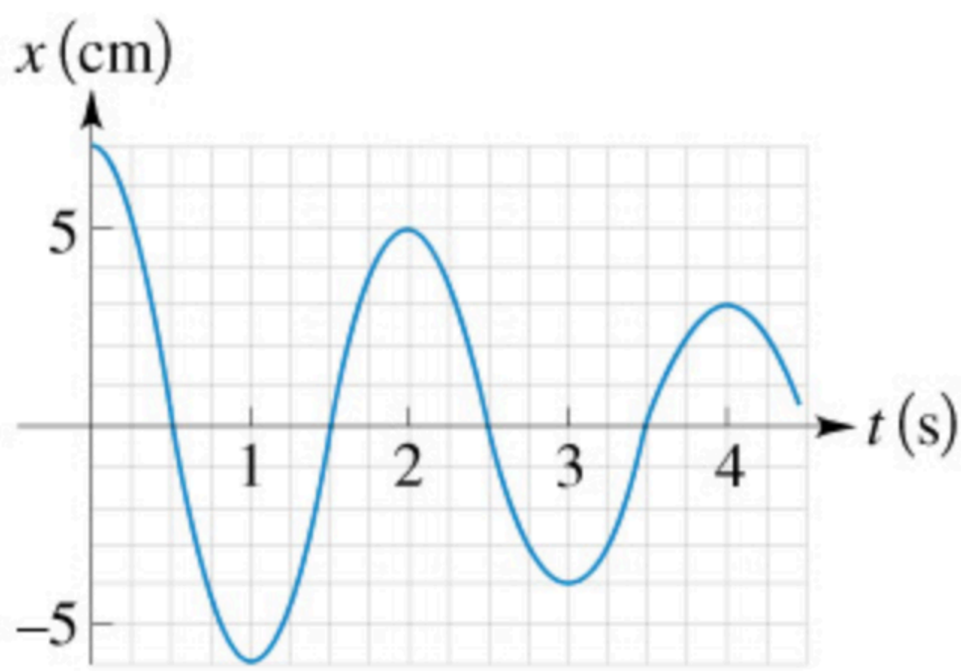
Exercise 14.58

A mass is vibrating at the end of a spring of force constant 225 $\mathrm{N/m}$. The figure (Figure 1) shows a graph of its position x as a function of time t.

Figure



Part A

At what times between t = 0 s and t = 4.5 s including the endpoints of the interval, is the mass not moving?

If there is more than one answer, enter your answers in ascending order separated by commas.

ΑΣφ ?

t = s

Submit Request Answer

Part B

How much energy did this system originally contain?

Express your answer with the appropriate units.

μÅ ?

E = Value Units

Submit Request Answer

Part C

How much energy did the system lose between t = 1.0 s and t = 4.0 s?

Express your answer with the appropriate units.

$E_{1\ \mathrm{s}} - E_{4\ \mathrm{s}} =$ Value Units

Submit Request Answer

Part D

Where did this lost energy go?

- The mechanical energy lost was converted to other forms of energy by nonconservative forces, such as gravity, air resistance, and tension.
- The mechanical energy lost was converted to other forms of energy by conservative forces, such as friction and tension.
- The mechanical energy lost was converted to other forms of energy by nonconservative forces, such as friction and air resistance.
- The mechanical energy lost was converted to potential and internal energy of the spring.

Review | Constants

Quantum mechanics is used to describe the vibrational motion of molecules, but analysis using classical physics gives some useful insight. In a classical model the vibrational motion can be treated as SHM of the atoms connected by a spring. The two atoms in a diatomic molecule vibrate about their center of mass, but in the molecule HI, where one atom is much more massive than the other, we can treat the hydrogen atom as oscillating in SHM while the iodine atom remains at rest.

Part A

A classical estimate of the vibrational frequency is $f = 7.0 \times 10^{13}\ \mathrm{Hz}$. The mass of a hydrogen atom differs little from the mass of a proton. If the HI molecule is modeled as two atoms connected by a spring, what is the force constant of the spring?

Express your answer to two significant figures and include the appropriate units.

μÅ ?

k = Value Units

Submit Request Answer

Part B

The vibrational energy of the molecule is measured to be about $5 \times 10^{-20}\ \mathrm{J}$. In the classical model, what is the maximum speed of the H atom during its SHM?

Express your answer to one significant figure and include the appropriate units.

μÅ ?

v = Value Units

Part C

What is the amplitude of the vibrational motion?

Express your answer to one significant figure and include the appropriate units.

A = Value Units

Submit Request Answer

Part D

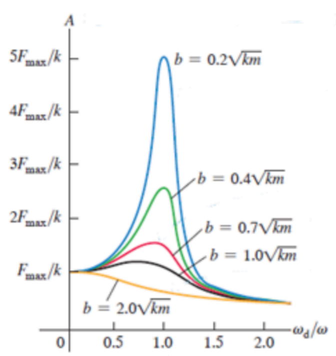
How does your result compare to the equilibrium distance between the two atoms in the HI molecule, which is about 1.6×10^{-10} m?

Express your answer using one significant figure.

$\frac{A}{\text{equilibrium distance}}$ =

Equation $A = \frac{F_{\max}}{\sqrt{(k-m\omega_d^2)^2+b^2\omega_d^2}}$ and the graph of the amplitude of forced oscillation as a function of the angular frequency, shown in (Figure 1), describe a damped and driven oscillator.

Figure



Review | Constants

Part A

For a damping constant $b = 0.20\sqrt{km}$, express the amplitude A when $\omega_d = \omega$, where $\omega = \sqrt{k/m}$ is the natural angular frequency.

Express your answer in terms of the variables $F_{\max}$ and k.

ΑΣφ ?

$A_{b=0.20\sqrt{km}}$ =

Submit Request Answer

Part B

Repeat part A for $b = 0.40\sqrt{k \cdot m}$, and express that the amplitude A when $\omega_d = \omega$.

Express your answer in terms of the variables $F_{\max}$ and k.

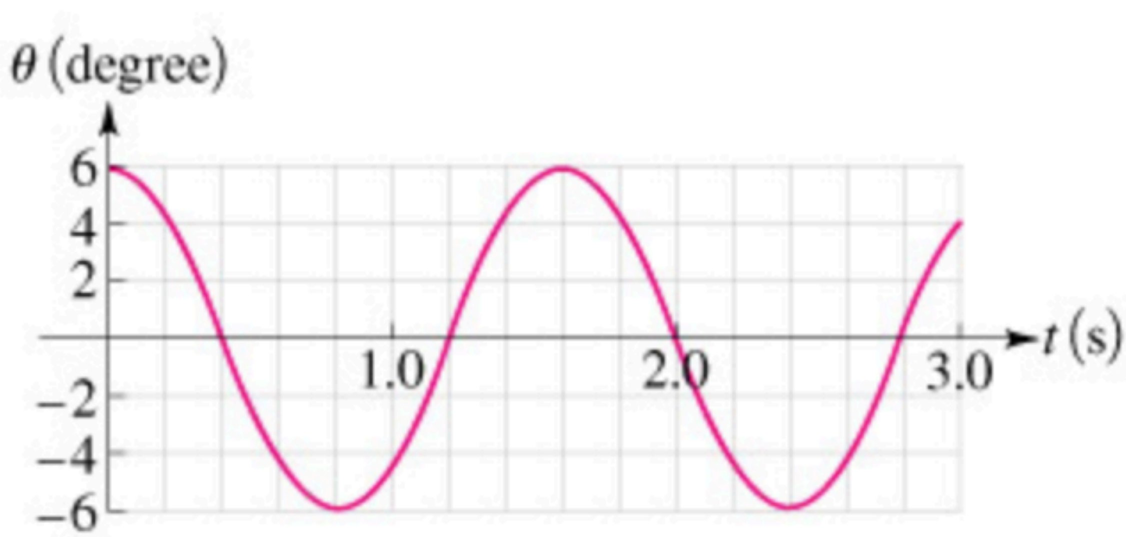
ΑΣφ ?

$A_{b=0.40\sqrt{km}}$ =

Exercise 14.48 - Enhanced - with Feedback

In the laboratory, a student studies a pendulum by graphing the angle θ that the string makes with the vertical as a function of time t, obtaining the graph shown in the figure (Figure 1).

Figure



Part A

What is the period of the pendulum's motion?

Express your answer to two significant figures and include the appropriate units.

$T = 1.6\ \mathrm{s}$

Submit Previous Answers

Correct

Part B

What is the frequency of the pendulum's motion?

Express your answer to two significant figures and include the appropriate units.

$f = 0.63\ \mathrm{Hz}$

Submit Previous Answers

Correct

Part C

What is the angular frequency of the pendulum's motion?

Express your answer in radians per second to two significant figures.

$\omega = 3.9 \ \mathrm{rad/s}$

Submit

Previous Answers

Correct

Part D

What is the amplitude of the pendulum's motion?

Express your answer in degrees to one significant figure.

$\theta_{\mathrm{max}} = 6 \ ^{\circ}$

Submit

Previous Answers

Correct

Part E

How long is the pendulum?

Express your answer to two significant figures and include the appropriate units.

L = Value Units

Submit Request Answer

Part F

Is it possible to determine the mass of the bob?

