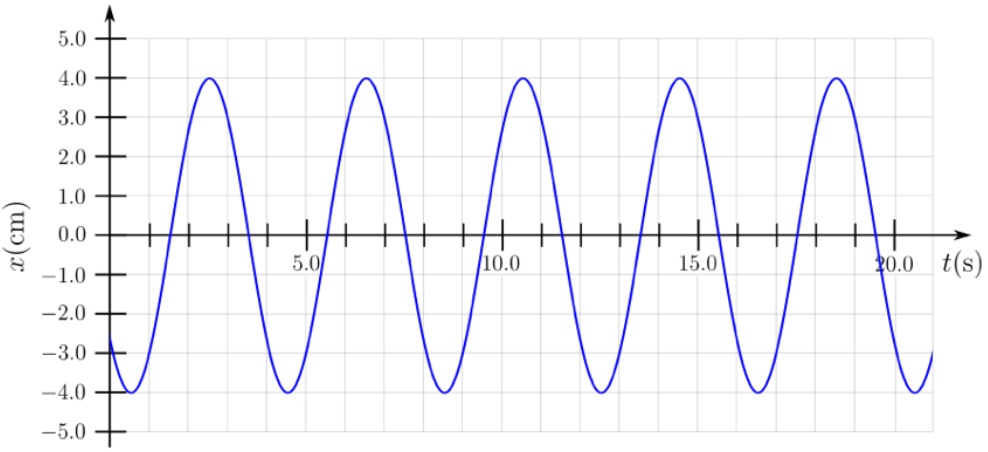
Problem 1: Some College Physics students are studying periodic motion using an oscillating mass on a spring. After collecting data, they sketched the position *versus* time graph shown.



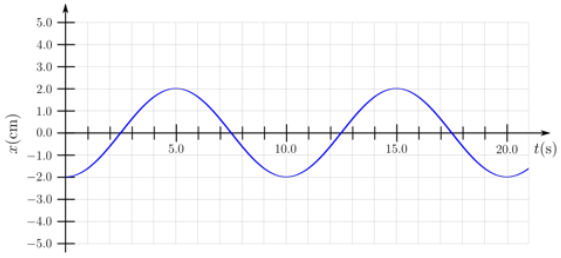
The function that represents the data on the graph may be written as

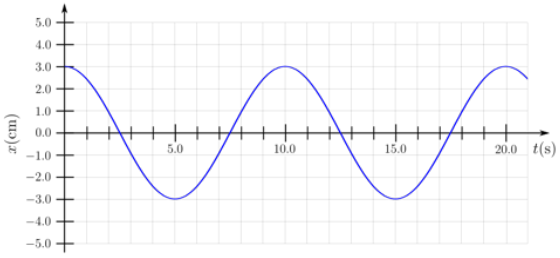
$$x = A\cos(\omega t + \phi) \quad \text{with} \quad \phi \in [0, 2\pi)$$

The phase constant for the graph presented is most nearly
MultipleChoice :

1) $\phi = 90^\circ$
2) $\phi = 225^\circ$
3) $\phi = 315^\circ$
4) $\phi = 0^\circ$
5) $\phi = 135^\circ$
6) $\phi = 270^\circ$
7) $\phi = 45^\circ$
8) $\phi = 180^\circ$

Problem 2: Some Introductory Physics students are studying periodic motion using an oscillating mass on a spring. After acquiring data, they drew position *versus* time graphs, including the two shown.





Select *all* attributes that are the same for both graphs. All phase constants are a multiple of 45˚.
MultipleSelect :

1) amplitude
2) frequency

3) phase constant

Problem 3: One kind of cuckoo clock keeps time by using a mass bouncing on a spring, usually something cute like a cherub in a chair.

What is the force constant, in newtons per meter, needed to produce a period of ***0.375*** s for a ***0.019***-kg mass on the spring?
Numeric : A numeric value is expected and not an expression.
k = _____

Problem 4: The midpoint M of a guitar string is pulled a distance d = ***1.3*** mm from equilibrium and released. Point M is observed to undergo simple harmonic motion with a frequency f = ***140*** Hz.

