Name _____ Student ID: _____
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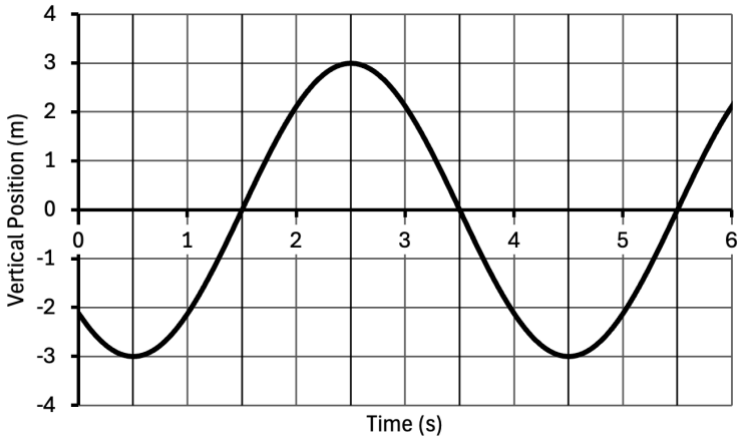
1. [3 pts] The figure at right shows the position-versus-time graph for an object in SHM. For the time interval shown in the graph, (a) at what time(s) does the particle move with its maximum negative velocity and (b) at what time(s) is the particle moving at its maximum positive acceleration?



A) (a) 1.5 s, 5.5 s (b) 2.5 s

B) (a) 1.5 s, 5.5 s (b) 0.5 s, 4.5 s

C) (a) 3.5 s (b) 2.5 s

D) (a) 3.5 s (b) 1.5 s, 5.5 s

E) (a) 3.5 s (b) 0.5 s, 4.5 s

2. [4 pts] Which of the equations below best describes the position-time function for the object in the previous question? The vertical axis intercept coordinate is (0 s, -2.12 m).

A) $y(t) = (3\text{ m})\cos\left(\left(\frac{\pi}{2}\frac{\text{rad}}{\text{s}}\right)t + 2.36\text{ rad}\right)$

B) $y(t) = (3\text{ m})\cos\left(\left(\frac{\pi}{2}\frac{\text{rad}}{\text{s}}\right)t - 2.36\text{ rad}\right)$

C) $y(t) = (3\text{ m})\cos\left(\left(\frac{\pi}{4}\frac{\text{rad}}{\text{s}}\right)t - 2.36\text{ rad}\right)$

D) $y(t) = (6\text{ m})\cos\left(\left(\frac{\pi}{4}\frac{\text{rad}}{\text{s}}\right)t - 0.784\text{ rad}\right)$

E) $y(t) = (3\text{ m})\cos\left(\left(\frac{\pi}{2}\frac{\text{rad}}{\text{s}}\right)t + 0.784\text{ rad}\right)$

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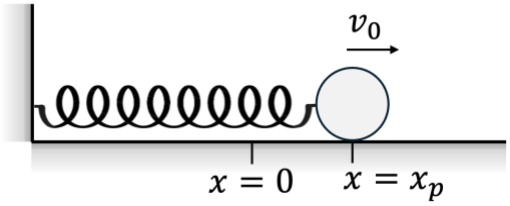
3. [3 pts] A ball of mass m_0 that is attached to an ideal spring with spring constant k_0 oscillates horizontally on a frictionless table. The ball is located at $x = 0$ cm when the spring is in its equilibrium position. The ball's velocity is v_0 when $x = x_p$. What is the amplitude of oscillation?



A) $A = \sqrt{\frac{m_0 v_0^2}{k_0} + x_p^2}$

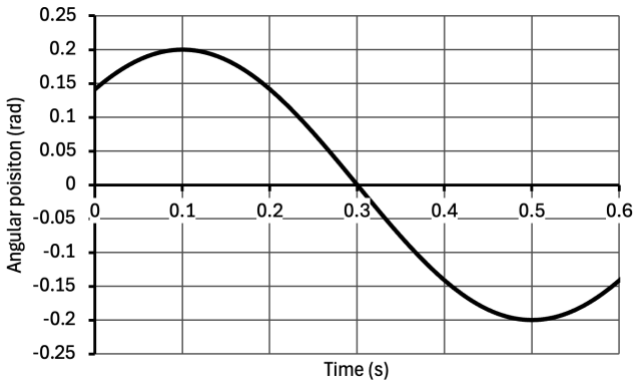
B) $A = \sqrt{m_0 v_0^2 + k_0 x_p^2}$

C) $A = m_0 v_0^2 + \sqrt{k_0 x_p}$

D) $A = \sqrt{m_0 v_0^2} + x_p$

E) Other

4. [3 pts] The angular position-versus-time curve of a simple pendulum is shown at right. What is the length of the pendulum?