- yes
- no

Submit Request Answer

A 55.0 g hard-boiled egg moves on the end of a spring with force constant 25.0 $\mathrm{N/m}$. Its initial displacement 0.500 m. A damping force $F_x = -bv_x$ acts on the egg, and the amplitude of the motion decreases to 0.100 m in a time of 5.00 s.

Part A

Calculate the magnitude of the damping constant b.

Express your answer in kilogram per second.

b = $\mathrm{kg/s}$

Submit Request Answer

Review | Constants

Part C

As a measure of the width of the resonance peak, calculate A when $\omega_d = \omega/2$ for $b = 0.20\sqrt{km}$.

Express your answer to three significant figures.

A_{b_1} = $\cdot \frac{F_{max}}{k}$

Submit Request Answer

Part D

In case of $b = 0.20\sqrt{km}$, what is the ratio of the amplitude for $\omega_d = \omega$ to the amplitude for $\omega_d = \omega/2$?

Express your answer to three significant figures.

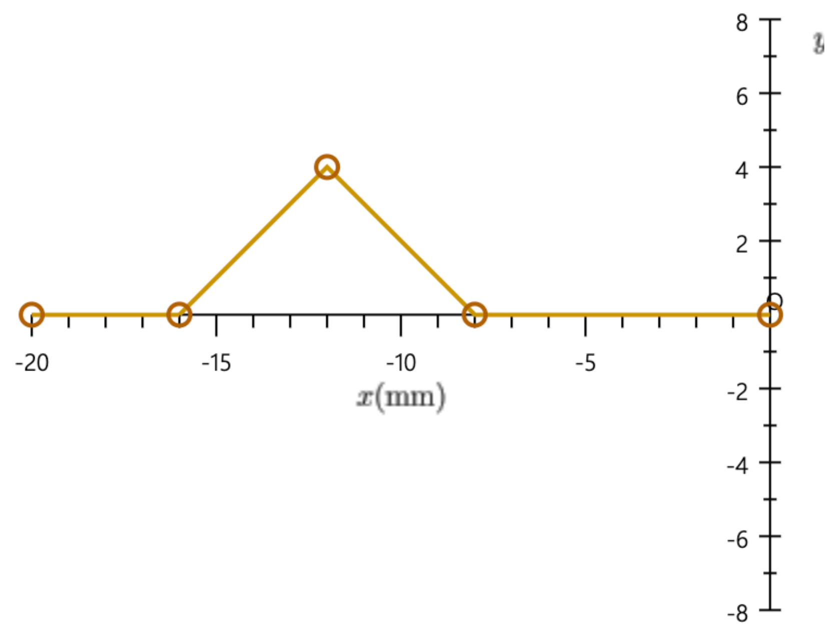
$\frac{A_\omega}{A_{\omega/2}}$ =

Submit Request Answer

Part H

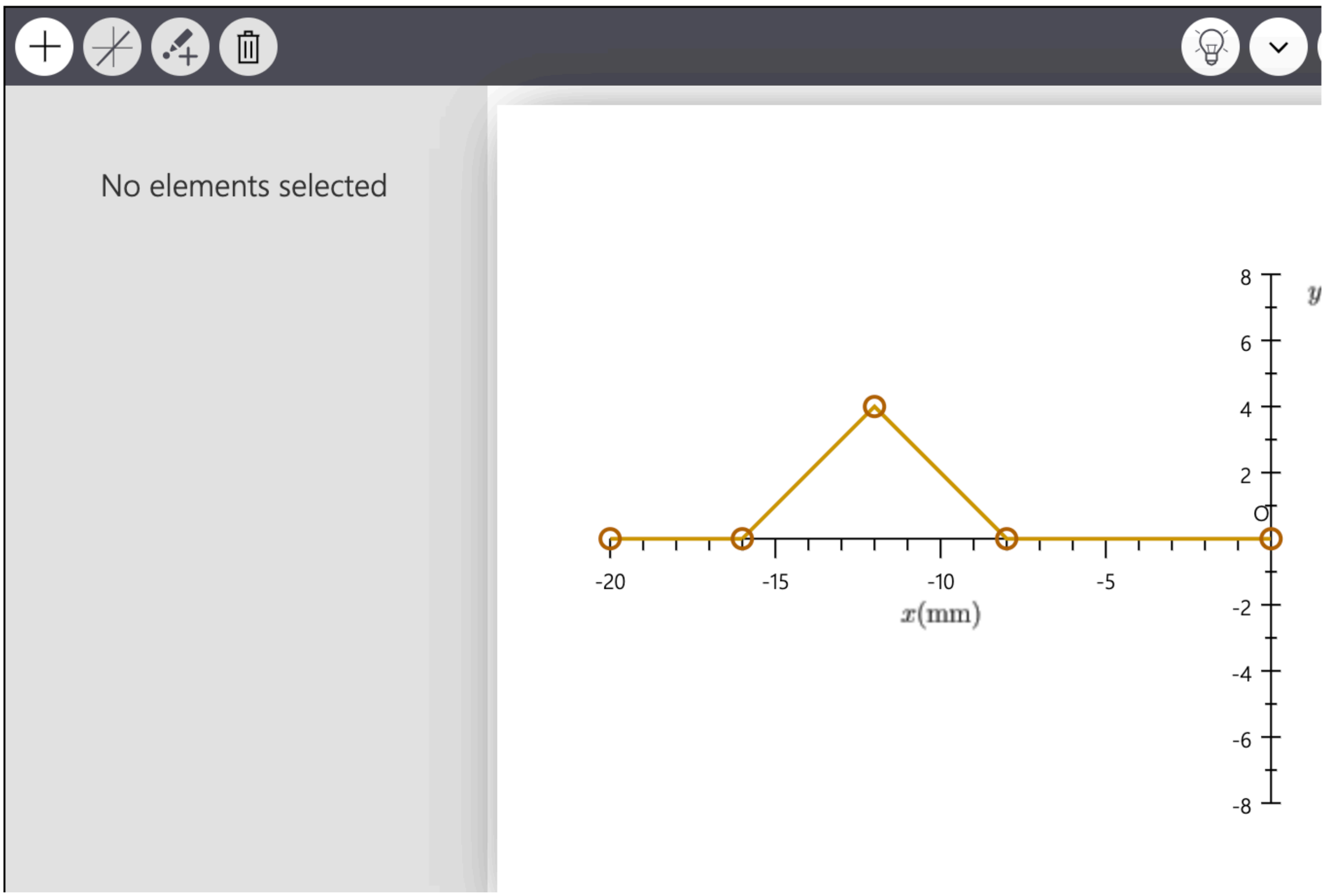
Repeat part A for the case in which point O is a free end for t=15 ms.

No elements selected



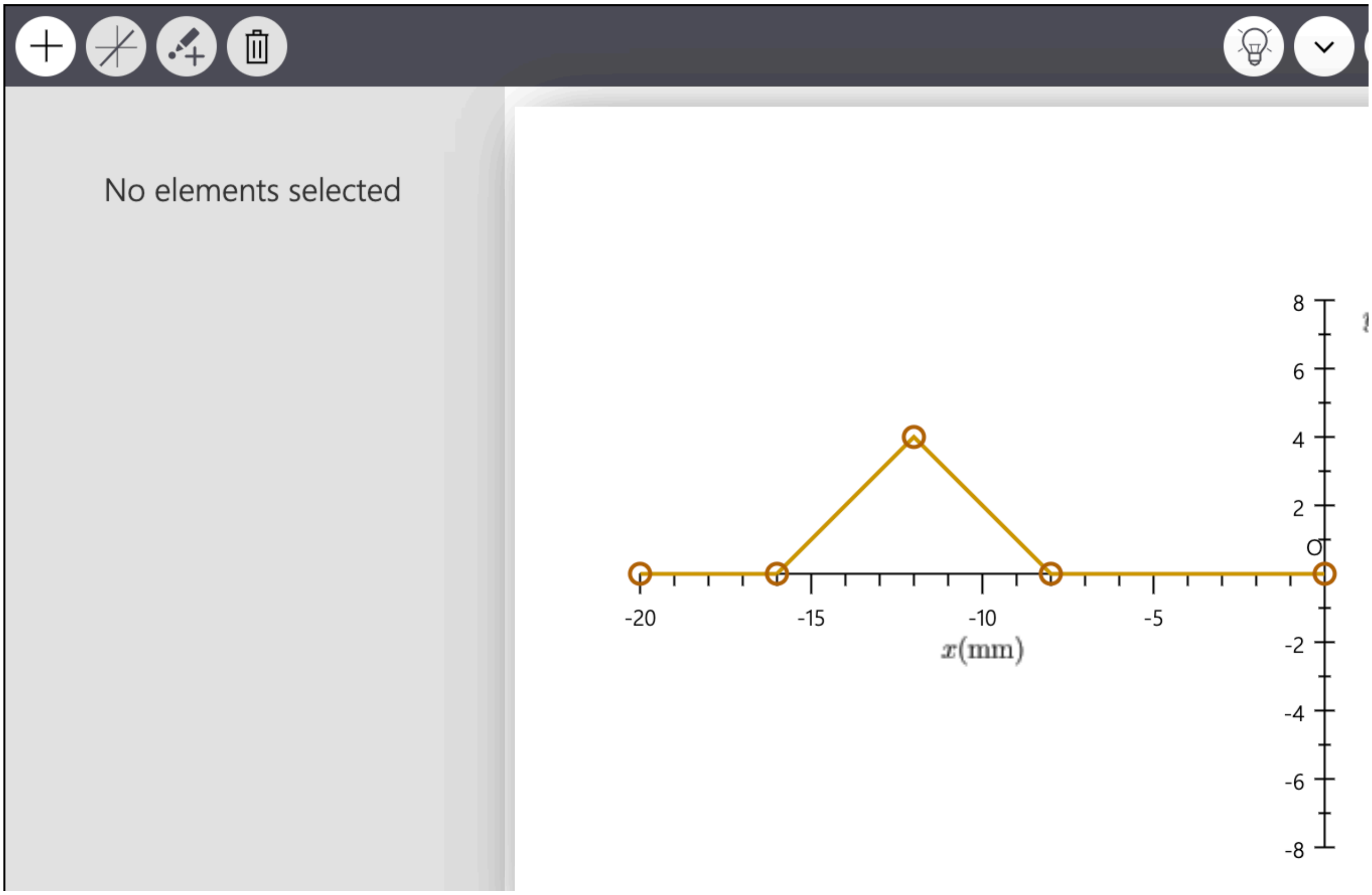
Part I

Repeat part B for the case in which point O is a free end for t=20 ms.



