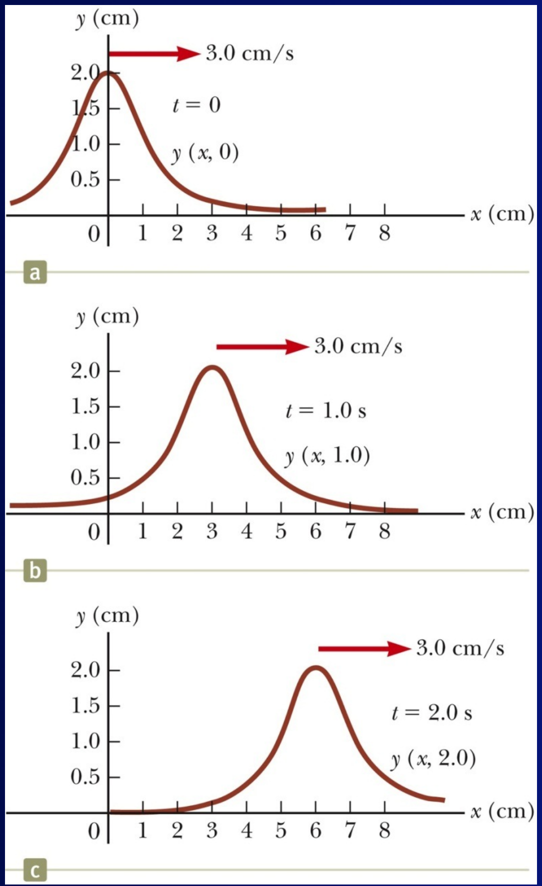
# Physics 1C: SHM and Mechanical Waves




## Monday, 6 April 2015

# Important Info

- course website: http://ted.ucsd.edu
- backup course website: http://cass.ucsd.edu/~rskibba/work/Teaching.html

- http://www.webassign.net

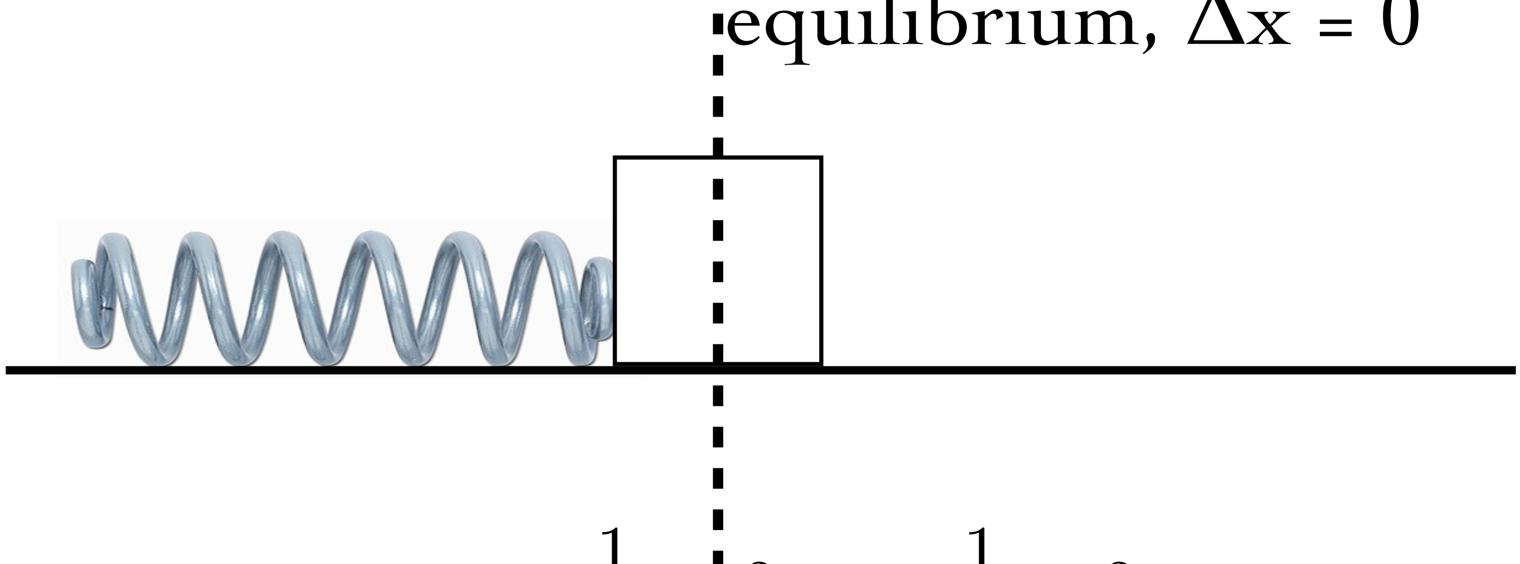
Chapter 13 homework problems and reading quiz are available on WebAssign and are due on Friday. Give yourself plenty of time to work through them.