A) 3.9 cm

B) 8.9 cm

C) 16 cm

D) 36 cm

E) 1.0 m

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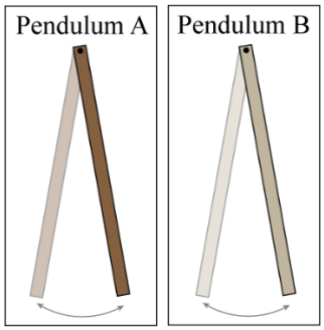
5. [4 pts] A physical pendulum, pendulum A, is formed from a uniform rod of mass $2m$ and length L. It is allowed to pivot about one of its ends. $\left(I_{rod} = \frac{1}{12}mL^2\right)$



A second physical pendulum, B, is formed from a uniform rod also of length L, but of mass m. It is also allowed to pivot from one of its ends.

Is the period of pendulum A *greater than, less than,* or *equal to* the period of pendulum B?

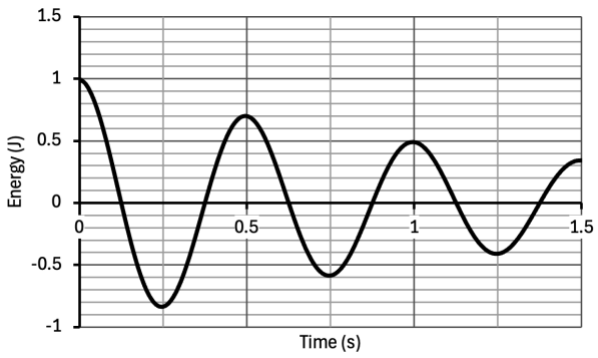
A) Greater than

B) Less than

C) Equal to

D) More information is needed.

6. [4 pts] The mechanical energy of a damped oscillator is shown as a function of time at right. What is the value of the time constant (τ) for this damped oscillator?



A) 0.25 s

B) 0.53 s

C) 0.82 s

D) 1.1 s

E) 1.4 s

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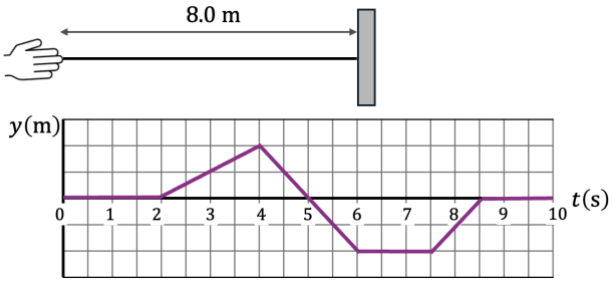
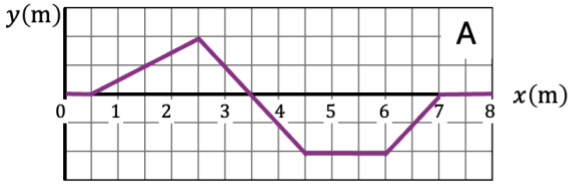
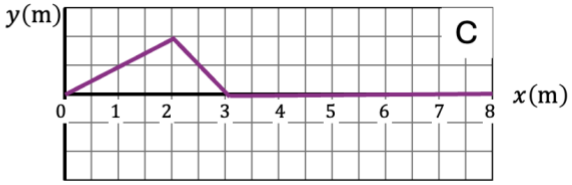
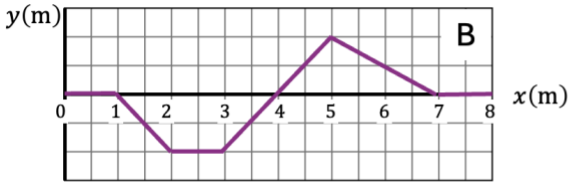
7. [4 pts] A student creates a pulse in a 8-m long string at $t = 0$ s. The pulse moves at 1 m/s. The figure at right shows a displacement curve (history graph) of a point on the string that is located 2 m from the student's hand for a time interval $t = 0$ to $t = 10$ s.