Part (a) Calculate the angular frequency ω of oscillation in radians per second.
Numeric : A numeric value is expected and not an expression.
$\boldsymbol{\omega}$ = _____

Part (b) Assume the displacement of point M from equilibrium as a function of time t after release is of the form $x(t) = x_{max} \cos(\omega t + \Phi)$. What is x_{max} in meters?
Numeric : A numeric value is expected and not an expression.
$\boldsymbol{x_{max}}$ = _____

Part (c) After the string is first released, how many seconds will elapse before it first reaches its equilibrium position?
Numeric : A numeric value is expected and not an expression.
t = _____

Part (d) Calculate the maximum speed of point M during its oscillation v_{max} in meters per second.
Numeric : A numeric value is expected and not an expression.
$\boldsymbol{v_{max}}$ = _____

Part (e) Select the position(s) at which Point M reaches its maximum speed. There may be more than one point where Point M reaches maximum speed.
MultipleChoice :

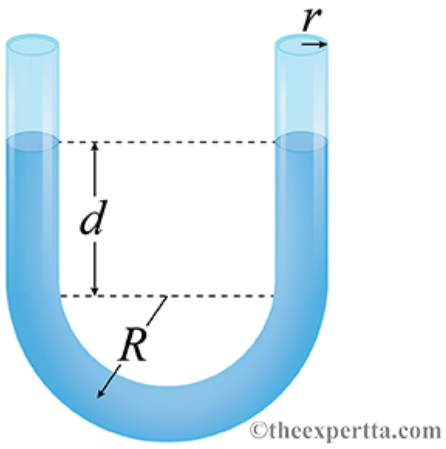
1) Cannot be determined with the given information.
2) $0 < x < d$
3) $x = 0$
4) $-d < x < 0$
5) $x = -d$
6) $x = d$

Part (f) Calculate the magnitude of the maximum acceleration experienced by point M during its oscillation a_{max} in meters per square second.
Numeric : A numeric value is expected and not an expression.
a_{max} = _____

Part (g) Select the position(s) at which the acceleration of point M is maximized.
MultipleSelect :

1) $x = -d$
2) $x = 0$
3) Cannot be determined with the given information.
4) $x = d$
5) $-d < x < 0$
6) $0 < x < d$

Problem 5: A section of uniform pipe is bent into an upright U shape and partially filled with water, which can then oscillate back and forth in simple harmonic motion. The inner radius of the pipe is r = ***0.027*** m. The radius of curvature of the curved part of the U is R = ***0.23*** m. When the water is not oscillating, the depth of the water in the straight sections is d = ***0.42*** m.



Part (a) Enter an expression for the mass of water in the tube, in terms of the defined quantities and the density of water, ϱ. Use the approximation $r << R$.
Expression :
m = _____

Select from the variables below to write your expression. Note that all variables may not be required.
β, **γ**, **π**, **ϱ**, **θ**, **d**, **g**, **h**, **j**, **k**, **m**, **n**, **P**, **r**, **R**

Part (b) Calculate the mass of the water, in kilograms. Take $\varrho = 1000$ kg/m^3.
Numeric : A numeric value is expected and not an expression.
m = _____

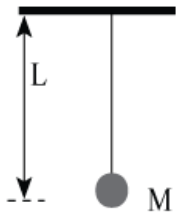
Part (c) Enter an expression for the force constant of the U-shaped column of water when displaced from equilibrium, in terms of the defined quantities, ϱ, and g. This constant is analogous to the spring constant in Hooke's law.
Expression :
k = _____

Select from the variables below to write your expression. Note that all variables may not be required.
β, **γ**, **π**, **ϱ**, **θ**, **d**, **g**, **h**, **j**, **k**, **m**, **n**, **P**, **r**, **R**

Part (d) Find the value of the force constant, in newtons per meter. Take $\varrho = 1000$ kg/m^3 and $g = 9.81$ m/s^2.
Numeric : A numeric value is expected and not an expression.
k = _____

Part (e) Calculate the period of oscillation, in seconds.
Numeric : A numeric value is expected and not an expression.
T = _____

Problem 6: A pendulum is shown in the figure to the right. It consists of a solid ball with uniform density and has a mass *M* and is suspended from the ceiling with a massless rod as shown in the figure. The ball on the pendulum is extremely small.



Randomized Variables

L = *4.2* m

Part (a) How does the period of the pendulum change if the mass is doubled? Choose the best answer.
MultipleChoice :

1) The period is increased by a factor of √2.
2) The period remains unchanged.
3) The period is doubled.
4) The period is decreased by a factor of √2.