# Reminders

- *The first test will be this Friday at 1pm!*
- class participation now counts: clickers, homework problems, and reading quizzes
- if after reading the book and working on problems you have difficulty with anything, take advantage of office hours
- also take advantage of TA's problem sessions (Thursdays) and bring the HW problems with you there
- note: next Monday we will have a guest instructor

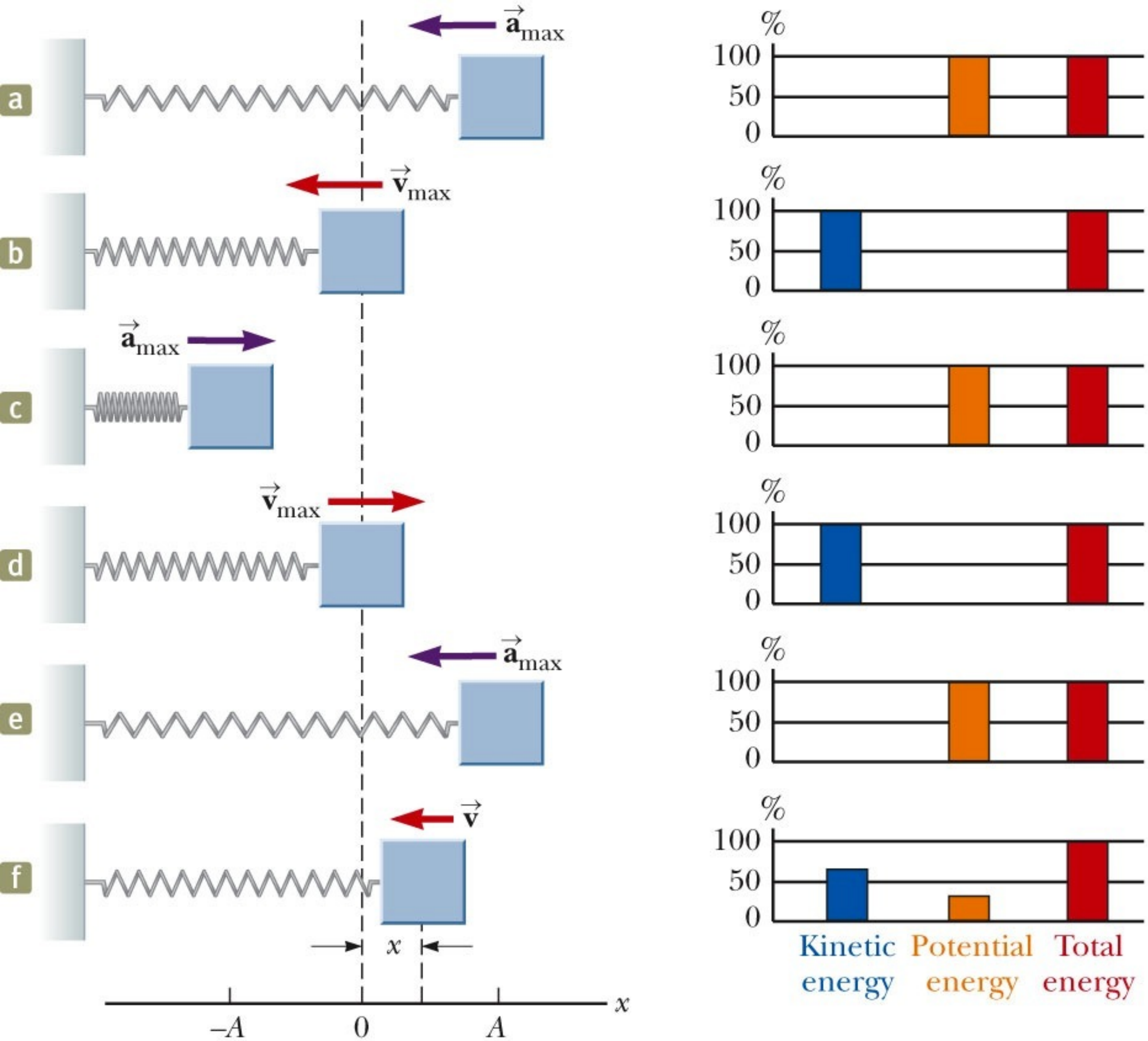
# Conservation of Energy

$$K = \frac{1}{2}mv^2 \qquad U_s = \frac{1}{2}k(\Delta x)^2$$



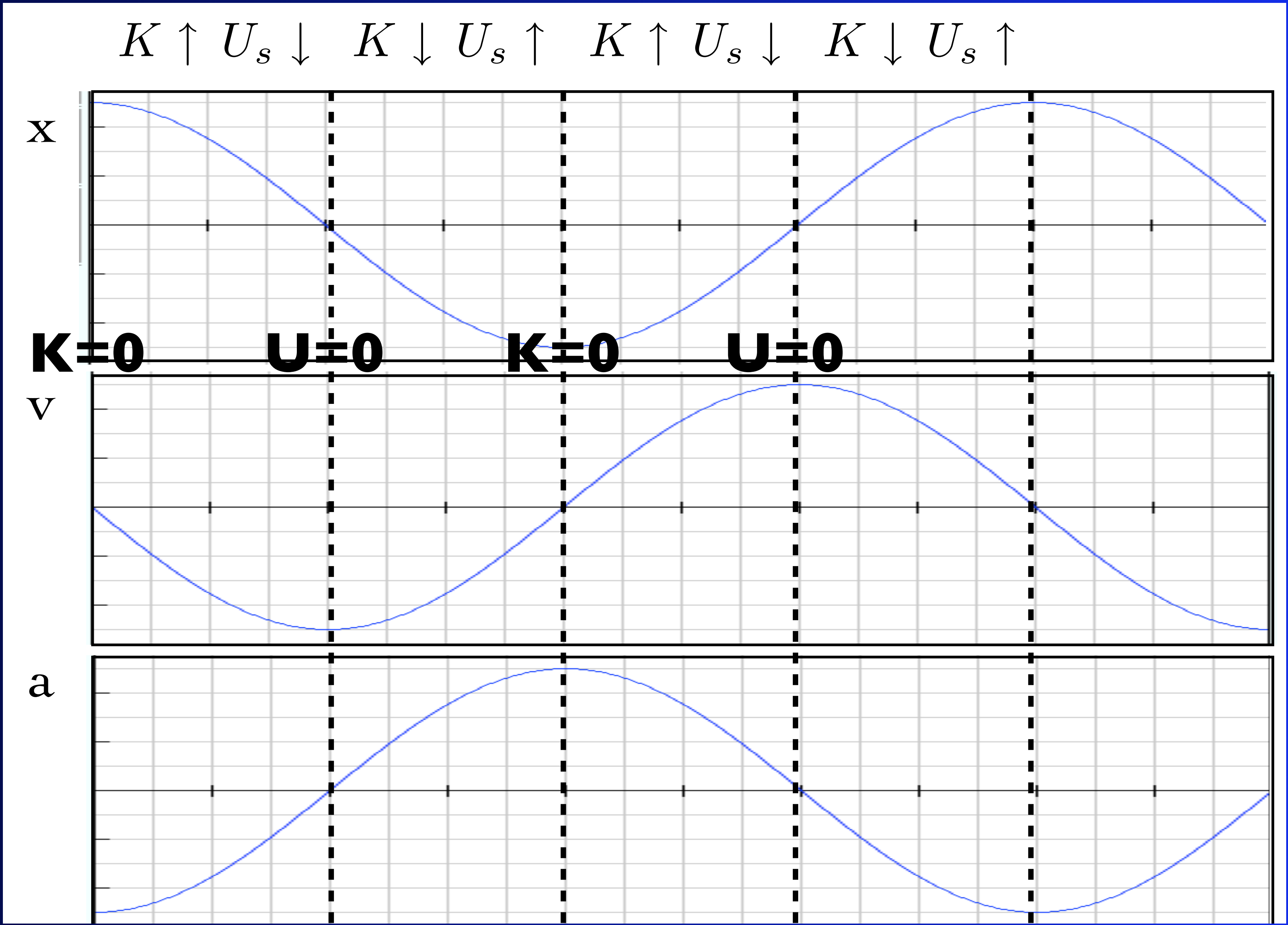

