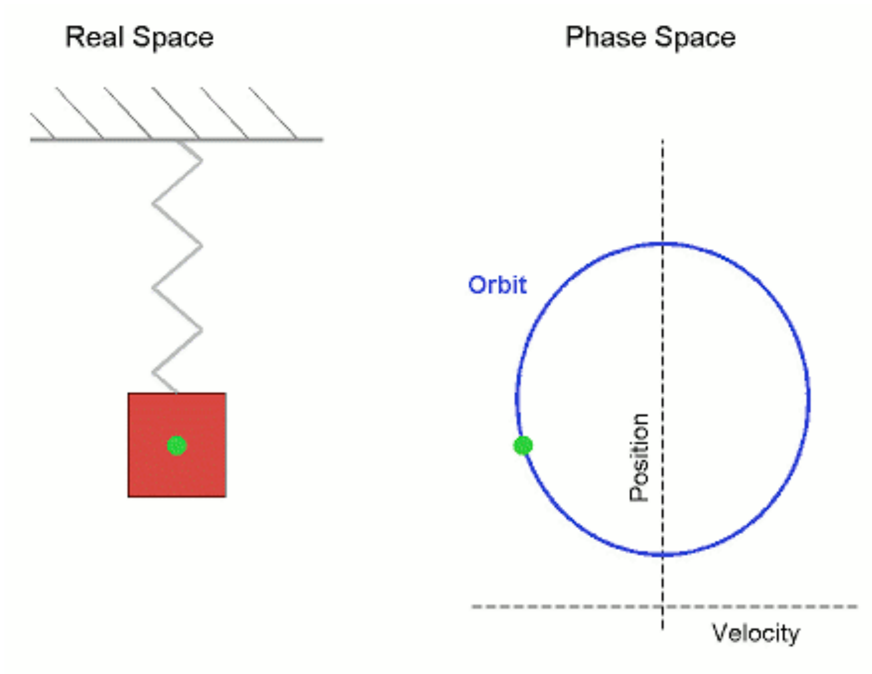


A wave pulse is moving, as illustrated, with uniform speed v along a rope. Which of the graphs 1–4 below correctly shows the relation between the displacement s of point P and time t ?





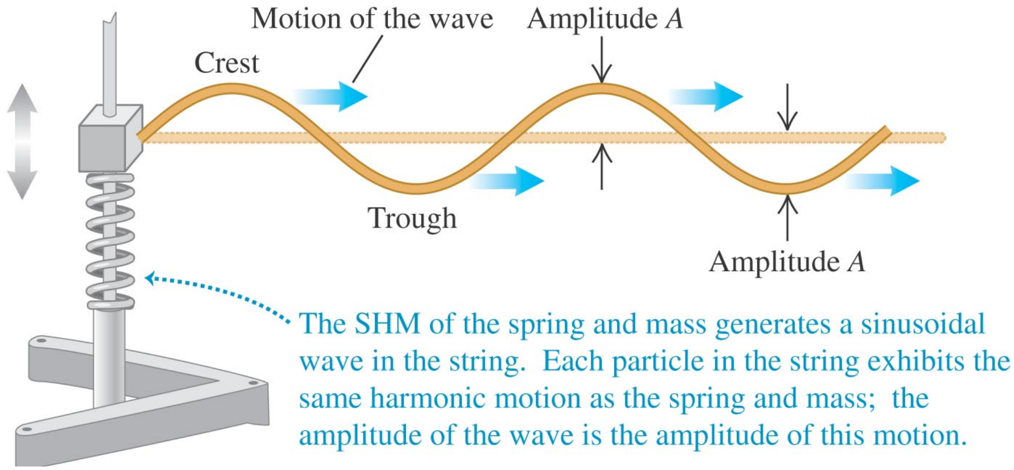
Periodic Waves

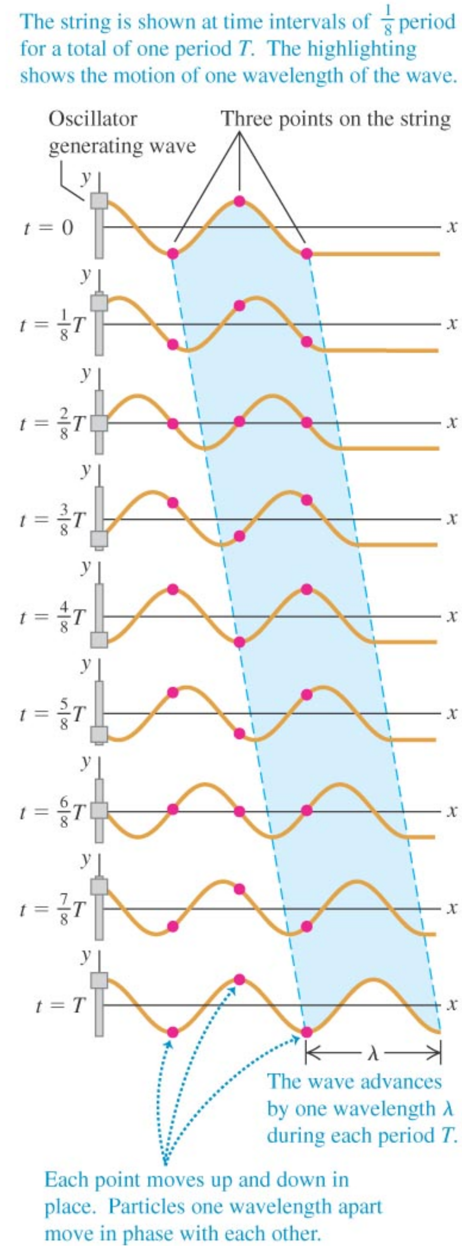


The angular frequency (ω) of the oscillator is the angular speed (ω) of the circle.