Part (b) Find the period *T* of the pendulum for small displacements in s.
Numeric : A numeric value is expected and not an expression.
T = _____

Problem 7: A uniform rod of mass *M* and length *L* is free to swing back and forth by pivoting a distance *x* from its center. It undergoes harmonic oscillations by swinging back and forth under the influence of gravity.

Randomized Variables

M = *3.2* kg

L = *1.5* m

x = *0.22* m

Part (a) In terms of *M*, *L*, and *x*, what is the rod's moment of inertia *I* about the pivot point.
Expression :
I = _____

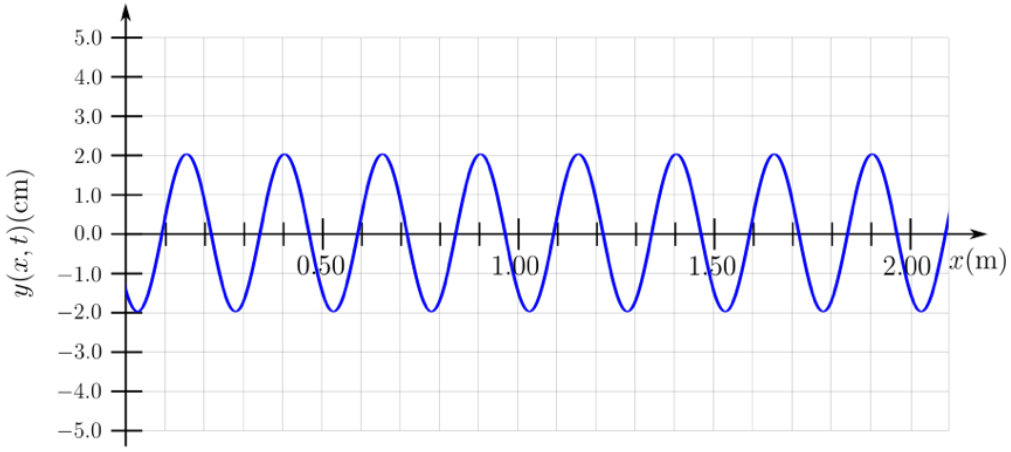
Select from the variables below to write your expression. Note that all variables may not be required.
α, **β**, **θ**, **a**, **d**, **g**, **h**, **j**, **k**, **L**, **M**, **n**, **P**, **t**, **x**

Part (b) Calculate the rod's period *T* in seconds for small oscillations about its pivot point.
Numeric : A numeric value is expected and not an expression.
T = _____

Part (c) In terms of L, find an expression for the distance x_m for which the period is a minimum.
Expression :
x_m = _____

Select from the variables below to write your expression. Note that all variables may not be required.
α, β, θ, a, d, g, h, j, k, L, M, n, P, t, x

Problem 8: The graph below shows the transverse displacement *versus* position at a fixed time for a traveling wave with a propagation speed of 3.92 m/s.

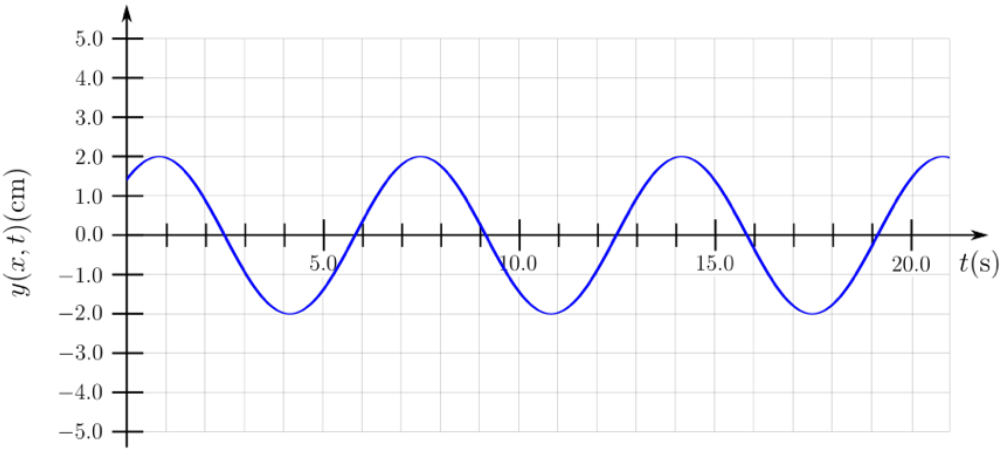


Part (a) What is the amplitude, in centimeters, of the wave?
Numeric : A numeric value is expected and not an expression.
A = _____ cm

Part (b) What is the wavelength, in meters, of the wave.
Numeric : A numeric value is expected and not an expression.
λ = _____ m

Part (c) What is the frequency, in hertz, of the wave?
Numeric : A numeric value is expected and not an expression.
f = _____ Hz

Problem 9: The graph below shows the transverse displacement *versus* time at a fixed location for a traveling wave with a propagation speed of 4.92 m/s.