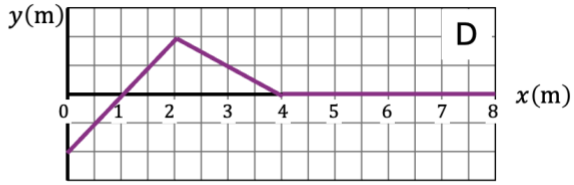


Which of the figures below could correctly represent a wave function (snapshot graph) of the pulse created by the student?



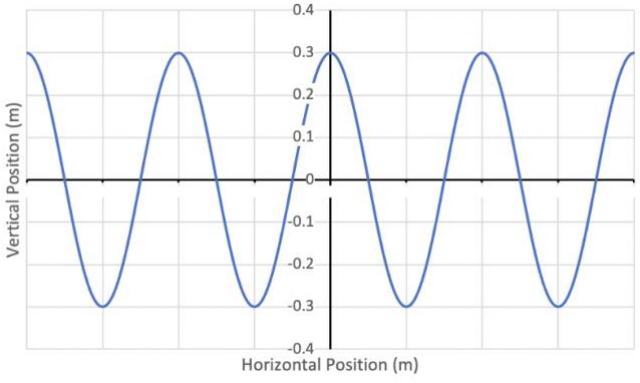






A) Figure A only
B) Figure A and B
C) Figure A and C
D) Figure B and D
E) Figure B only

8. [4 pts] A sinusoidal wave in the ocean has an amplitude of 0.300 m and a period of 8.33 s. The wave moves in the negative x-direction with a speed of 1.20 m/s. A snapshot graph of the wave is shown below at $t = 0$ s. What is the vertical position of the surface of the wave at $x = 4.00$ m at $t = 2.40$ s?



A) +0.20 m
B) +0.14 m
C) +0.062 m
D) -0.11 m
E) -0.15 m

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9. [4 pts] A journalist for the The Daily attends the Guns n Roses concert at the Gorge. The journalist gets access to the pit area and stands 30.0 m from the speakers on the right of the stage. If the sound intensity level at the journalist's location is 88.0 dB, what is the sound intensity at her location?

   A) $2.59 \times 10^{-3}\ \mathrm{W/m^2}$

   B) $3.16 \times 10^{-3}\ \mathrm{W/m^2}$

   C) $6.31 \times 10^{-4}\ \mathrm{W/m^2}$

   D) $3.84 \times 10^{-4}\ \mathrm{W/m^2}$

   E) $1.58 \times 10^{-3}\ \mathrm{W/m^2}$

10. [4 pts] A ambulance siren emits a sound of frequency 440.0 Hz. A student perceives a frequency of 422.4 Hz. The student also perceives that the speed of the sound waves has increased. Which of the following is true? Note that v_{sound} represents the speed of sound in air.

    A) The ambulance is stationary and the student is moving at $14.4\ \mathrm{m/s}$ toward the ambulance.

    B) The ambulance is stationary and the student is moving at $13.7\ \mathrm{m/s}$ away from the ambulance.

    C) The ambulance is stationary and the student is moving at $14.4\ \mathrm{m/s}$ away from the ambulance.

    D) The student is stationary and the ambulance is moving at $13.7\ \mathrm{m/s}$ away from the student.

    E) The student is stationary and the ambulance is moving at $14.4\ \mathrm{m/s}$ toward from the student.

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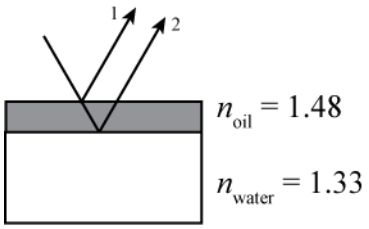
11. [3 pts] A 66.0 cm string is tied down at both of its end, and the tension in the strong is 15.6 N. The linear mass density of the string is measured to be 0.00863 kg/m and the string forms a standing wave that oscillates at 193.0 Hz. How many antinodes does this standing wave have?