$$E_{\text{total}} = \frac{1}{2}mv_{\text{max}}^2 = \frac{1}{2}kA^2$$

# Conservation of Energy



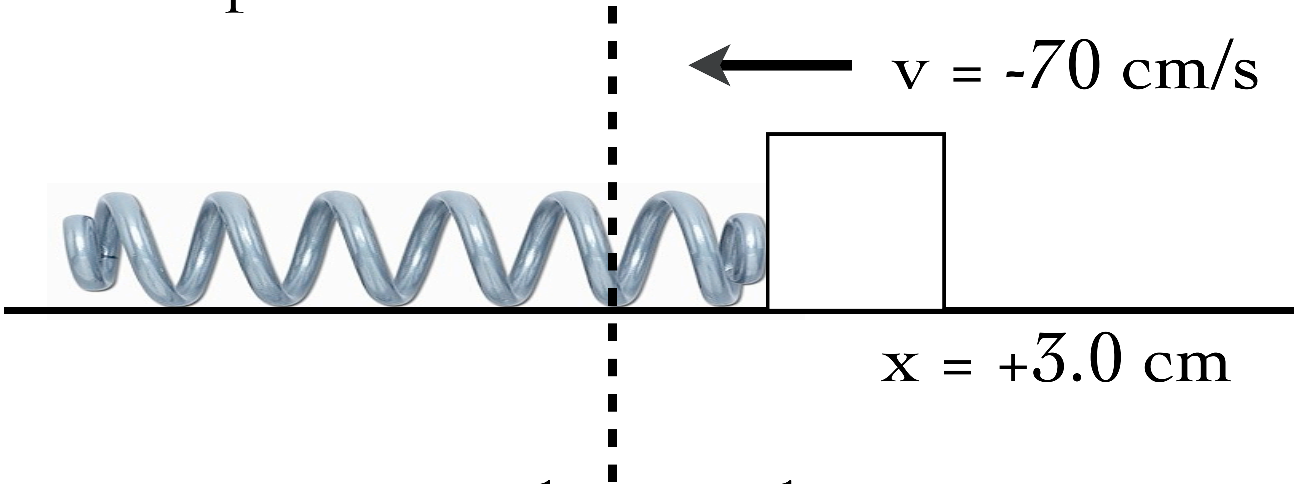

| $t$ | $x$ | $v$ | $a$ | $K$ | $U$ |
|---|---|---|---|---|---|
| 0 | $A$ | 0 | $-\omega^2 A$ | 0 | $\frac{1}{2}kA^2$ |
| $\frac{T}{4}$ | 0 | $-\omega A$ | 0 | $\frac{1}{2}kA^2$ | 0 |
| $\frac{T}{2}$ | $-A$ | 0 | $\omega^2 A$ | 0 | $\frac{1}{2}kA^2$ |
| $\frac{3T}{4}$ | 0 | $\omega A$ | 0 | $\frac{1}{2}kA^2$ | 0 |
| $T$ | $A$ | 0 | $-\omega^2 A$ | 0 | $\frac{1}{2}kA^2$ |
| $t$ | $x$ | $v$ | $-\omega^2 x$ | $\frac{1}{2}mv^2$ | $\frac{1}{2}kx^2$ |