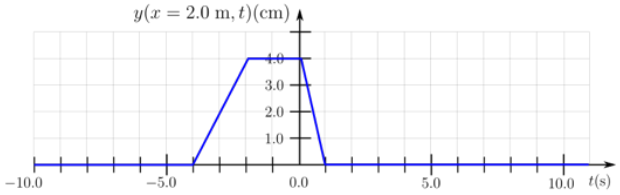


Part (a) What is the amplitude, in centimeters, of the wave?
Numeric : A numeric value is expected and not an expression.
A = _____ cm

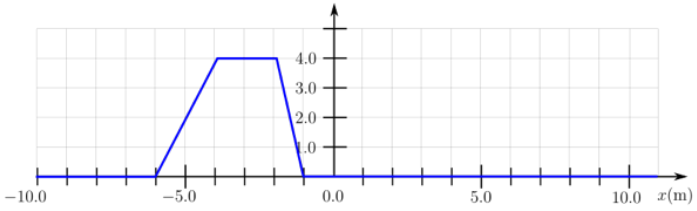
Part (b) What is the frequency, in hertz, of the wave.
Numeric : A numeric value is expected and not an expression.
f = _____ Hz

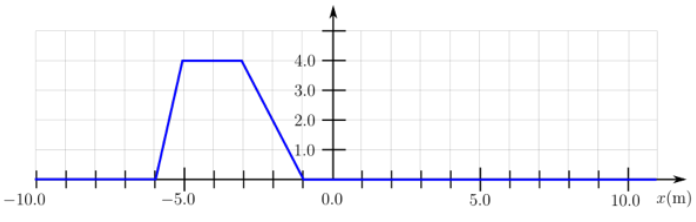
Part (c) What is the wavelength, in meters, of the wave?
Numeric : A numeric value is expected and not an expression.
λ = _____ m

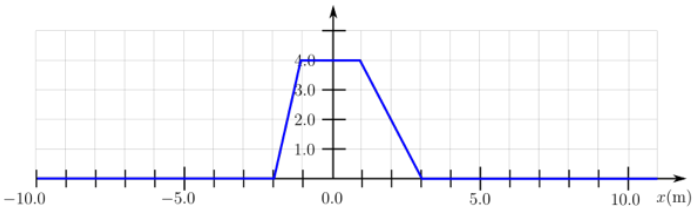
Problem 10: Because the transverse displacements along a wave depend upon both position and time, there are two approaches to presenting its graph. If the position is held constant, then the transverse displacement *versus* time graph, a "history" plot, represents a single point along the wave acting as a simple harmonic oscillator. If the time is held constant, then the transverse displacement *versus* position graph, a "snapshot" plot, shows the appearance of the wave at an instant in time. The plot below is a history plot of a wave pulse at $x = 2.0$ m that is moving to the left at 1.0 m/s.

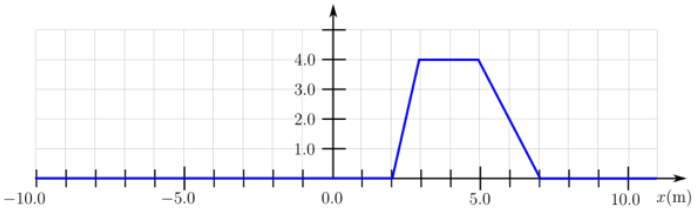


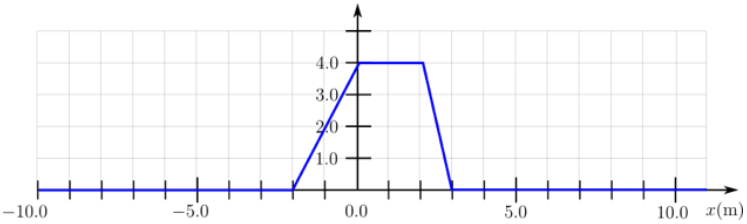
Which of these graphs is the corresponding snapshot plot at $t = -4.0$ s?
MultipleChoice :