Periodic transverse waves

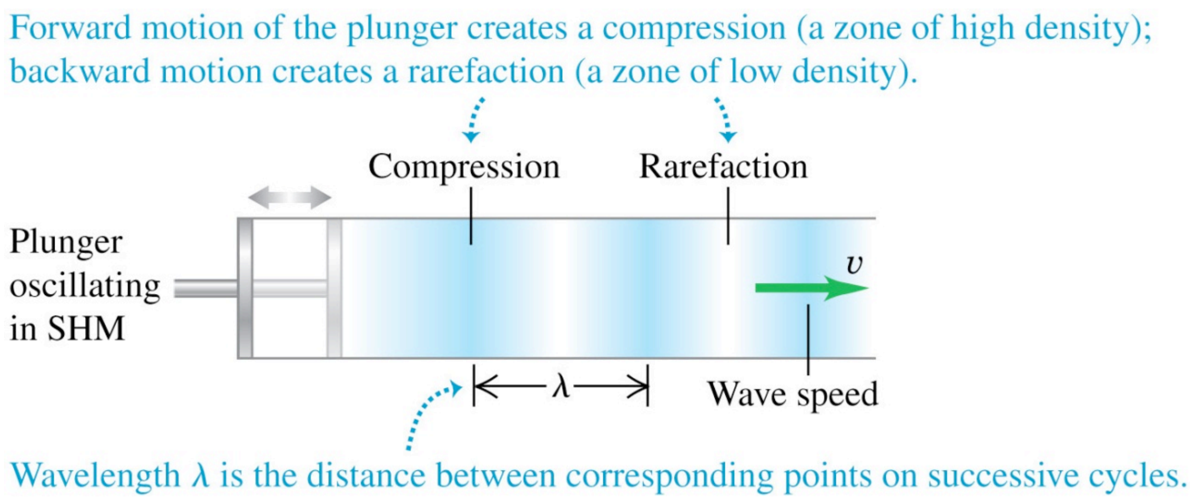
- For the transverse waves shown here in Figures 15.3 and 15.4, the particles move up and down, but the wave moves to the right.

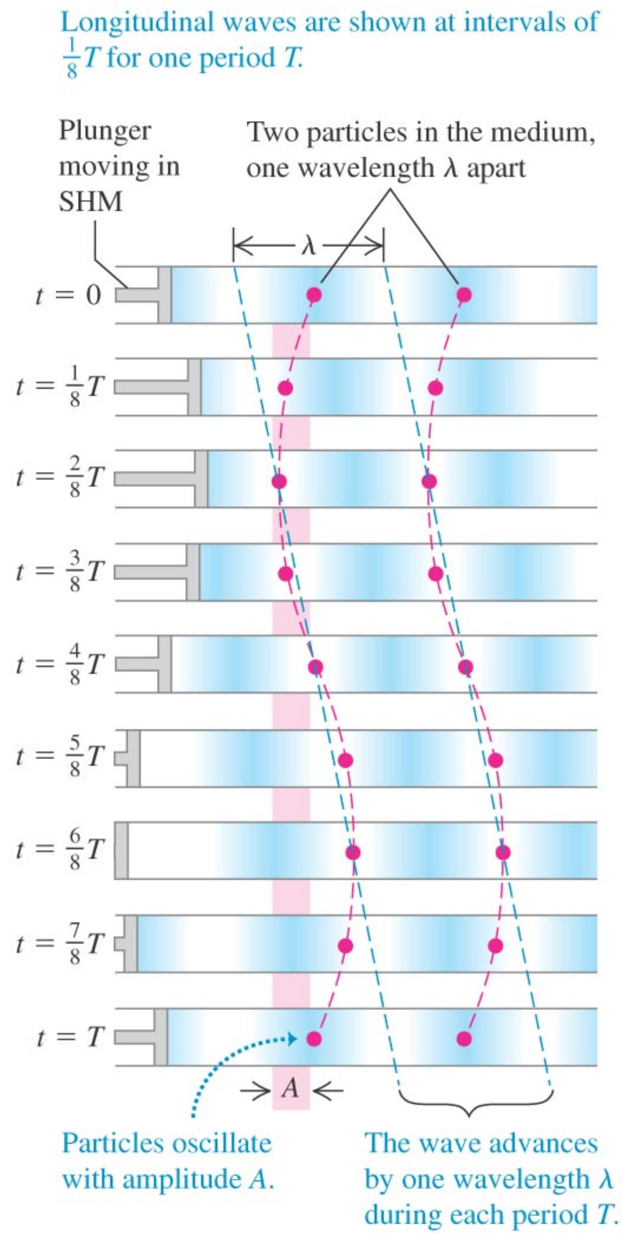




Periodic longitudinal waves

- For the longitudinal waves shown here in Figures 15.6 and 15.7, the particles oscillate back and forth along the same direction that the wave moves.
- Follow Example 15.1.