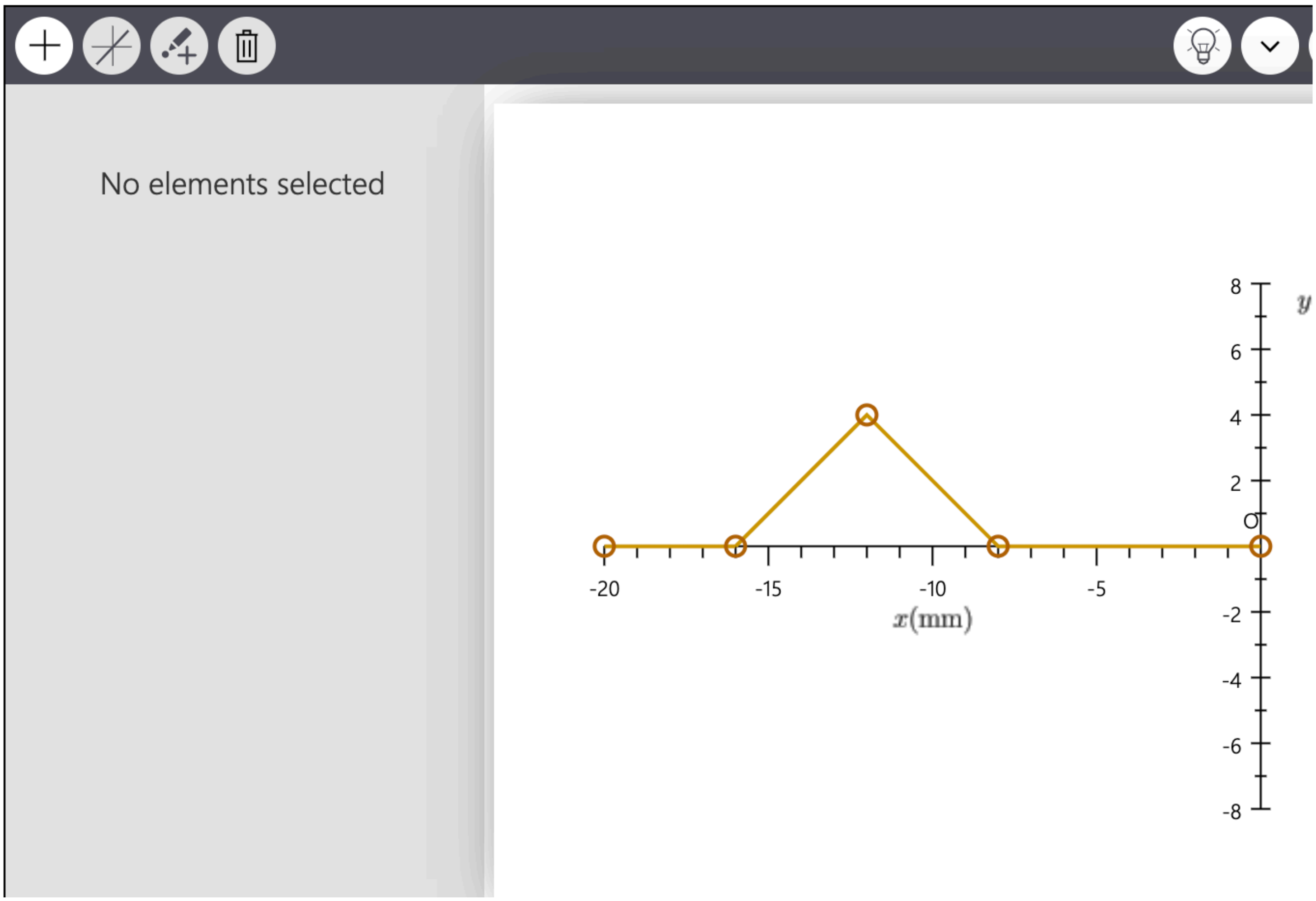
Part J

Repeat part C for the case in which point O is a free end for t=25 ms.



Part K

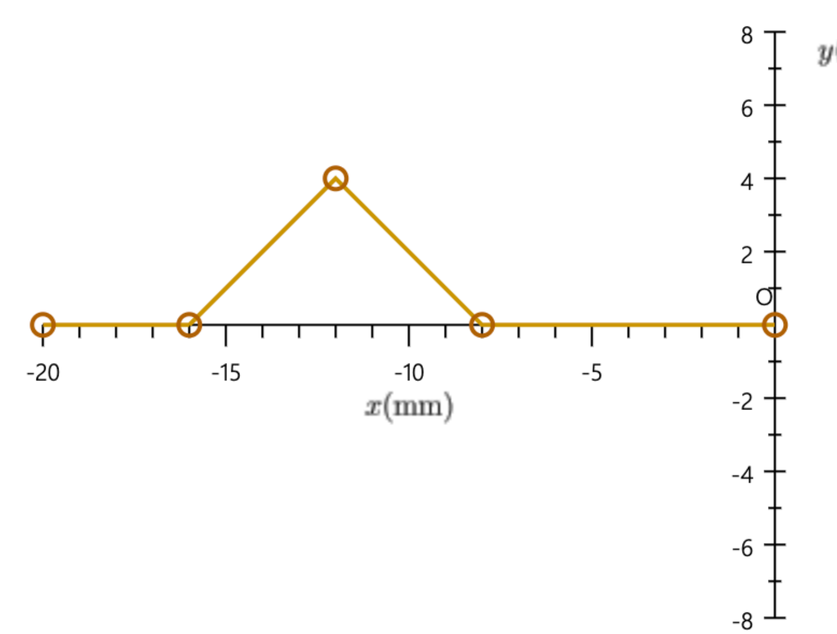
Repeat part D for the case in which point O is a free end for t=30 ms.



Part L

Repeat part E for the case in which point O is a free end for t=35 ms.

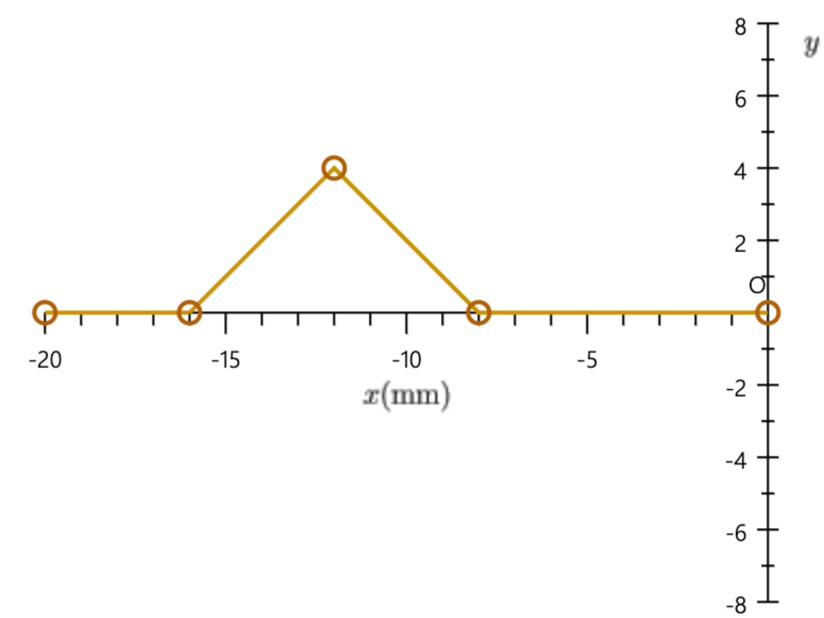
No elements selected



Part M

Repeat part F for the case in which point O is a free end for t=40 ms.