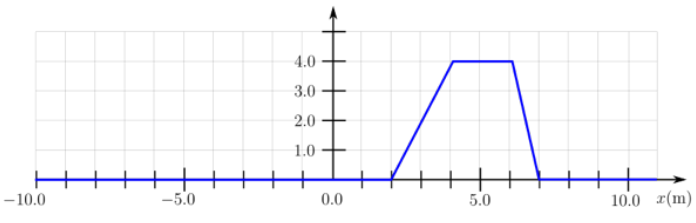
1)


2) 

3) 

4) 

5) 

6) 

Problem 11: A string is under a tension of T = *136* N. The string has a mass of m = *6* g and length L. When the string is played the velocity of the wave on the string is V = *326* m/s.

Randomized Variables

T = *136* N

m = *6* g

V = *326* m/s

Part (a) What is the length of the string, in meters?
Numeric : A numeric value is expected and not an expression.
L = _____

Part (b) If L is one wavelength, what is the frequency, in hertz?
Numeric : A numeric value is expected and not an expression.
ν = _____

Problem 12: A string of length L = *1.9* m and mass m = *0.025* kg is fixed between two stationary points, and when the string is played a transverse wave of frequency f = *98* Hz is generated. The wave is vibrating in an unknown harmonic.

Randomized Variables

L = *1.9* m

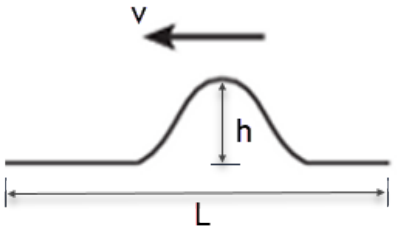
m = *0.025* kg

f = *98* Hz

Part (a) What is the strings linear density, ϱ, in kilograms per meter?
Numeric : A numeric value is expected and not an expression.
ϱ = _____

Part (b) If the wavelength is λ = 10.0 cm what is the tension in N?
Numeric : A numeric value is expected and not an expression.
T = _____

Problem 13: Two students stretch a uniform rope of length L = *4.4* m and mass m = *1.2* kg between them. One of the students gives the rope a quick up-and-down shake and produces a transverse pulse that travels the length of the rope in time t_1 = *1.3* s.

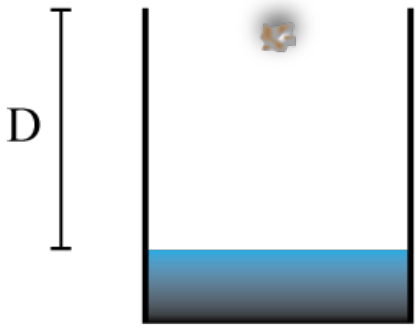


Part (a) What is the tension in the rope in units of newtons?
Numeric : A numeric value is expected and not an expression.
T = _____ N

Part (b) A third student uses a slow-motion camera to observe the pulse and measures that it takes a time t_2 = *0.15* s for the full width of the pulse to pass by her. She also carefully measures the height of pulse (from the equilibrium level of the rope to the pulse's peak) to be h = *0.15* m. What is the pulse's width, in meters?
Numeric : A numeric value is expected and not an expression.
w = _____ m

Part (c) A point on the rope is marked with a red spot. As the pulse passes by, what is the spot's average speed, in meters per second, during its transverse motion from equilibrium position to peak and back?
Numeric : A numeric value is expected and not an expression.
v = _____ m/s

Problem 14: You stand at the top of a deep well. To determine the depth, D, of the well you drop a rock from the top of the well and listen for the splash as the rock hits the water's surface. The sound of the splash arrives t = *3.9* s after you drop the rock. The speed of sound in the well is v_s = *345* m/s.



Part (a) Enter the quadratic equation for the distance, D, in terms of the time, the acceleration due to gravity, and the speed of sound. Arrange the expression so that the coefficient of the D^2 term is 1.
Expression :
0 = _____

Select from the variables below to write your expression. Note that all variables may not be required.
α, **β**, **π**, **θ**, **a**, **D**, **g**, **h**, **j**, **k**, **m**, **P**, **S**, **t**, $\mathbf{v_s}$

Part (b) Solve the quadratic equation for the depth of the well, D, and calculate it's value, in meters.
Numeric : A numeric value is expected and not an expression.
D = _____

Problem 15: You are hiking along a trail in a wide, dry canyon where the outdoor temperature is T = *28*° C. To determine how far you are away from the canyon wall you yell "Hello" and hear the echo t = *3.2* s later.