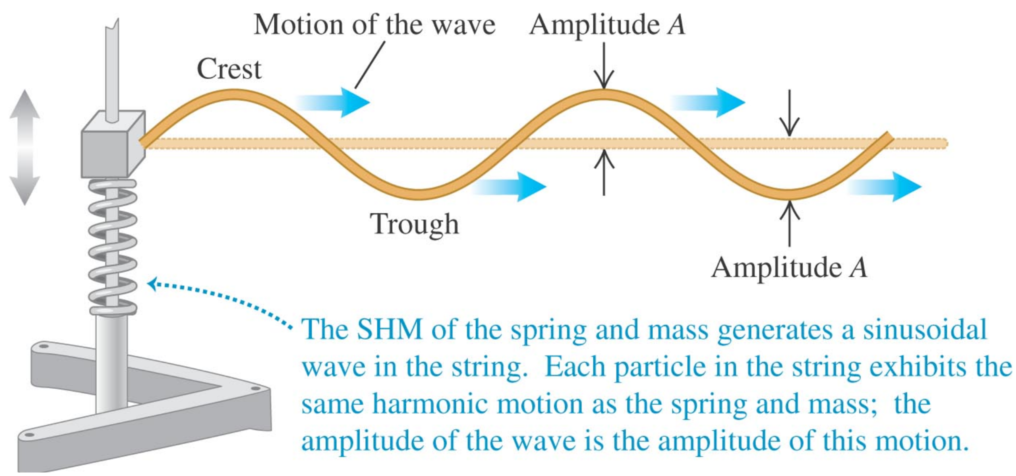




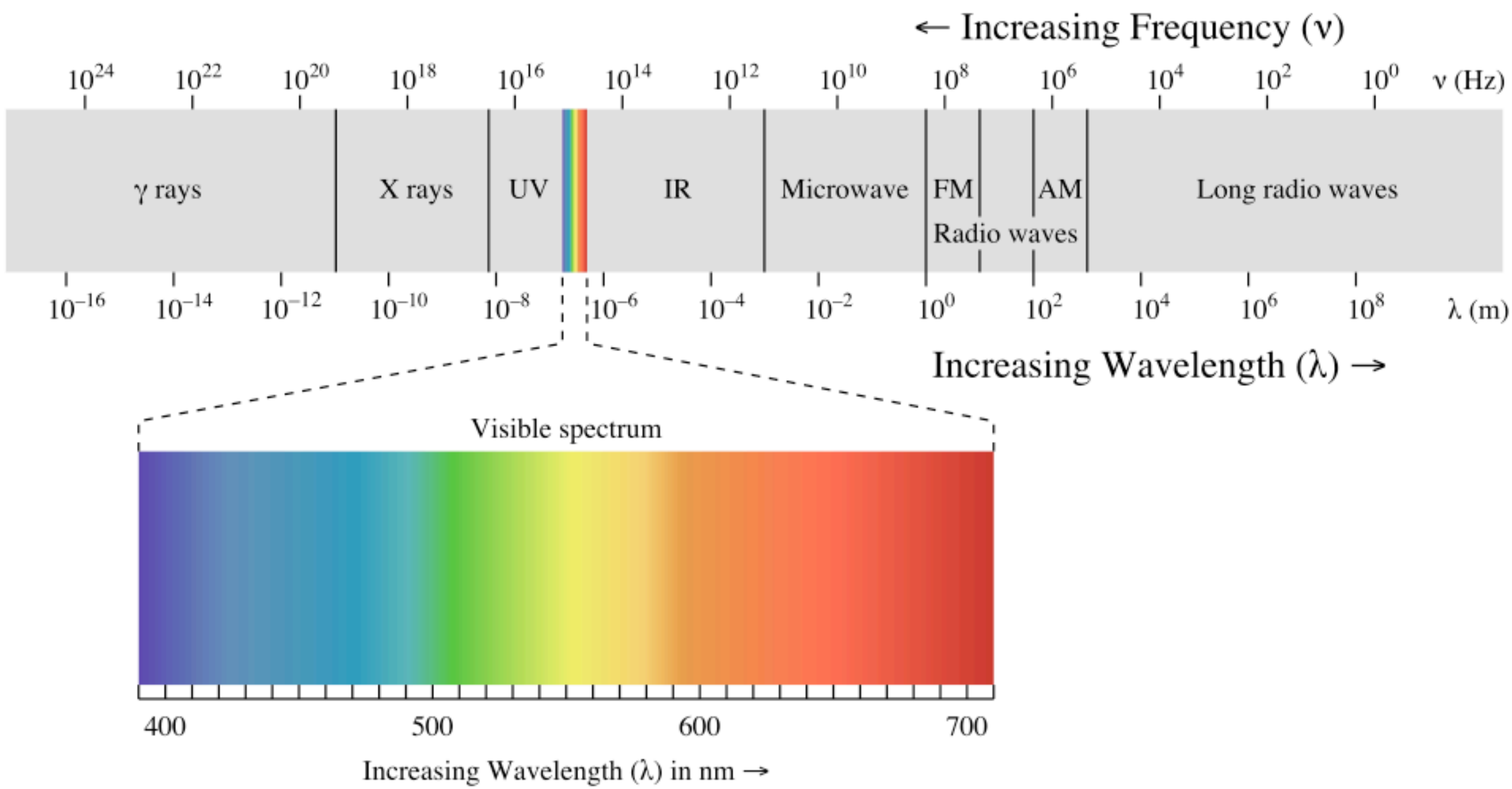
Periodic waves

- For a *periodic wave*, each particle of the medium undergoes periodic motion.
- The *wavelength* λ of a periodic wave is the length of one complete wave pattern.
- The speed of any periodic wave of frequency f is

$$v = \lambda f.$$



Electromagnetic Radiation



Electromagnetic Radiation

Wyoming Public Radio broadcasts from UW at 91.9 MHz (1 MHz = 10^6 s^{-1}). If the speed of EM waves is $3x10^8$ m/s, what is the wavelength of this radiation?