A) 1
B) 2
C) 3
D) 4
E) 6

12. [4 pts] As you walk up the Ave on a rainy Seattle day, you notice a small oil spill. A thin layer of oil sits on top of a puddle of water. The index of refraction of oil is 1.48 and the index of refraction of water is 1.33. For the reflected waves 1 and 2, what colors in the visible spectrum (400 nm – 700 nm) will be absent from the oil film? Assume the light is initially incident normal to the surface and the oil film has a thickness of 700.0 nm.



A) 562 nm and 430 nm
B) 592 nm and 460 nm
C) 612 nm and 440 nm
D) 691 nm, 518 nm and 414 nm
E) 648 nm, 538 nm and 422 nm

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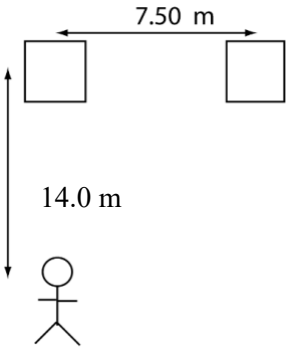
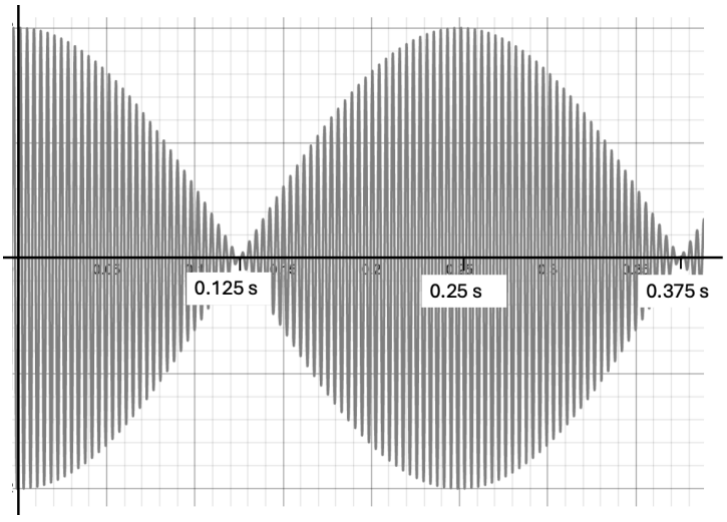
13. [4 pts] While attending a concert at the Neptune theater, you are sitting 14.0 m directly in front of the speaker on the left part of the stage. The speaker at the left part of the stage is positioned 7.50 m from the right speaker. v_{sound} = 343 m/s.



If the speakers are emitting a frequency of 410 Hz, will you hear a maximum sound, a minimum sound, or something in between?

A) Maximum sound
B) Minimum sound
C) Something in between
D) More information is needed.

14. [3 pts] A student is tuning their guitar string by counting the beats when they pluck the string and simultaneously strike a tuning fork. The tuning fork has a known frequency of 256 Hz. The summation of the sounds produced by the guitar string and the tuning fork is shown at right. The student also notices that the pitch of the combined sounds is greater than 256 Hz. What is the frequency of the note produced by the guitar string?



A) 258 Hz
B) 260 Hz
C) 262 Hz
D) 264 Hz
E) 268 Hz

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15. [4 pts] Your Physics instructor carries out a diffraction grating demonstration in class using a laser of wavelength λ. The screen is 6.50 m from the grating and the grating has 300 lines/mm. A student assistant measures the distance between the third bright fringe and the central maximum on the screen. They find the distance to be 3.70 m. Determine the wavelength of the laser.

A) 480 nm

B) 550 nm

C) 600 nm

D) 630 nm

E) 825 nm

Lab Multiple Choice Questions

16. [4 pts] Match the missing words in the sentences below to the list of words below the statement.

In Lab A1, you investigated standing waves on a string. The control variable was _(1)__. Possible options for the independent variable were ____(2)_____ and ____(3)_____, and the dependent variable was ____(4)____.

a. Frequency of function generator
b. Number of antinodes
c. Linear mass density of the string
d. String tension

A) 1 matches to b, 2 and 3 match to either a or d, and 4 matches to c.

B) 1 matches to b, 2 and 3 match to either a or c, and 4 matches to d.