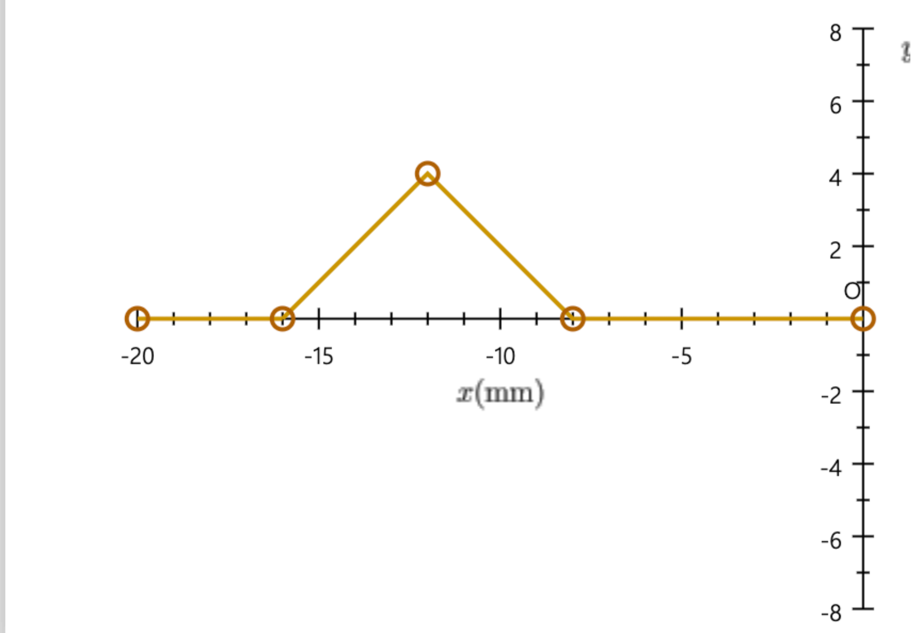
No elements selected



Part N

Repeat part G for the case in which point O is a free end for t=45 ms.

No elements selected

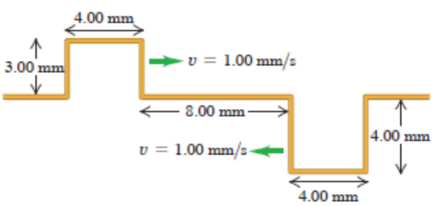


Review | Constants

(Figure 1) shows two rectangular wave pulses on a stretched string traveling toward each other. Each pulse is traveling with a speed of 1.00 $\mathrm{mm/s}$ and has the height and width shown in the figure.

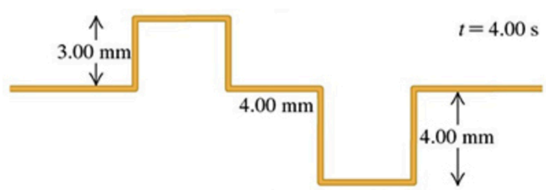
Figure

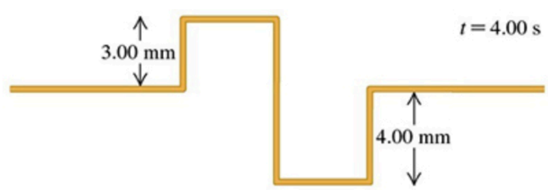
1 of 1



Part A

If the leading edges of the pulses are 8.00 mm apart at t = 0, select the sketch that correctly shows the shape of the string at t = 4.00 s.



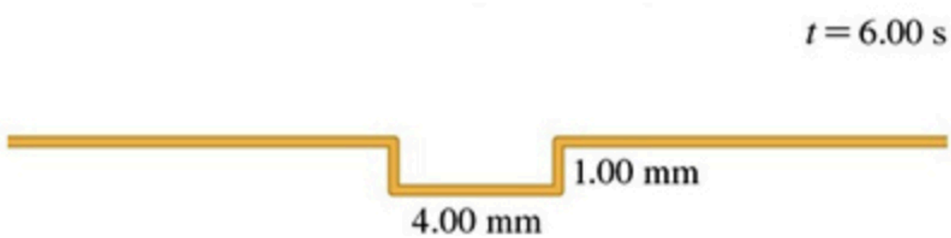


Submit

Request Answer

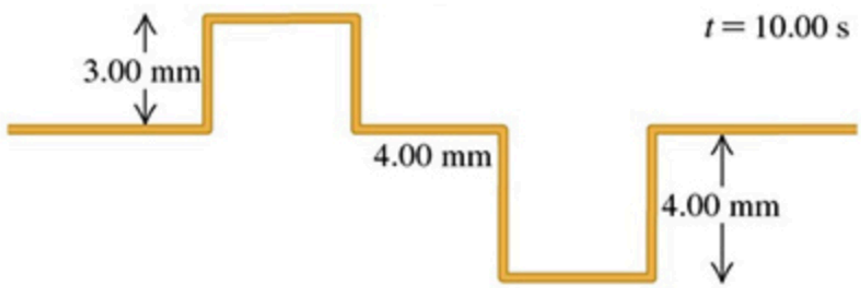
Part B

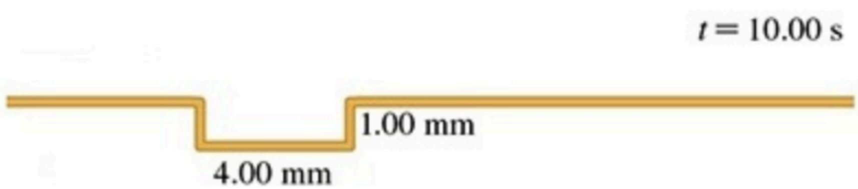
Select the sketch that correctly shows the shape of the string at t = 6.00 s.

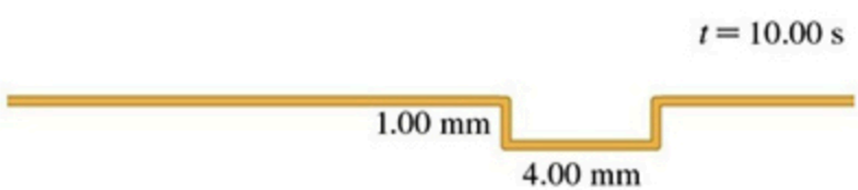


Part C

Select the sketch that correctly shows the shape of the string at t = 10.00 s.







Review | Constants

An ant with mass m is standing peacefully on top of a horizontal, stretched rope. The rope has mass per unit length μ and is under tension F. Without warning, Throckmorton starts a sinusoidal transverse wave of wavelength λ propagating along the rope. The motion of the rope is in a vertical plane.

Part A

What minimum wave amplitude will make the ant become momentarily weightless? Assume that m is so small that the presence of the ant has no effect on the propagation of the wave.

Express your answer in terms of the variables m, λ, F, μ, and g.

$$A = \frac{\mu\lambda^2 g}{4\pi^2 F}$$

Submit Previous Answers

Correct

Part E

As a measure of the width of the resonance peak, calculate A when $\omega_\mathrm{d} = \omega/2$ for $b = 0.40\sqrt{km}$.

Express your answer to three significant figures.

A_{b_2} = $\cdot \dfrac{F_{\mathrm{max}}}{k}$

Submit Request Answer

Part F

In case of $b = 0.40\sqrt{km}$, what is the ratio of the amplitude for $\omega_\mathrm{d} = \omega$ to the amplitude for $\omega_\mathrm{d} = \omega/2$?

Express your answer to three significant figures.

$\dfrac{A_\omega}{A_{\omega/2}}$ =

Part G

For which value of the damping constant does the amplitude increase by the larger factor?

- The amplitude increases by a larger factor for $b = 0.20\sqrt{km}$ than for $b = 0.40\sqrt{km}$.
- The amplitude increases by a larger factor for $b = 0.40\sqrt{km}$ than for $b = 0.20\sqrt{km}$.

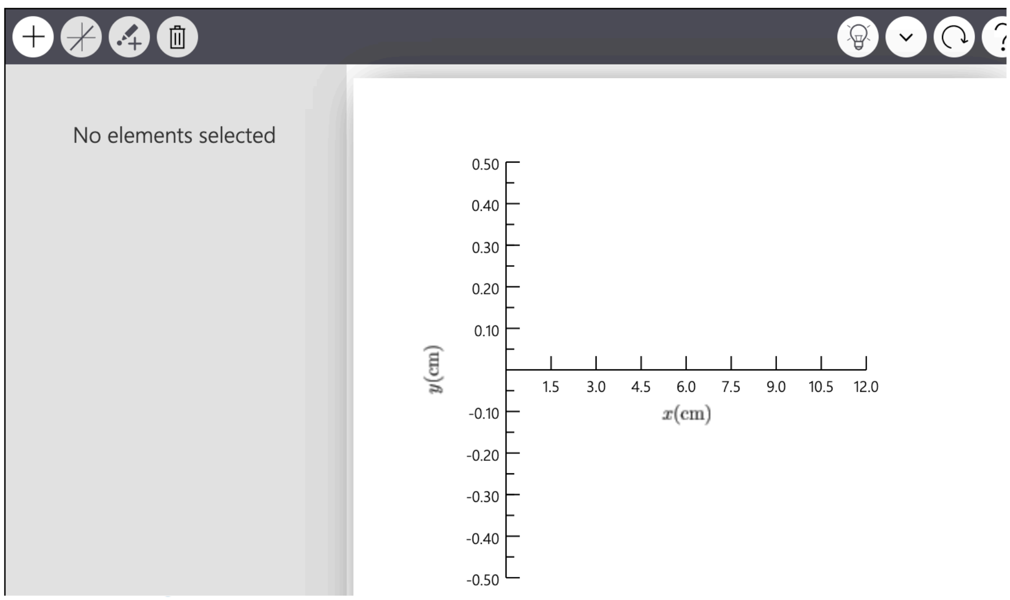
Submit Request Answer

Review | Constants

A transverse wave on a string has amplitude 0.300 cm, wavelength 12.0 cm, and speed 6.00 cm/s. It is represented by equation $y(x,t) = A\cos\left[\frac{2\pi}{\lambda}(x - vt)\right]$.