K. $2.8x10^{14}$ m

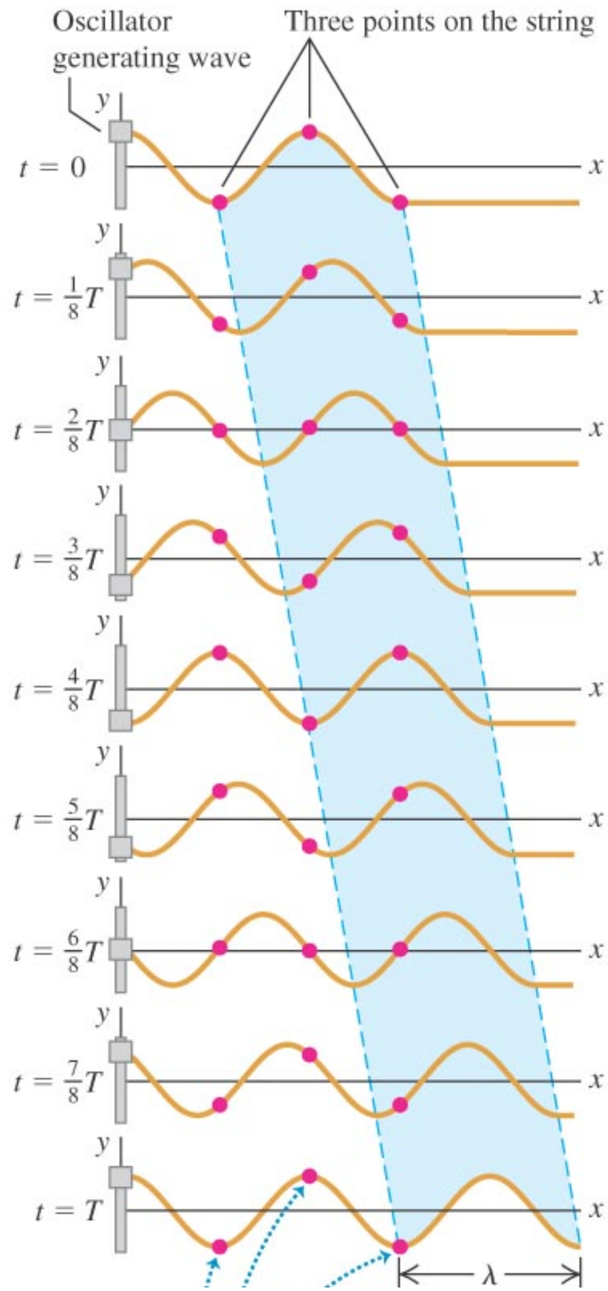
L. $3.26x10^6$ m

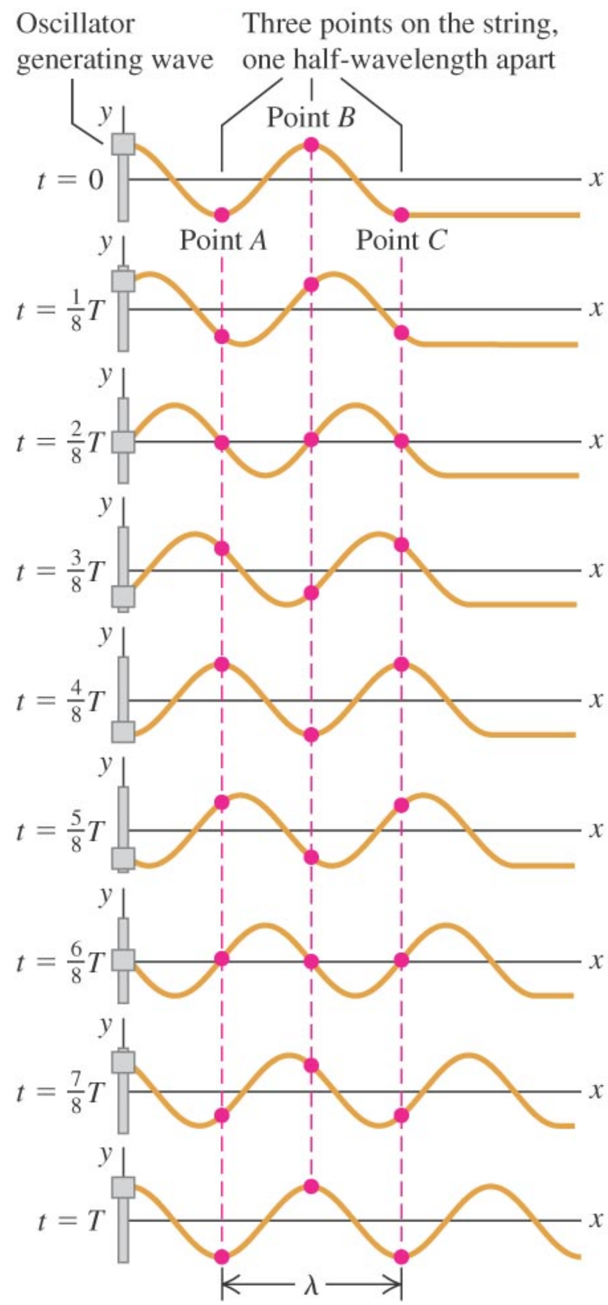
M. 3.26 m