C) 1 matches to a, 2 and 3 match to either c or d, and 4 matches to b.

D) 1 matches to a, 2 and 3 match to either b or c, and 4 matches to d.

E) 1 matches to b, 2 and 3 match to either c or d, and 4 matches to a.

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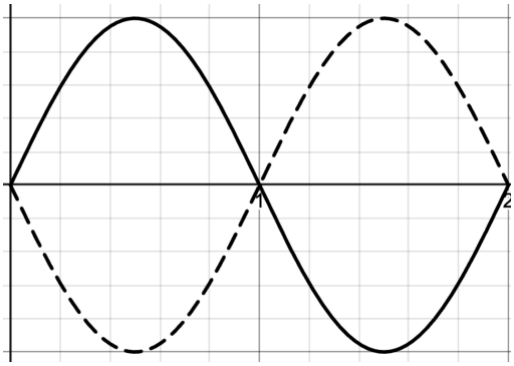
17. [4 pts] In Lab A1, two groups of students, group 1 and group 2 have adjusted the function generator to a frequency f_0 to form the standing wave at right. The string has a length L_0, and the mass of the hanger is m_0. Group 1 has decided to investigate how the standing wave frequency varies with length and group 2 is investigating how the standing wave frequency varies with mass.



Group 1 changes the length of the string to $2L_0$ and group 2 changes the mass of the hanger to $m_0/4$. How should the groups change the function generator to find the same standing wave pattern?

A) Group 1 should decrease the frequency to $f_0/2$, and group 2 should increase the frequency to $\sqrt{2}f_0$.

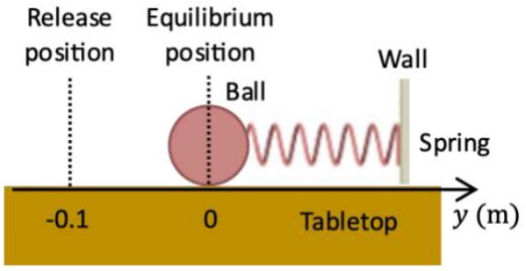
B) Group 1 should increase the frequency to $4f_0$, and group 2 should decrease the frequency to $f_0/\sqrt{2}$.

C) Group 1 should increase the frequency to $2f_0$, and group 2 should decrease the frequency to $f_0/\sqrt{2}$.

D) Group 1 should decrease the frequency to $f_0/2$, and group 2 should decrease the frequency to $f_0/2$.

E) Other

18. [4 pts] As part of Lab 2 homework and Lab A2, you examined the context at right. For this question, the ball has a mass 0.2500 kg and is resting on a frictionless tabletop. The ball is connected to one end of a spring with spring constant 5.000 N/m. The other end of the spring is attached to a wall that does not move. The position of the ball measured from equilibrium position is *y*. The ball is pulled 0.1000 m in the negative *y*-direction from the equilibrium position, and at time $t = 0$ s it is released from rest.



Using the same assumptions as those stated in the Phys 123 lab homework, what is the position of the ball at $t = 0.01$ s?

A) -0.09978 m

B) -0.09980 m

C) -0.09984 m

D) -0.09987 m

E) -0.09990 m

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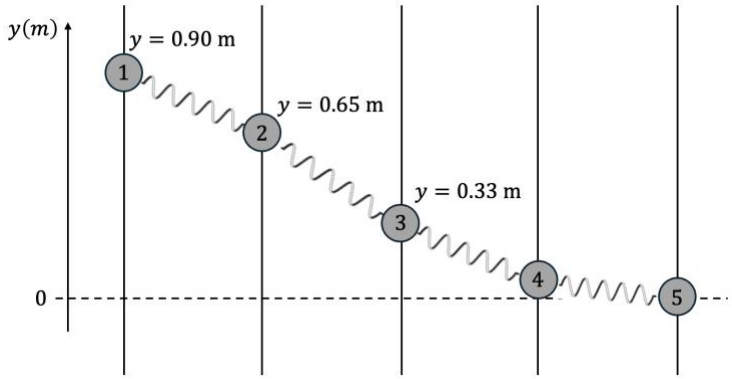
19. [3 pts] For the simulation of the five balls in Lab A2, balls 2, 3, and 4 are free to move and the net force on each of these balls is due to the springs to the left and right. Assume that the force from the left spring on ball 2 only depends on the difference of *y* positions of balls 1 and 2. Likewise, assume the force from the right spring on ball 2 only depends on the difference in the *y* positions of balls 2 and 3.