# Conservation of Energy



# Conservation of Energy: An Example

A 2.0 kg block is connected to a 150 N/m spring. At time t = 0 s, the block is located at x = +3.0 cm from equilibrium and has velocity v = -70 cm/s. What is the amplitude of the block's oscillations?




$$E_{\text{total}} = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$$

$$E_{\text{total}} = \frac{1}{2}(2.0 \text{ kg})(-0.70 \text{ m/s})^2 + \frac{1}{2}(150 \text{ N/m})(0.03 \text{ m})^2 = 0.5575 \text{ J}$$

$$E_{\text{total}} = \frac{1}{2}kA^2$$

$$A = 8.6 \text{ cm}$$

# Conservation of Energy: An Example

A 2.0 kg block is connected to a 150 N/m spring. At time $t$=0 s, the block is located at $x$=3.0 cm from equilibrium and has velocity $v$=-70 cm/s.

a. What is the speed of the block when it is located at $x$ = -2.0 cm?
b. Use energy considerations to determine the maximum speed of the block.
c. What is the angular frequency and period of oscillation?
d. What is the phase constant, $\phi_0$?

(Remember that we calculated $E_{total}$=0.56 J and $A$=8.6cm)

# Conservation of Energy: An Example

A 2.0 kg block is connected to a 150 N/m spring. At time $t$=0 s, the block is located at $x$=3.0 cm from equilibrium and has velocity $v$=-70 cm/s.

What is the speed of the block when it is located at $x$ = -2.0 cm?

a. 0.528 m/s
b. 0.726 m/s
c. 1.027 m/s
d. need more information

# Conservation of Energy: An Example

A 2.0 kg block is connected to a 150 N/m spring. At time t = 0 s, the block is located at x = +3.0 cm from equilibrium and has velocity v = -70 cm/s.

a. What is the speed of the block when it is located at x = -2.0 cm?

$$E_{\text{total}} = \frac{1}{2}(2.0 \text{ kg})(-0.70 \text{ m/s})^2 + \frac{1}{2}(150 \text{ N/m})(0.03 \text{ m})^2 = 0.5575 \text{ J}$$

$$E_{\text{total}} = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$$

$$0.5575 \text{ J} = \frac{1}{2}(2.0 \text{ kg})v^2 + \frac{1}{2}(150 \text{ N/m})(-0.02 \text{ m})^2$$

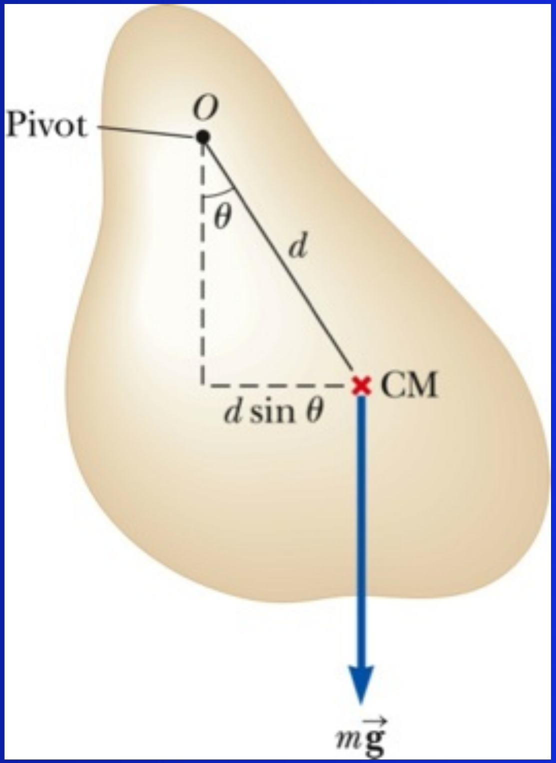
$$v = 0.726 \text{ m/s}$$

# Physical Pendulum

- The gravitational force provides a torque about an axis through *O*
  - The magnitude of the torque is $mgd \sin \theta$
  - $I$ is the moment of inertia about the axis through *O*

$$\omega = \sqrt{\frac{mgd}{I}}$$

$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{I}{mgd}}$$



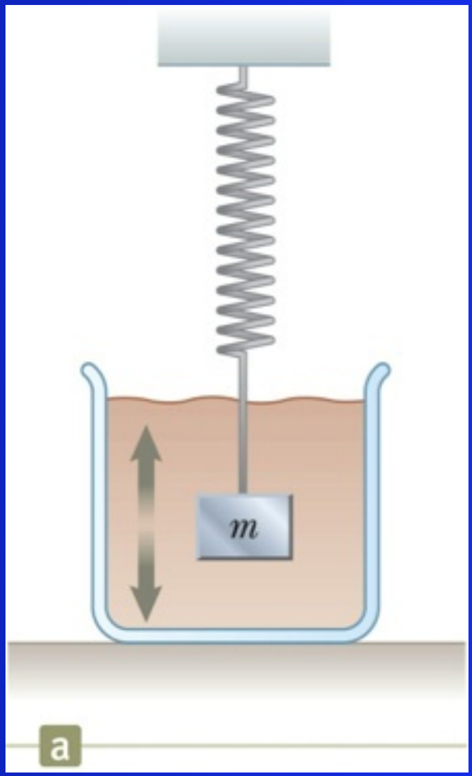

Note: if $I = md^2$ for a flat rigid object, then the physical pendulum behaves as a simple pendulum.

# Forced and Damped Oscillations

In the real world, on object moving through a medium experiences a *resistive force* that *damps* oscillations.