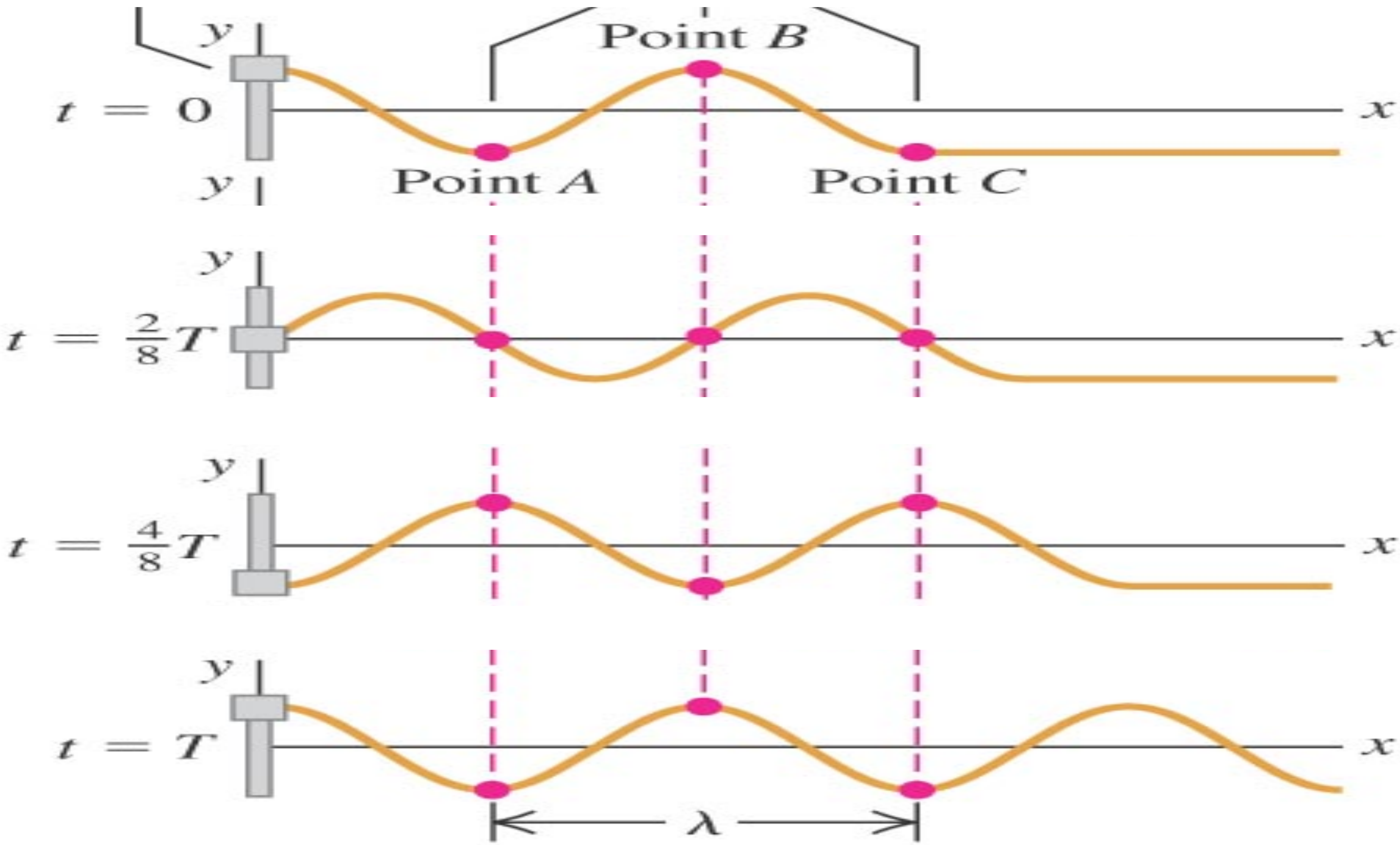
N. 0.306 m

P. None of the above

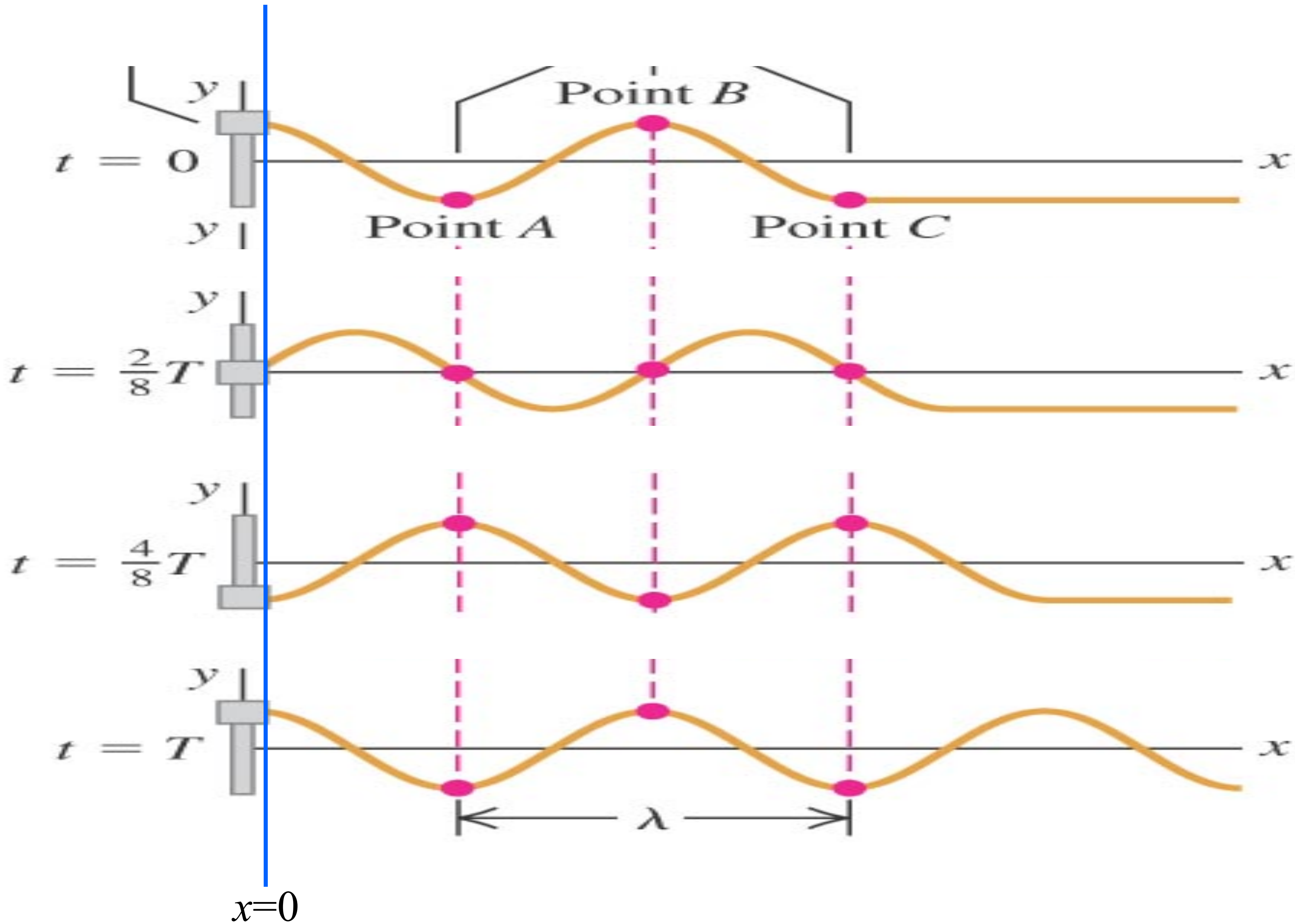
Text 'PHYSJC' and your answer to 22333.