As noted in Q18, the balls have a mass of 0.250 kg, and the spring constant of each spring is 5.00 N/m. Ball 1 is displaced at $t = 0$ s, and the displacement of balls 1, 2, 3 at $t = 1.0$ s is shown above. What is the magnitude of the acceleration of ball 2 at this instant?

A) $1.4\ \mathrm{m/s^2}$

B) $0.78\ \mathrm{m/s^2}$

C) $5.1\ \mathrm{m/s^2}$

D) $2.3\ \mathrm{m/s^2}$

E) $11\ \mathrm{m/s^2}$

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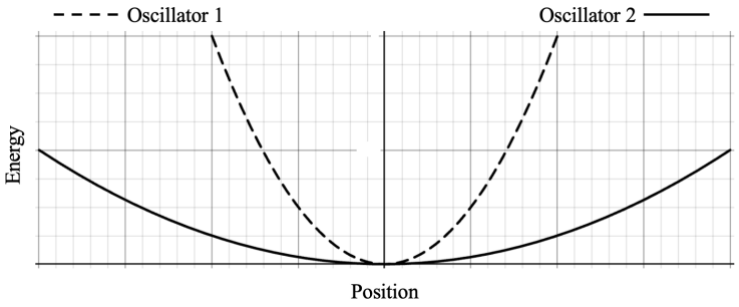
Lecture Free Response

The graphs at right show the potential energy of two separate SHM mass-spring oscillators as a function of their position. Oscillator 1 consists of block 1 of mass, m_1 and spring 1 with spring constant k_1. Oscillator 2 consists of block 2 of mass, m_2 and spring 2 with spring constant k_2.



20. [4 pts] On the graph at right, draw the kinetic energy curve for oscillator 1. Your curve should pass through at least 5 quantitatively correct data points.

21. [3 pts] Is the spring constant of oscillator 1 *greater than, less than,* or *equal to* the spring constant of oscillator 2? If it's not possible to tell, state so explicitly. Explain.

22. [4 pts] Suppose that $m_1 = 2m_2$. Is the maximum speed of block 1 *greater than, less than,* or *equal to* the maximum speed of block 2? If it's not possible to tell, state so explicitly. Explain.

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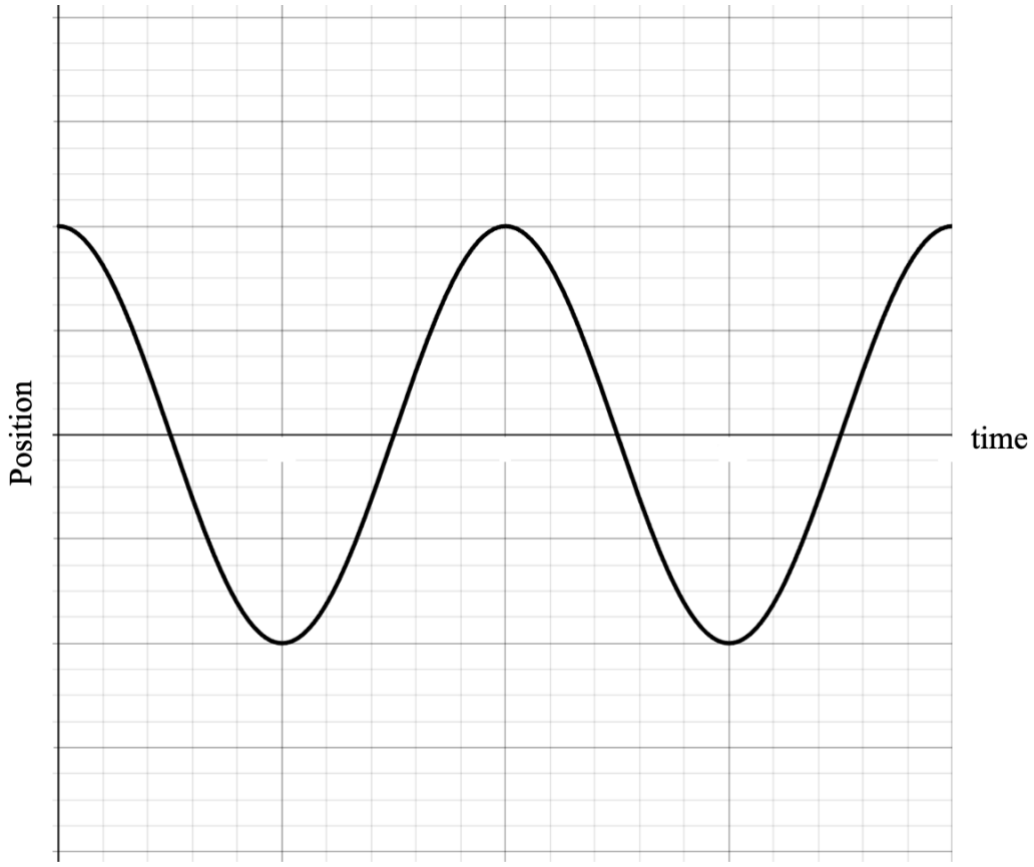
23. [4 pts] The position of **block 1** as a function of time is shown at right. On the same graph, make a plot of the position of block 2 (assume block 2 is released at its maximum positive displacement at $t = 0$ s). Your graph should have 5 quantitatively correct data points. Briefly show your work.