This affects the angular frequency and makes the amplitude, $A$, decrease with time. The energy, $(1/2)kA^2$, also decreases.

But *forced oscillations* can compensate for the loss in energy.

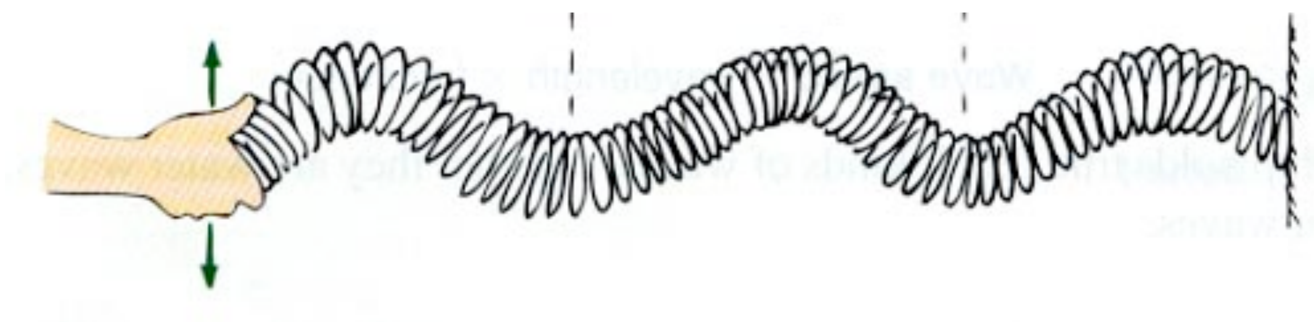


# Mechanical Waves: What is a Wave?

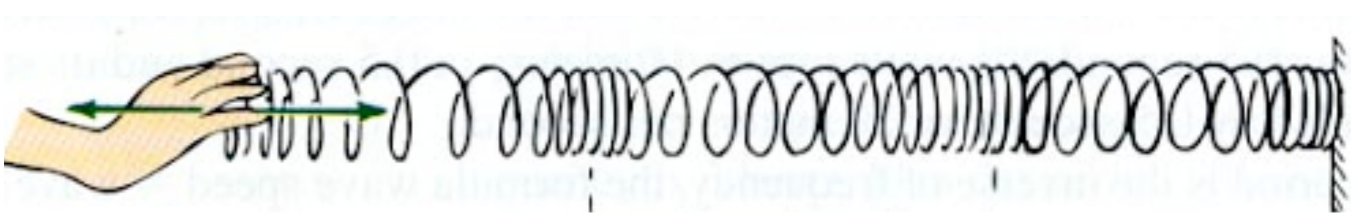
- a disturbance that carries *energy and momentum* from one location to another *without a transfer of matter*
- a wave is created by a source and typically needs a medium to travel through
- examples: ripples in water, sound
- waves of light and radiation are *not* mechanical waves

# What is a wave?

- Transverse wave:  motion of medium is perpendicular to direction of motion



- Longitudinal wave:  motion of medium is parallel to direction of motion



# Mechanical Waves: transverse waves

A transverse wave travels to the left through a medium. The individual particles in the medium move:

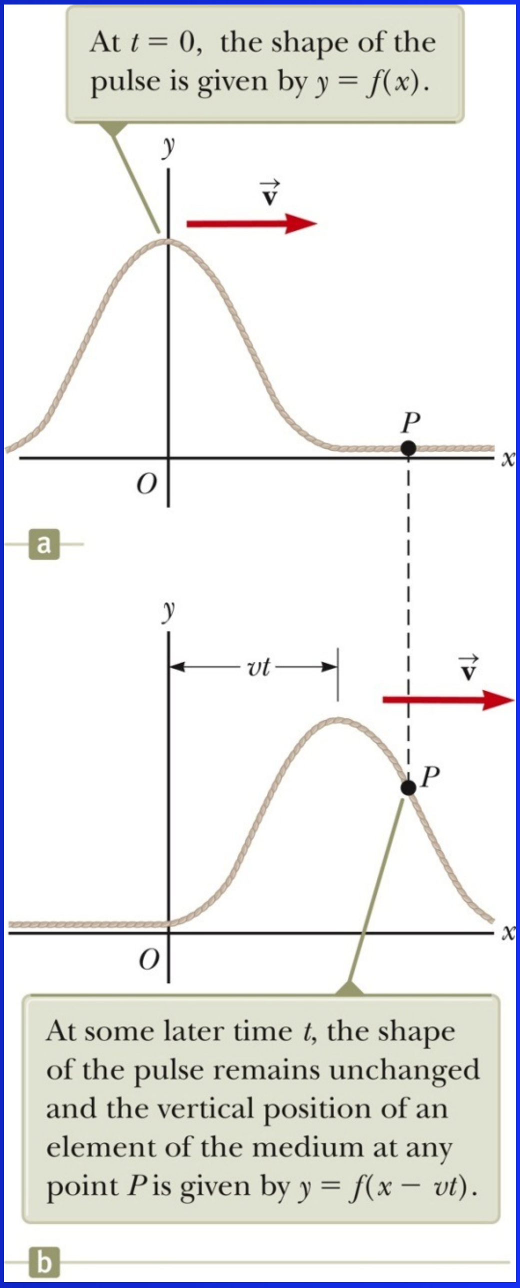
A. to the right
B. to the left
C. up/down
D. the particles in the medium do not move