Part A

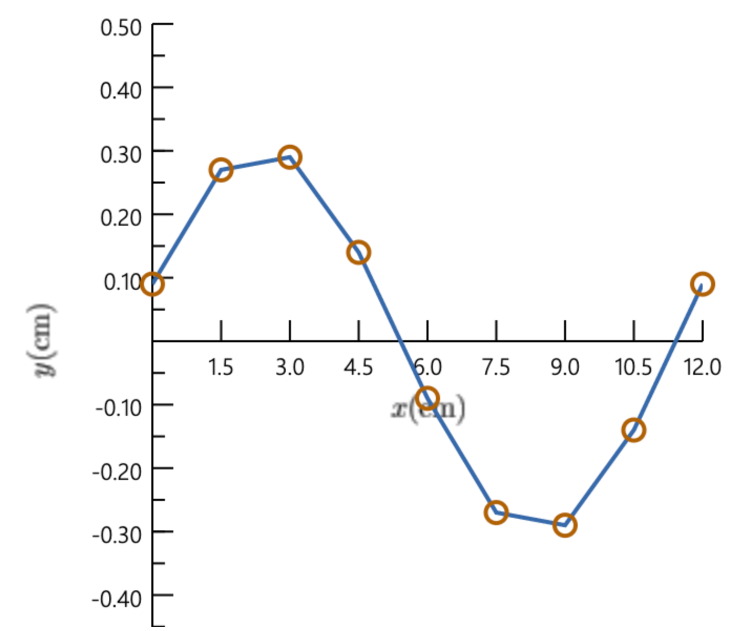
At time t = 0, compute y at 1.5-cm intervals of x (that is, at x = 0, x = 1.5 cm, x = 3.0 cm, and so on) from x = 0 to x = 12.0 cm. Graph the results. This is the shape of the string at time t = 0.



Part B

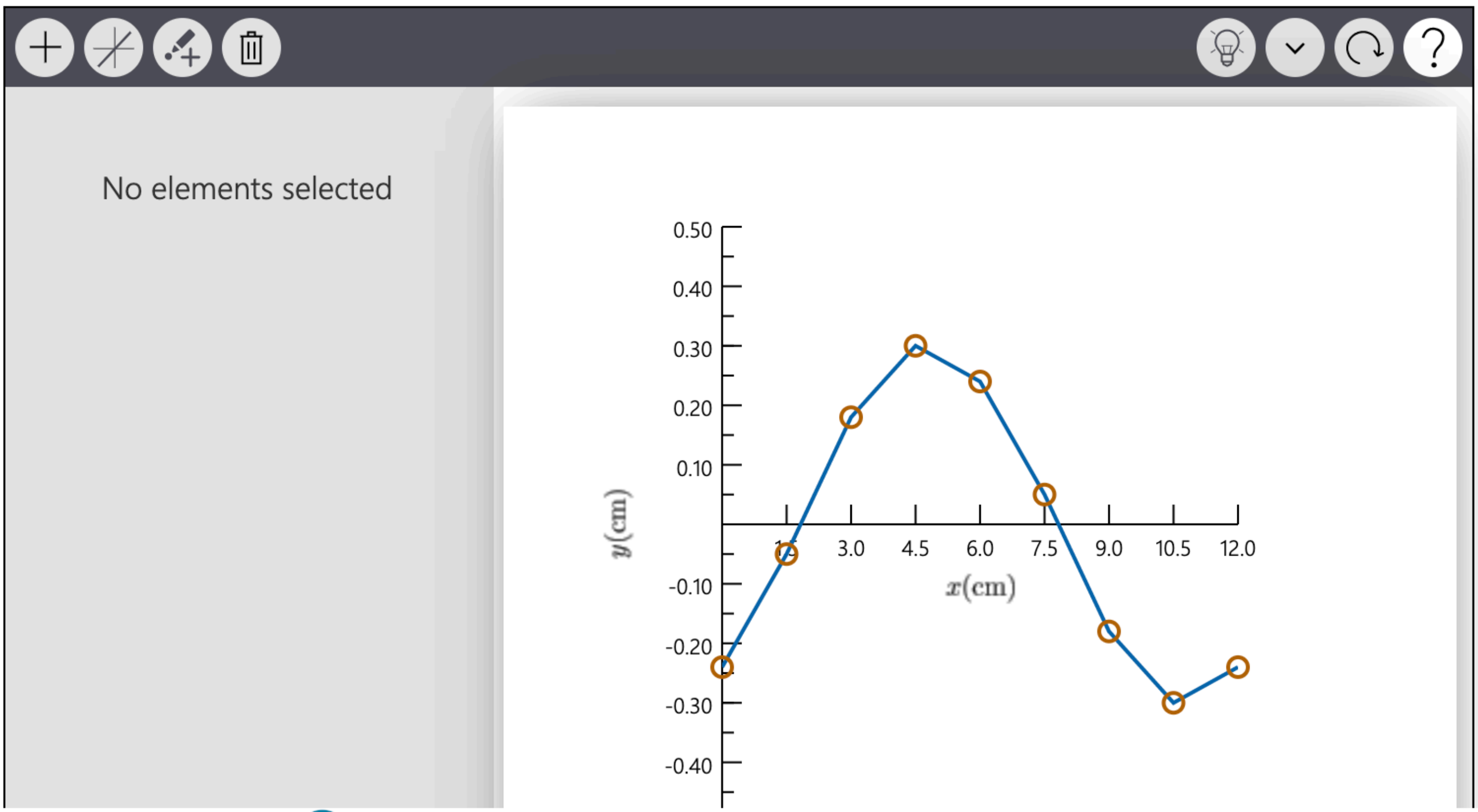
Repeat the calculations for the same values of x at time $t = 0.400$ s. Graph the shape of the string at these instants.

No elements selected



Part C

Repeat the calculations for the same values of x at time $t = 0.800$ s. Graph the shape of the string at these instants.



Part D

In what direction is the wave traveling?

- $+x$ direction
- $-x$ direction

Review | Constants

A 1.40 m string of weight 0.0135 N is tied to the ceiling at its upper end, and the lower end supports a weight W. Ignore the very small variation in tension along the length of the string that is produced by the weight of the string. When you pluck the string slightly, the waves traveling up the string obey the equation

$$y(x,t) = (8.50\ \mathrm{mm})\cos(172\ \mathrm{rad/m}\ x - 4830\ \mathrm{rad/s}\ t)$$

Assume that the tension of the string is constant and equal to W.

Part A

How much time does it take a pulse to travel the full length of the string?

Express your answer with the appropriate units.

t = Value Units

Submit Request Answer

Part B

What is the weight W?

Express your answer with the appropriate units.

W = Value Units

Part C

How many wavelengths are on the string at any instant of time?

Express your answer as an integer.

N =

Submit   Request Answer

Part D

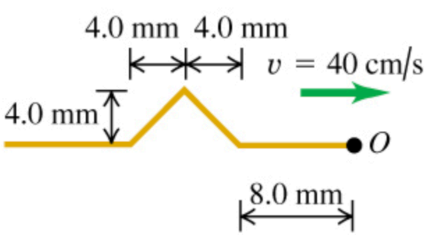
What is the equation for waves traveling *down* the string?

- $y(x,t) = (8.50\ \mathrm{mm})\cos(172\ \mathrm{rad/m}\ x - 4830\ \mathrm{rad/s}\ t)$
- $y(x,t) = (8.50\ \mathrm{mm})\cos(172\ \mathrm{rad/m}\ x + 4830\ \mathrm{rad/s}\ t)$
- $y(x,t) = (10.5\ \mathrm{mm})\cos(172\ \mathrm{rad/m}\ x + 4830\ \mathrm{rad/s}\ t)$
- $y(x,t) = (10.5\ \mathrm{mm})\cos(172\ \mathrm{rad/m}\ x - 4830\ \mathrm{rad/s}\ t)$

Review | Constants

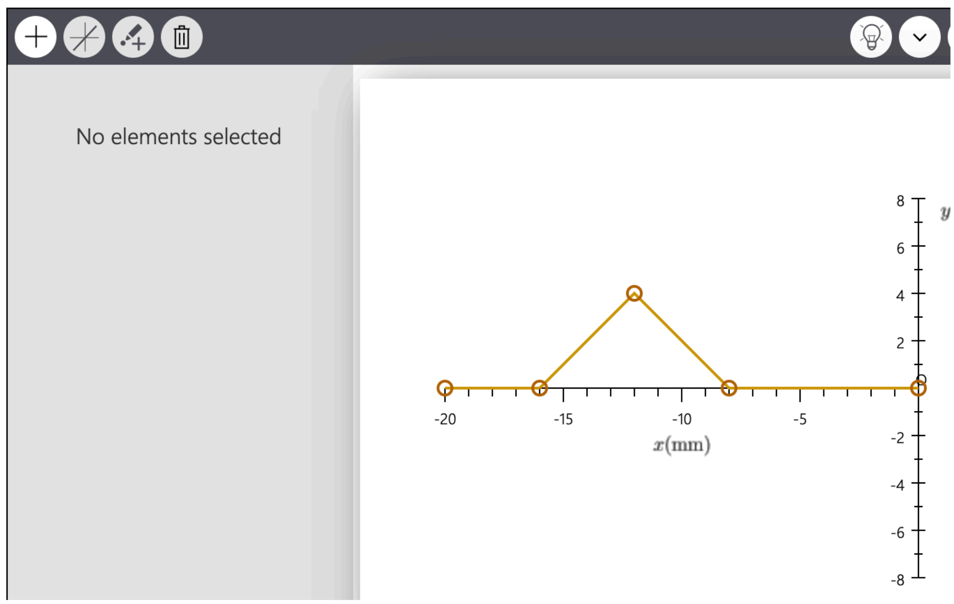
A wave pulse on a string has the dimensions shown in the figure (Figure 1) at $t = 0$. The wave speed is 40 $\mathrm{cm/s}$.