Randomized Variables

T = *28*° C

t = *3.2* s

Part (a) Calculate the speed of sound in the valley in meters per second, assuming the speed at 0° C is 330 m/s.
Numeric : A numeric value is expected and not an expression.
v = _____

Part (b) How far are you from the canyon wall, in meters?
Numeric : A numeric value is expected and not an expression.
D = _____

Part (c) If you stood at the same point on a cold morning where the temperature was T_2 = *-1.5* degrees C, how long would it have taken for you to hear the echo, in seconds?
Numeric : A numeric value is expected and not an expression.
$\boldsymbol{t_2}$ = _____

Problem 16: The human ear can detect a minimum intensity of $I_o = 10^{-12}$ W/m^2, which has a sound intensity of 0 dB.

Randomized Variables

β = *45* dB

If the student hears a sound at *45* dB, what is the intensity of the sound?
Numeric : A numeric value is expected and not an expression.
I = _____

Problem 17: Ten cars in a circle at a boom box competition produce a *140*-dB sound intensity level at the center of the circle.

I_2 / I_1	$\beta_2 - \beta_1$
2.0	3.0 dB
5.0	7.0 dB
10.0	10.0 dB

What is the average sound intensity level, in decibels, produced there by each stereo, assuming interference effects can be neglected?
Numeric : A numeric value is expected and not an expression.
β' = _____

Problem 18: An audio engineer takes decibel readings at distances of r_1 = *14* m and r_2 = *25* m from a concert stage speaker during a sound check. When he is r_1 from the speaker, the engineer registers a decibel level of $\square\beta_1$ = *110* dB on his loudness meter.

Randomized Variables

r_1 = *14* m
r_2 = *25* m
β_1 = *110* dB

Part (a) What is the intensity of the sound, I_1, in watts per square meter, that is measured by the loudness meter when the engineer is a distance of r_1 from the speaker?
Numeric : A numeric value is expected and not an expression.
I_1 = _____

Part (b) How much power P, in watts, is coming from the speaker during the sound check at distance r_1?

Numeric : A numeric value is expected and not an expression.
P = _____

Part (c) Assuming that the speaker output does not change between the two measurements at r_1 and r_2, what sound intensity level β_2, in decibels, will the loudness meter report when the engineer is at a distance r_2 from the speaker?
Numeric : A numeric value is expected and not an expression.
β_2 = _____

Problem 19: A single dog barks at a sound intensity level of β = *96* dB.

Part (a) Another dog runs up beside the first dog and starts barking at the same sound intensity level. What sound intensity level in decibels do you hear from the two dogs barking?
Numeric : A numeric value is expected and not an expression.
β_2 = _____ dB

Part (b) Now many other dogs run up and start barking at you. Assuming they all bark at the same sound intensity level, what will the sound intensity level in decibels be if there are n = *9* dogs barking at you?
Numeric : A numeric value is expected and not an expression.
β_n = _____ dB

Problem 20: One day when the speed of sound in air is 343 m/s, a fire truck traveling at v_s = *23* m/s has a siren which produces a frequency of f_s = *415* Hz.

Randomized Variables

v_S = *23* m/s
f = *415* Hz

Part (a) What frequency, in units of hertz, does the driver of the truck hear?
Numeric : A numeric value is expected and not an expression.
f_d = _____ Hz

Part (b) What frequency, in units of hertz, does an observer hear when the truck is moving away?
Numeric : A numeric value is expected and not an expression.
f_o = _____ Hz

Problem 21: A bat flying toward a wall emits a *49000*-Hz sonar pulse. The pulse is reflected back from the wall and the bat hears the reflected pulse at a frequency of (*49000* + *430*) Hz. Take the speed of sound to be 343 m/s.

Find the speed of the bat, in meters per second.
Numeric : A numeric value is expected and not an expression.
v_{bat} = _____

Problem 22: A bat, flying at *5.9* m/s, pursues an insect that is flying at *1.1* m/s in the same direction. The bat emits a *47000*-Hz sonar pulse. Take the speed of sound to be 343 m/s.

At what frequency, in hertz, does the bat hear the pulse reflected back from the insect?
Numeric : A numeric value is expected and not an expression.
f = _____