# Propagation of a Disturbance

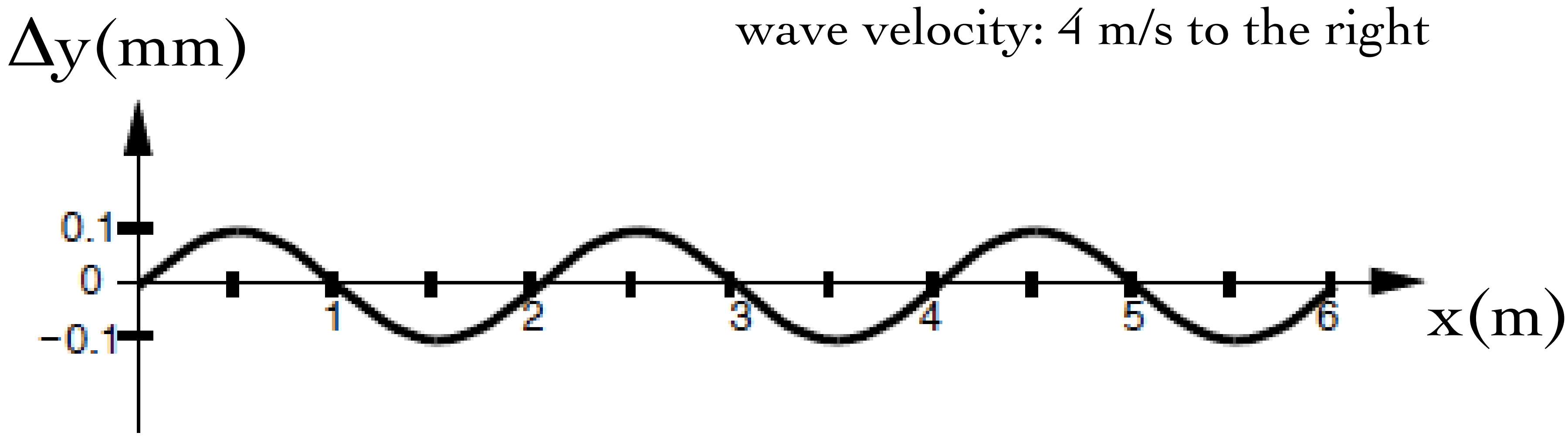
At $t$=0, we can describe the shape of a pulse of rope with $y(x,0) = f(x)$

At a later time, its position is:
$y(x,t) = y(x-vt,0)$ to the right

This is the *wave function*, which could be sinusoidal, parabolical, or something else

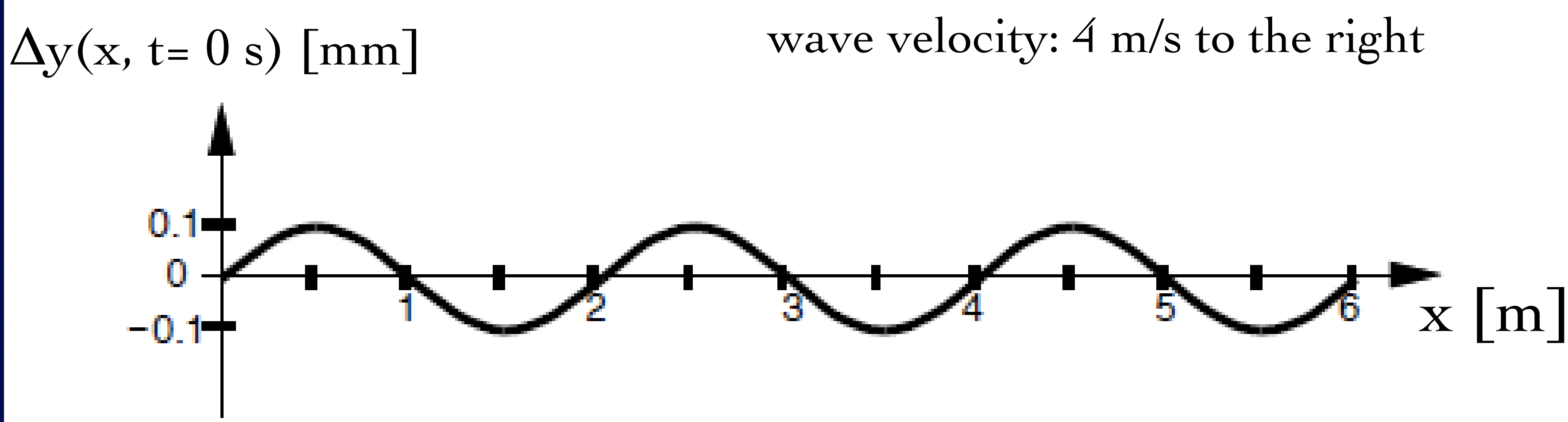


# Properties of Sinusoidal Waves




- Wavelength: the distance between two corresponding points on a wave
- Frequency: the number of cycles a wave undergoes in a given amount of time.
- Wave speed $v = \lambda f$