Figure



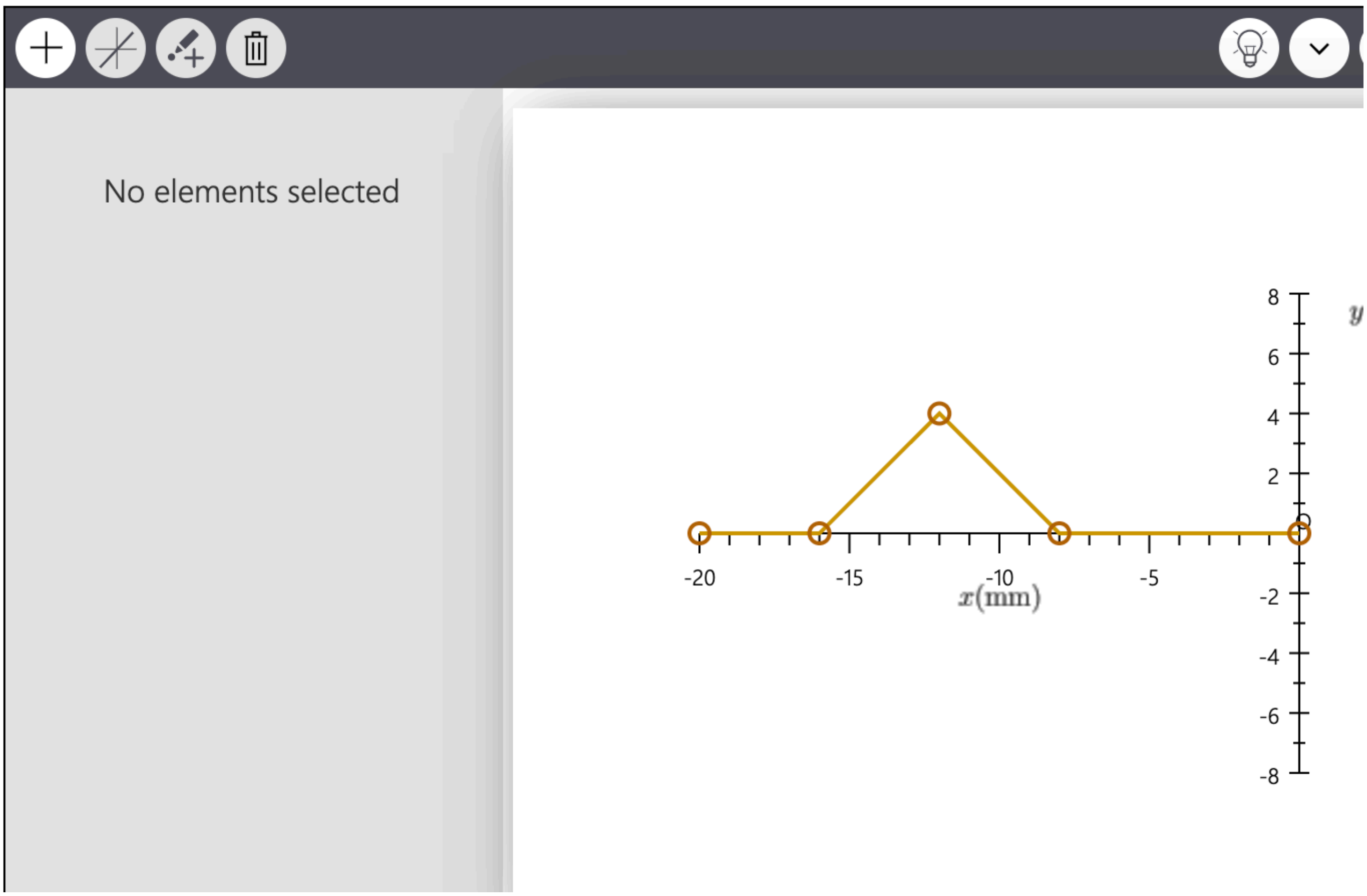
Part A

If point O is a fixed end, draw the total wave on the string at $t = 15\mathrm{ms}$.



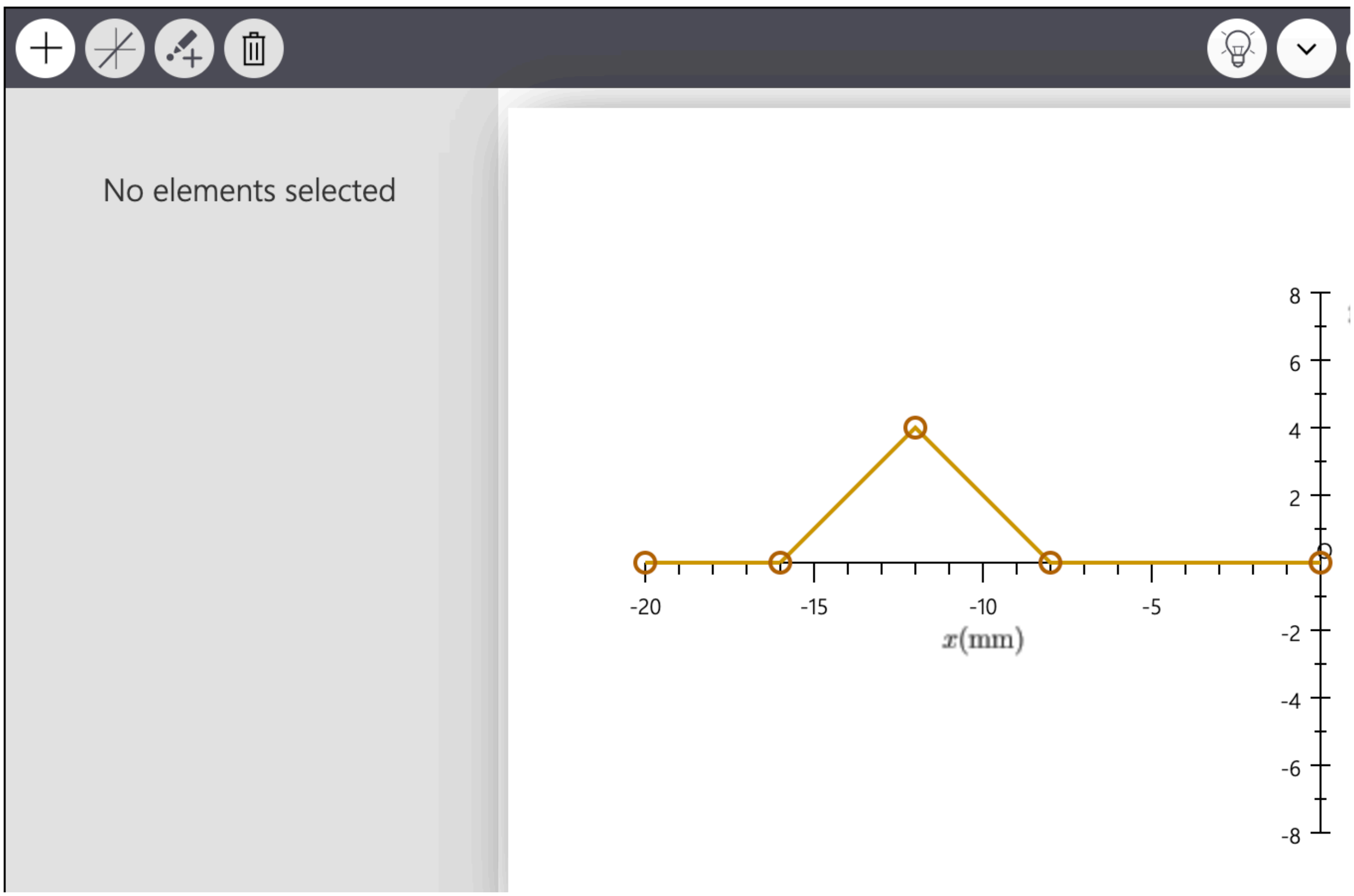
Part B

If point O is a fixed end, draw the total wave on the string at t = 20 ms.