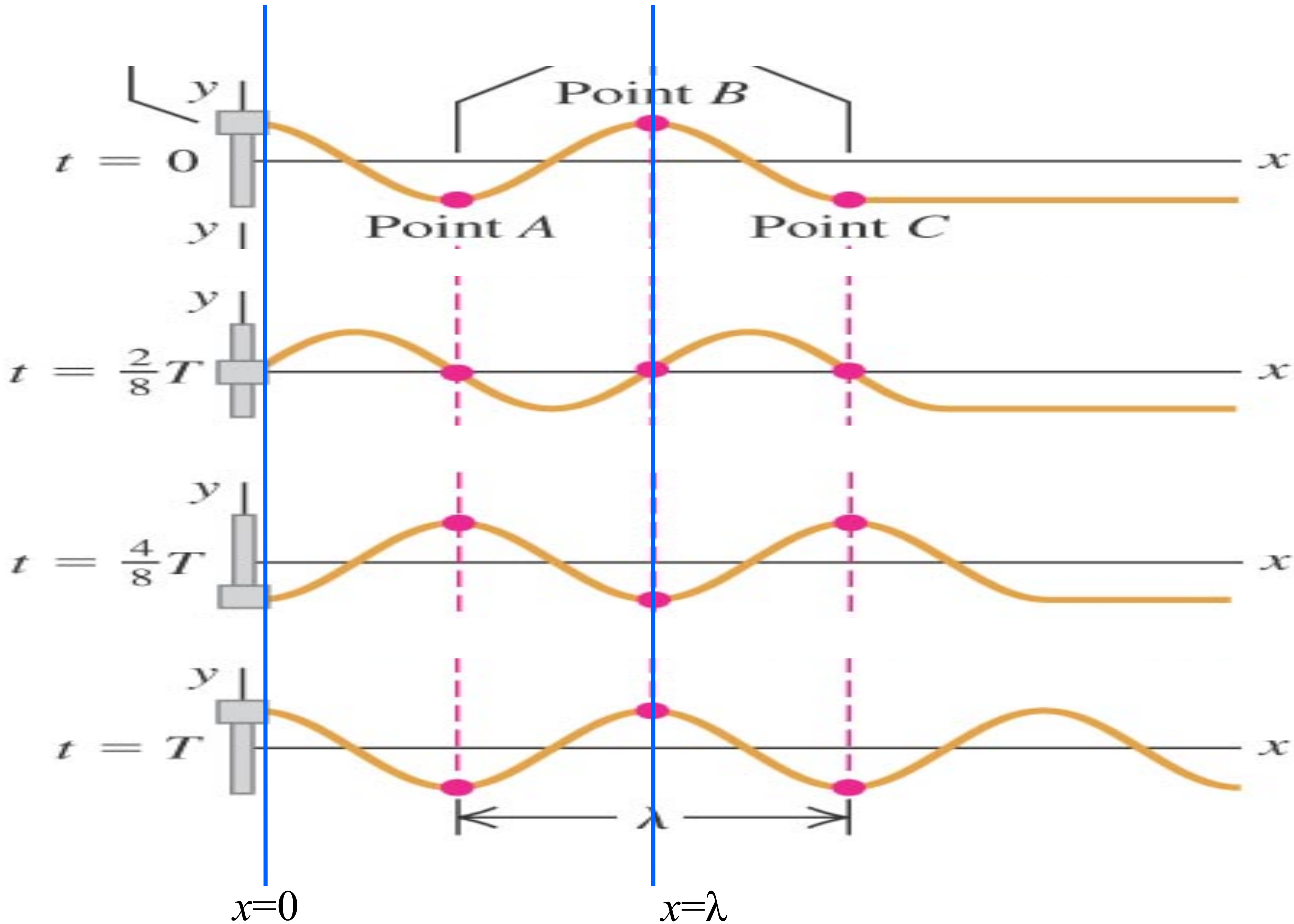

Oscillator generating wave
Three points on the string
t = 0
t = 1/8 T
t = 2/8 T
t = 3/8 T
t = 4/8 T
t = 5/8 T
t = 6/8 T
t = 7/8 T
t = T
λ

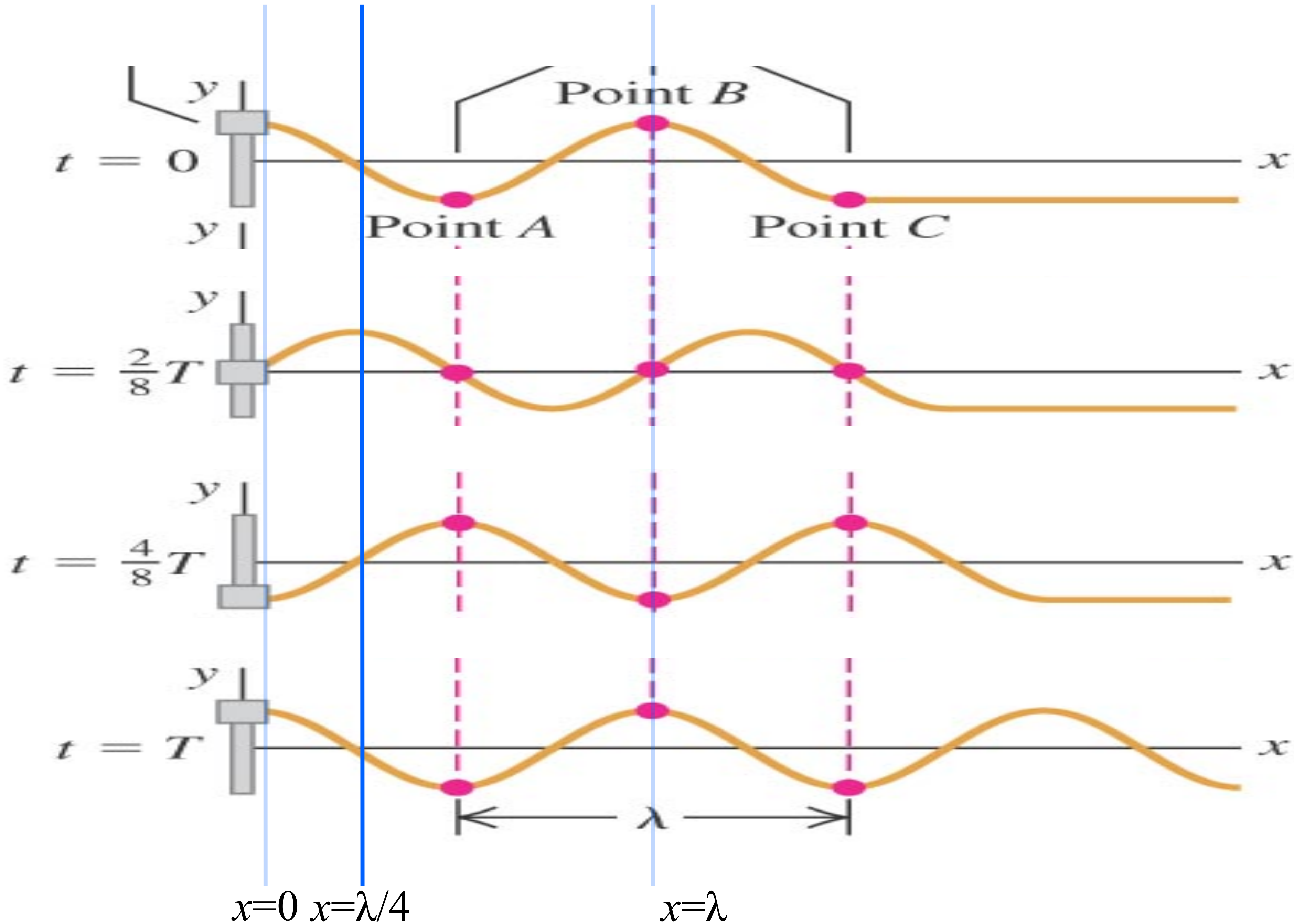

Oscillator generating wave
Three points on the string, one half-wavelength apart
Point A
Point B
Point C
t = 0
t = 1/8 T
t = 2/8 T
t = 3/8 T
t = 4/8 T
t = 5/8 T
t = 6/8 T
t = 7/8 T
t = T
λ