# Sinusoidal Waves

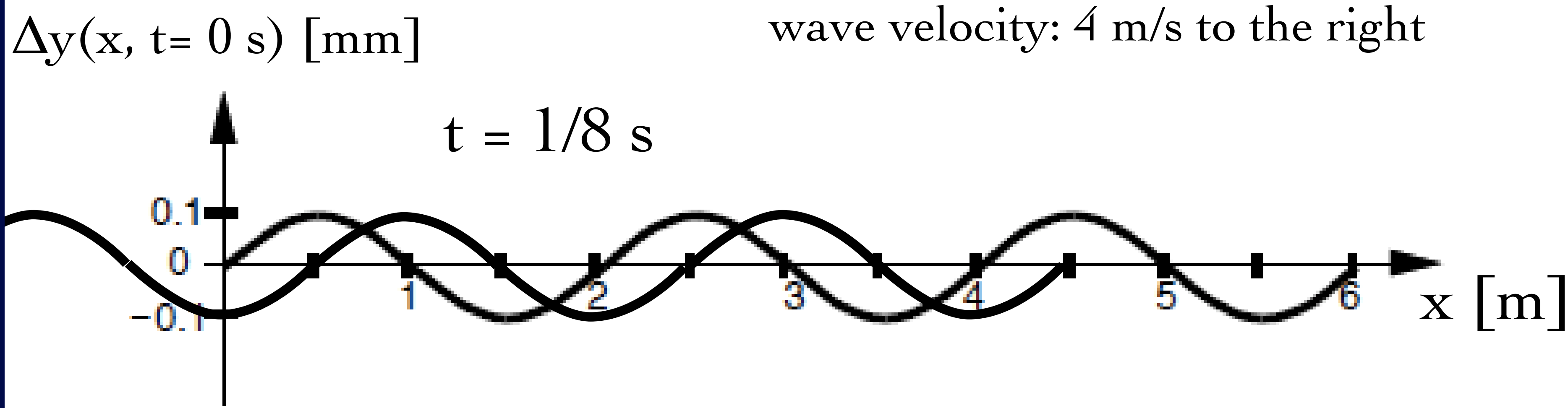



How do we determine the period of the wave?

Length of time needed to cycle through the wave

What about the amplitude?

# Sinusoidal Waves

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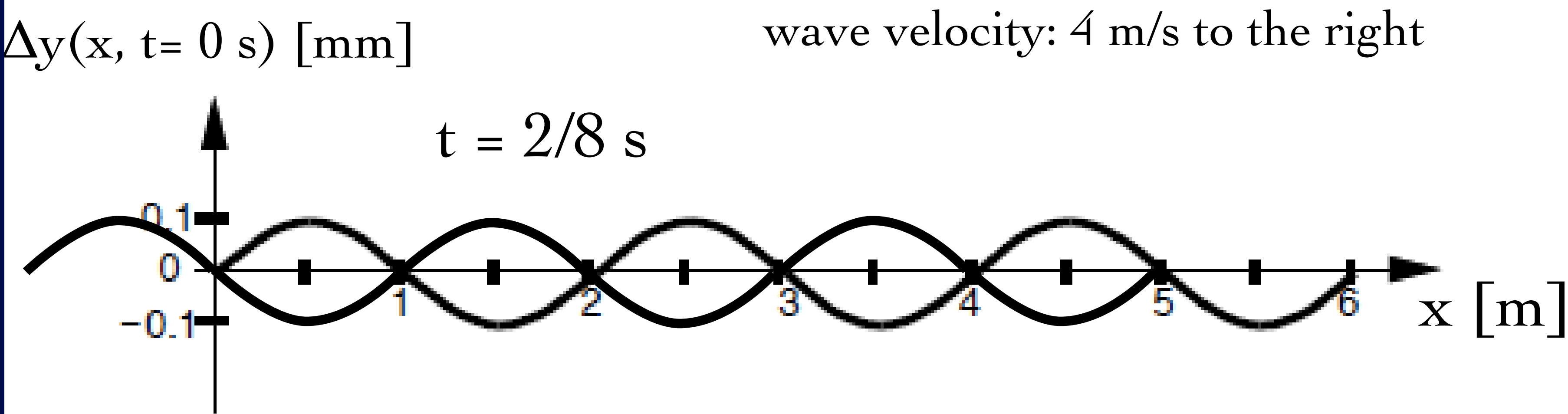
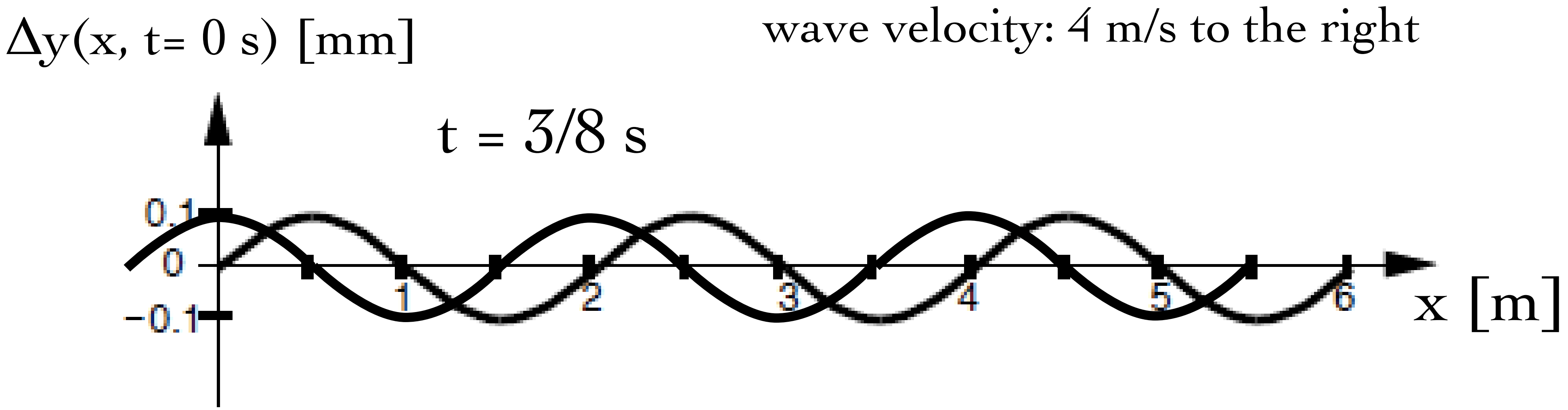
# Sinusoidal Waves




How do we determine the period of the wave?