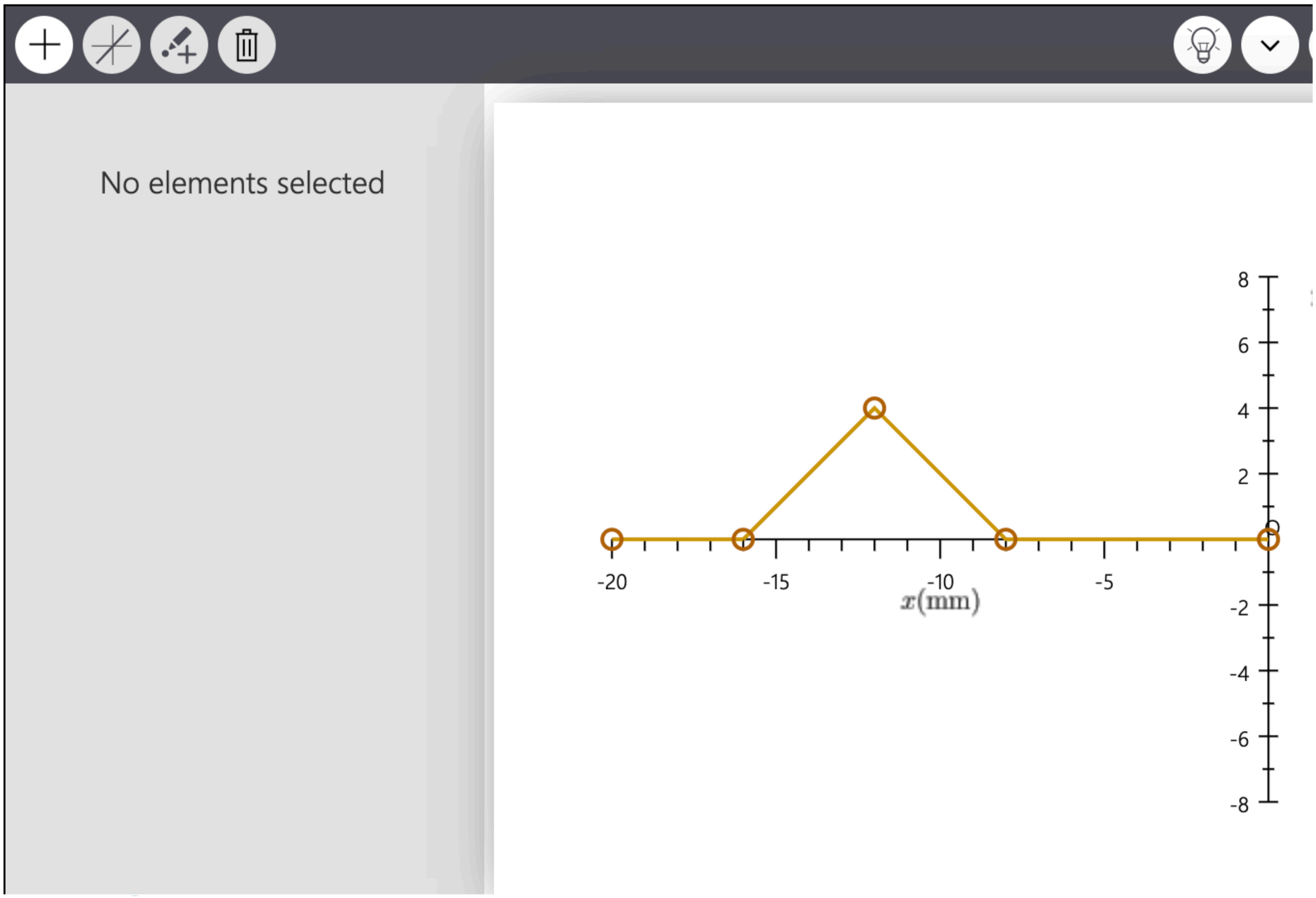
Part C

If point O is a fixed end, draw the total wave on the string at t = 25 ms.



Part D

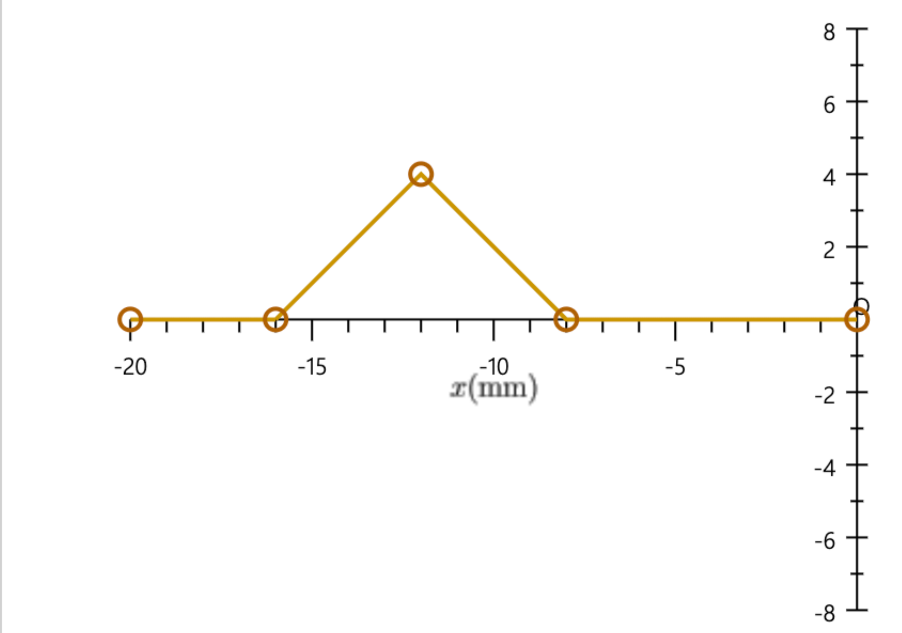
If point O is a fixed end, draw the total wave on the string at t = 30 ms.



Part E

If point O is a fixed end, draw the total wave on the string at $t = 35$ ms.

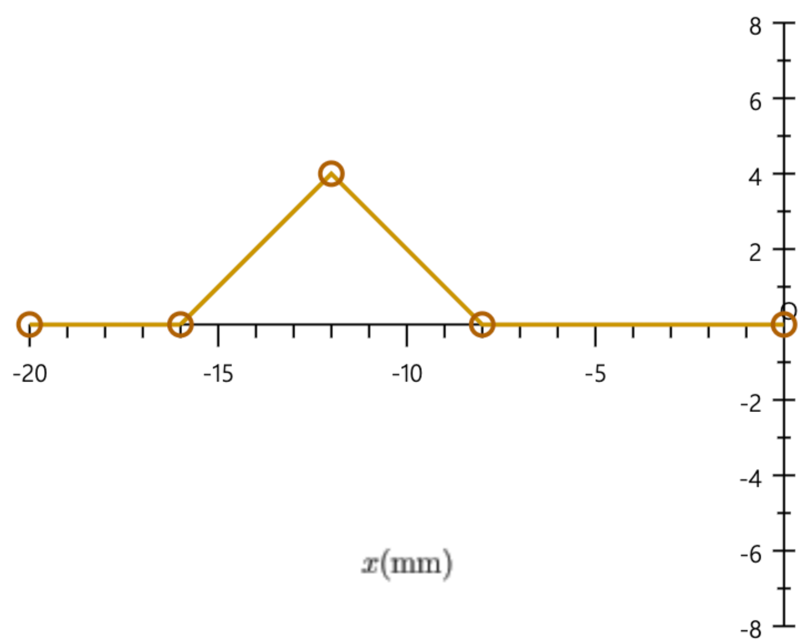
No elements selected



Part F

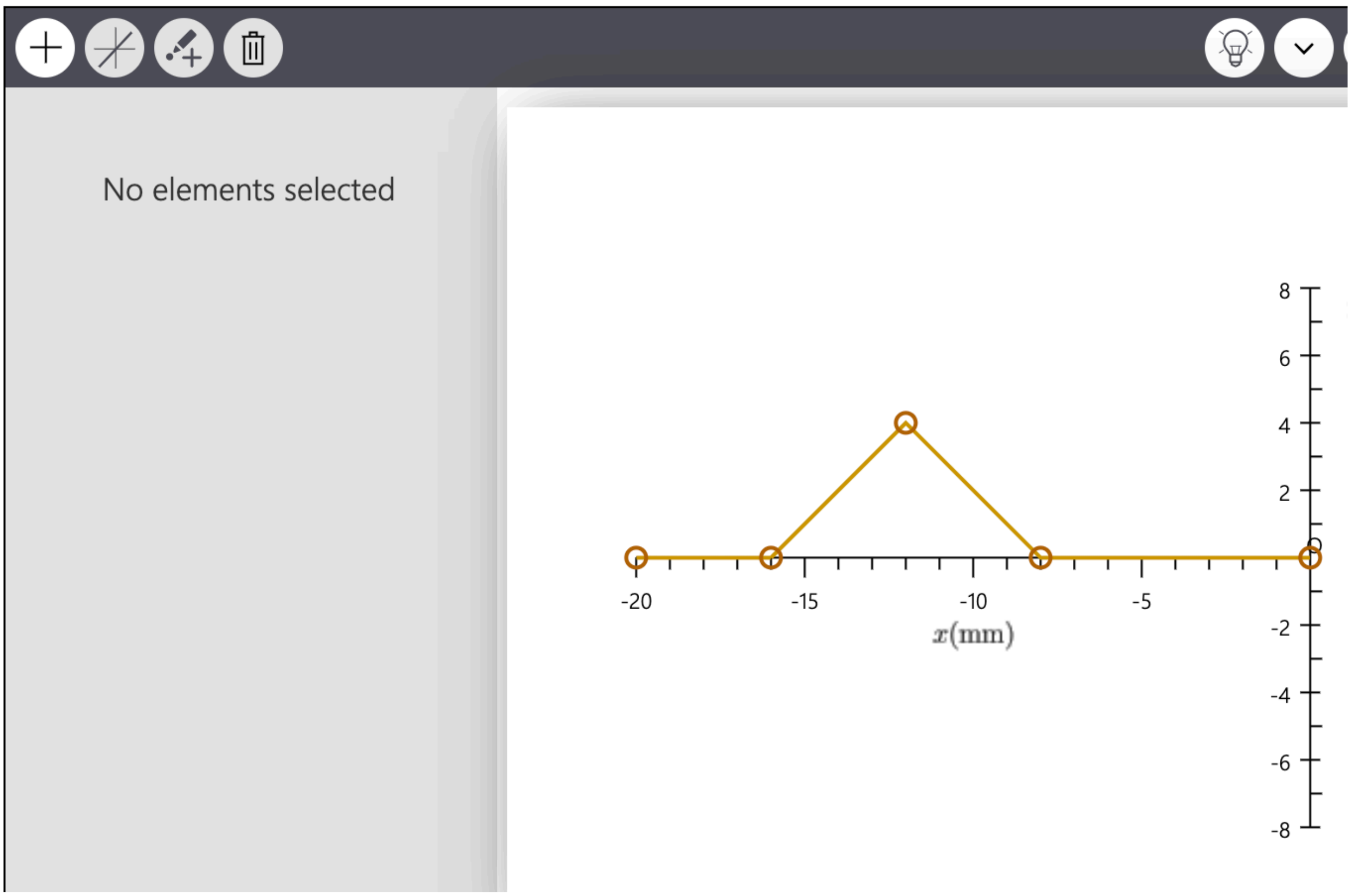
If point O is a fixed end, draw the total wave on the string at t = 40 ms.