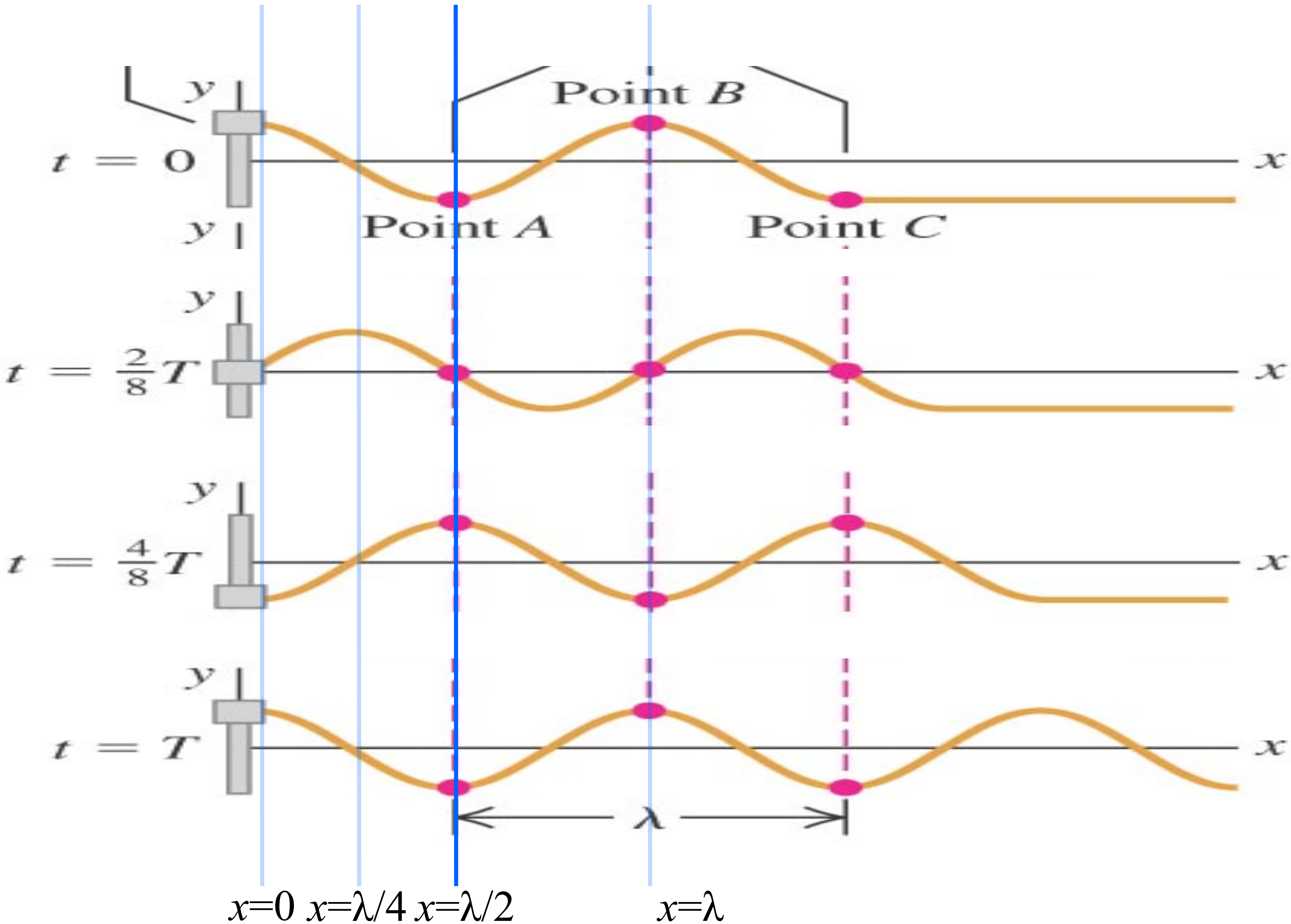


y
Point B
t = 0
x
y
Point A
Point C
y
t = 2/8 T
x
y
t = 4/8 T
x
y
t = T
x
λ

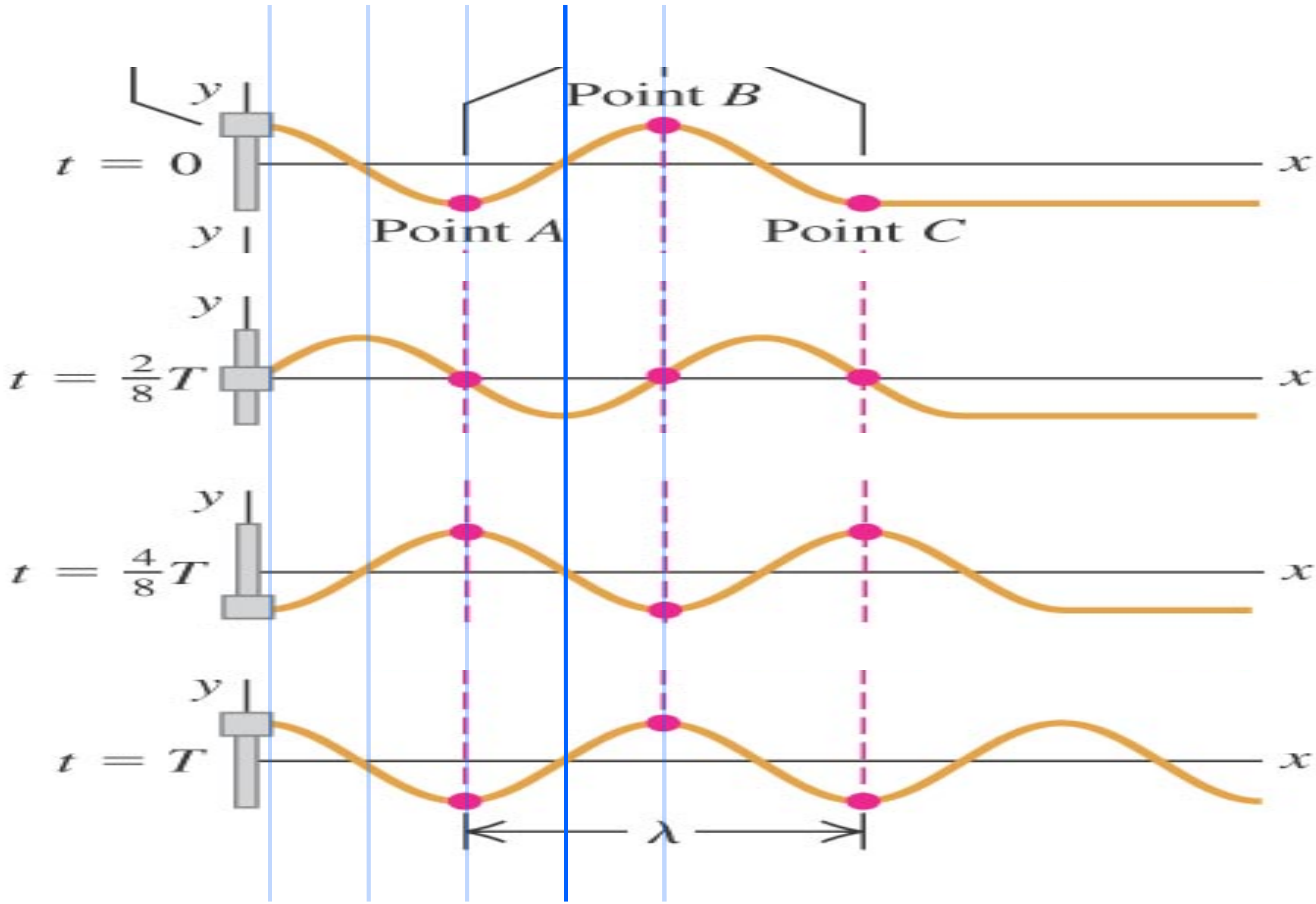

Point B
t = 0
Point A
Point C
t = $\frac{2}{8}T$
t = $\frac{4}{8}T$
t = T
λ
x=0


Point B
Point A
Point C
$t = 0$
$t = \frac{2}{8}T$
$t = \frac{4}{8}T$
$t = T$
y
x
λ
x=0
x=λ