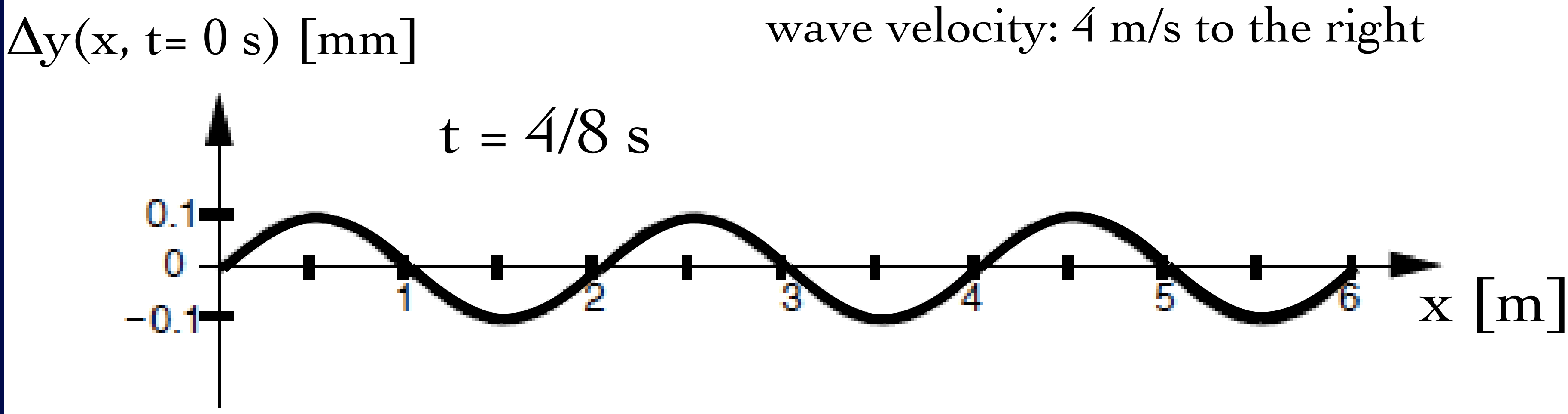
# Sinusoidal Waves




How do we determine the period of the wave?

# Sinusoidal Waves

wave velocity: 4 m/s to the right




How do we determine the period of the wave?

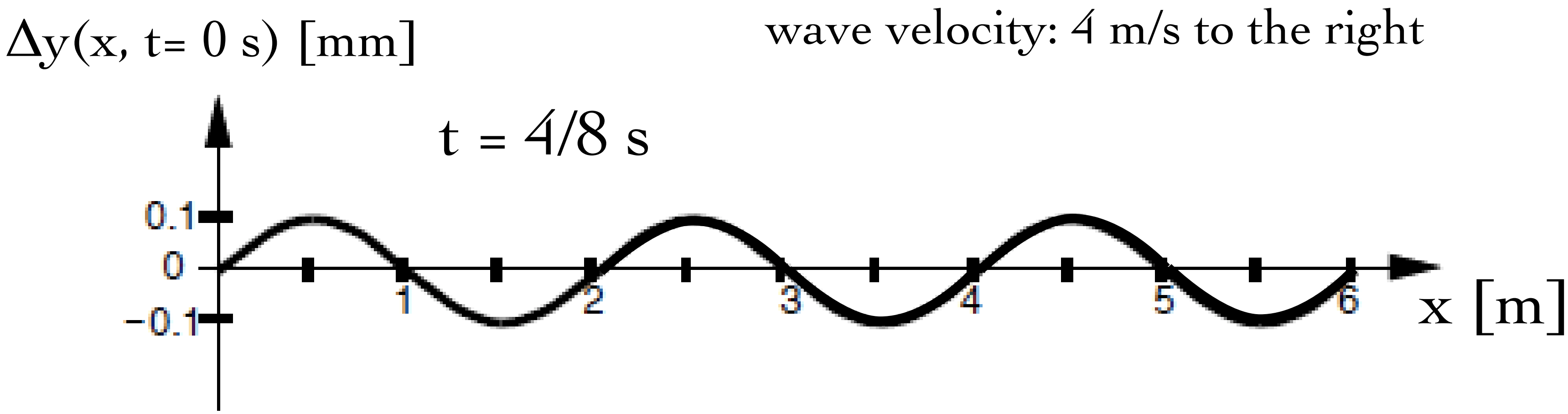
T = 1/2 s

How do we determine the frequency of the wave?

f = 1/T = 2 Hz

angular frequency: $\omega = 2\pi f = 12.57 \text{ rad/s}$

# Sinusoidal Waves




Period is the amount of time necessary for the wave to travel by one wavelength:

speed = wavelength / period

$$v = \lambda f$$

# For Wednesday:

1. work on chapter 13 homework problems and reading quiz, both available on www.webassign.net

2. continue reading chapter 13 up to section 13.5

3. start preparing for Friday's test