No elements selected



Part G

If point O is a fixed end, draw the total wave on the string at t = 45 ms.

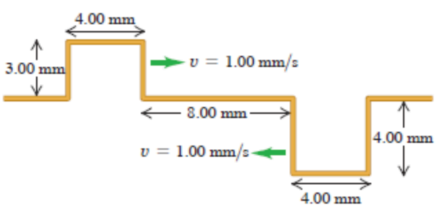


✔ Complete

Review | Constants

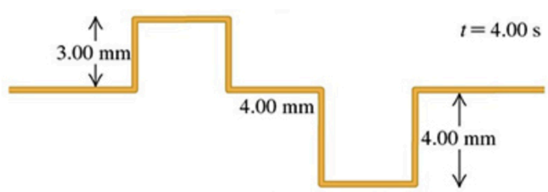
(Figure 1) shows two rectangular wave pulses on a stretched string traveling toward each other. Each pulse is traveling with a speed of 1.00 $\mathrm{mm/s}$ and has the height and width shown in the figure.

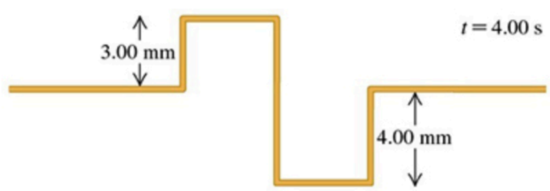
Figure



Part A

If the leading edges of the pulses are 8.00 mm apart at t = 0, select the sketch that correctly shows the shape of the string at t = 4.00 s.

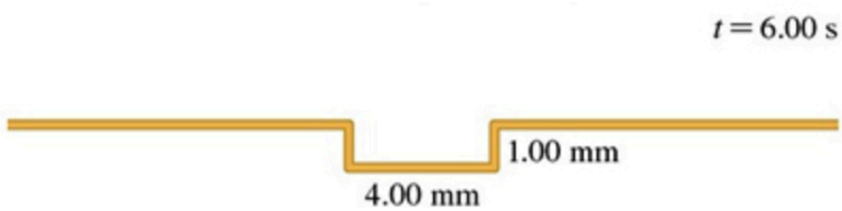




Submit   Previous Answers

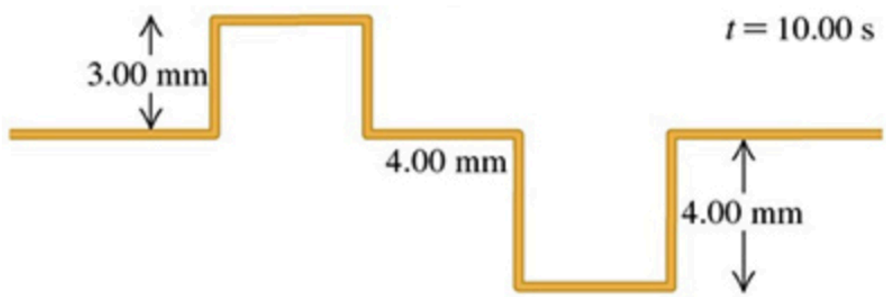
Part B

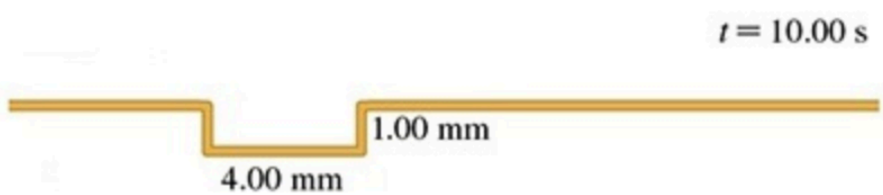
Select the sketch that correctly shows the shape of the string at t = 6.00 s.

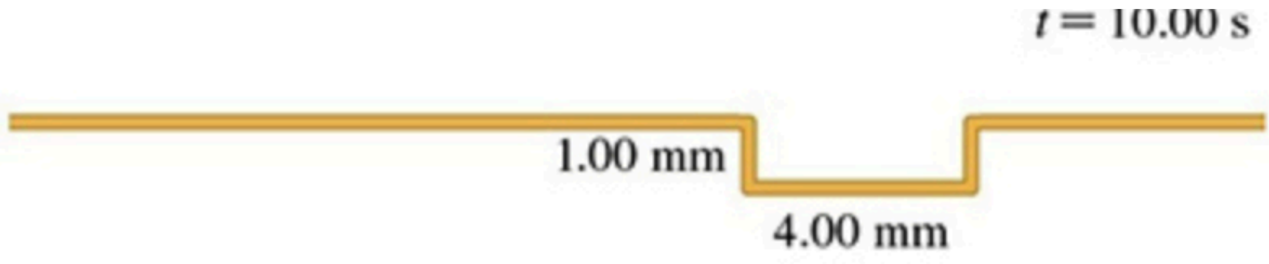


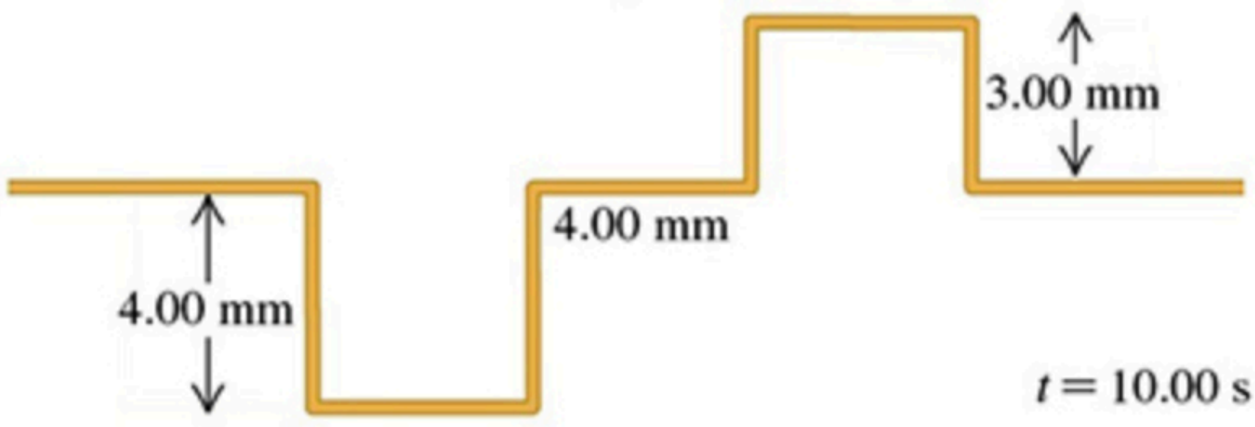
Part C

Select the sketch that correctly shows the shape of the string at t = 10.00 s.






t = 10.00 s
1.00 mm
4.00 mm


3.00 mm
4.00 mm
4.00 mm
t = 10.00 s

Problem 15.50

✓ Complete

An ant with mass m is standing peacefully on top of a horizontal, stretched rope. The rope has mass per unit length μ and is under tension F. Without warning, Throckmorton starts a sinusoidal transverse wave of wavelength λ propagating along the rope. The motion of the rope is in a vertical plane.

Review | Constants

Part A

What minimum wave amplitude will make the ant become momentarily weightless? Assume that m is so small that the presence of the ant has no effect on the propagation of the wave.

Express your answer in terms of the variables m, λ, F, μ, and g.

$$A = \frac{\mu\lambda^2 g}{4\pi^2 F}$$