Point B
Point A
Point C
y
x
t = 0
t = 2/8 T
t = 4/8 T
t = T
λ
x=0 x=λ/4
x=λ



Point B
Point A
Point C
t = 0
t = 2/8 T
t = 4/8 T
t = T
y
x
λ
x=0 x=λ/4 x=λ/2
x=λ



x=0 x=λ/4 x=λ/2 x=3λ/4 x=λ

Graphing the wave function

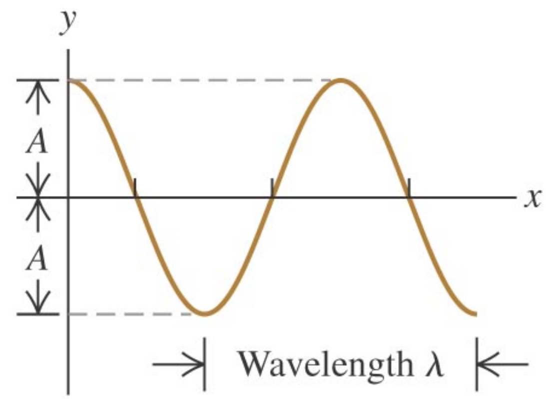
- The graphs to the right look similar, but they are *not* identical.
- Graph (a) shows the *shape* of the string at $t = 0$

$$y = A\cos(kx)$$

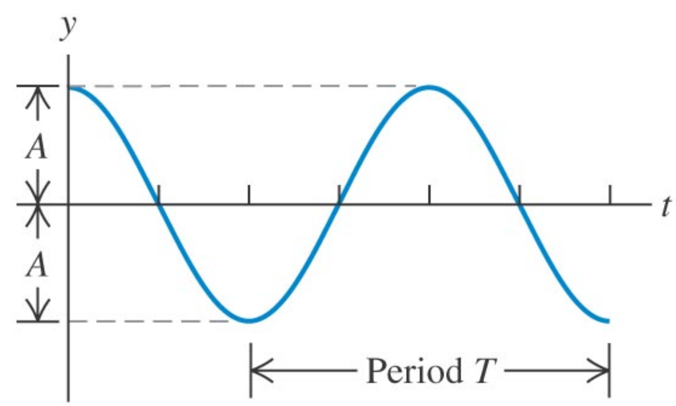
- Graph (b) shows the *displacement* y as a function of time at $x = 0$.

$$y = A\cos(-\omega t)$$

(a) If we use Eq. (15.7) to plot y as a function of x for time $t = 0$, the curve shows the *shape* of the string at $t = 0$.



(b) If we use Eq. (15.7) to plot y as a function of t for position $x = 0$, the curve shows the *displacement* y of the particle at $x = 0$ as a function of time.



Mathematical description of a wave

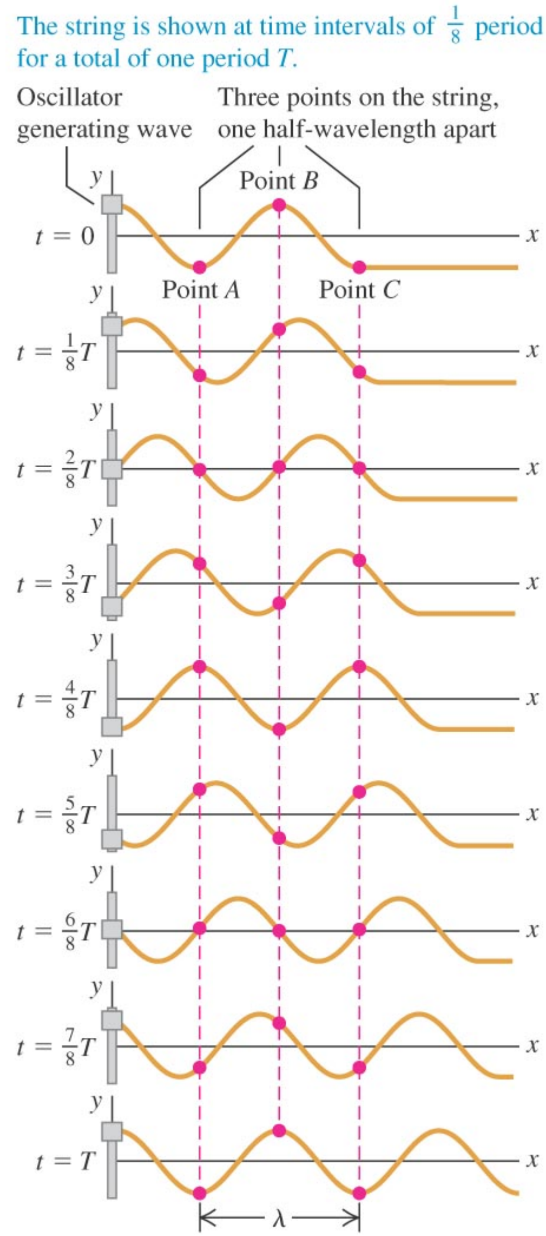
- The *wave function, y*(x,t), gives a mathematical description of a wave. In this function, y is the displacement of a particle at time t and position x.
- The wave function for a sinusoidal wave moving in the +x-direction is

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

where $k = 2\pi/\lambda$ is called the *wave number*.

- In the −x-direction,

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



Sinusoidal wave moving in +x direction

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

$$y(x, t) = A\cos\left[2\pi\left(\frac{x}{\lambda} - \frac{t}{T}\right)\right]$$

$$y(x, t) = A\cos\left[\omega\left(\frac{x}{v} - t\right)\right] = A\cos\left[2\pi f\left(\frac{x}{v} - t\right)\right]$$

Sinusoidal wave moving in −x direction

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

$$y(x, t) = A\cos\left[2\pi\left(\frac{x}{\lambda} + \frac{t}{T}\right)\right]$$

$$y(x, t) = A\cos\left[\omega\left(\frac{x}{v} + t\right)\right] = A\cos\left[2\pi f\left(\frac{x}{v} + t\right)\right]$$