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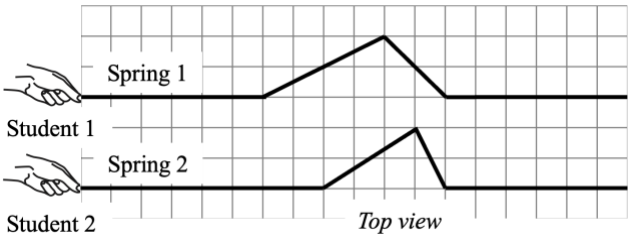
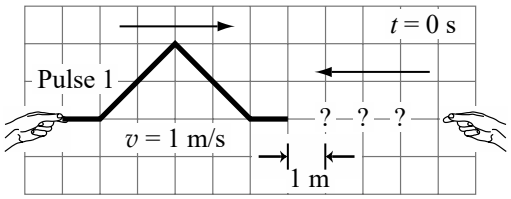
Tutorial Free Response Questions (All questions are independent of one another)

24. [4 pts] Two students generate two pulses on two tightly coiled springs by moving their hands up and down, as shown at right. The two students *finish* generating the pulses at exactly the same time.



Is the speed of the pulse on Spring 1 *greater than*, *less than* or *equal to* that of the pulse on Spring 2? Explain.

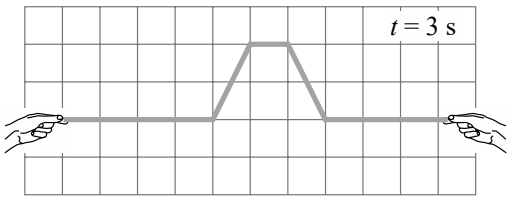
25. [3 pts] Pulses 1 and 2 are created on opposite ends of a spring. Pulse 1 travels at a speed of 1 m/s. (Each block is 1 m wide.) The top figure at right shows the shape and location of pulse 1 at time $t = 0$. Pulse 2 is not shown.



The shape of the entire spring at $t = 3$ s is shown in gray in the bottom figure at right.

In the bottom figure, clearly indicate the shape and location of pulse 2 at $t = 3$ s.

[No explanation required]



Sketch pulse 2 at time $t = 3$ s.

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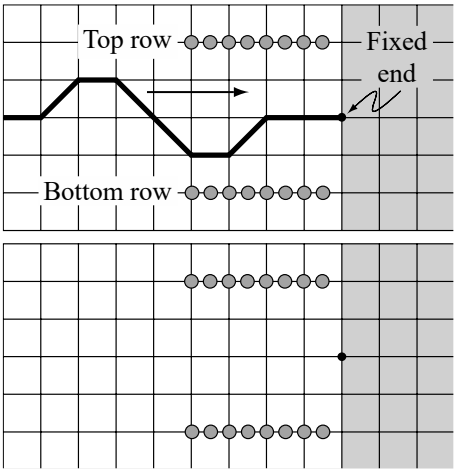
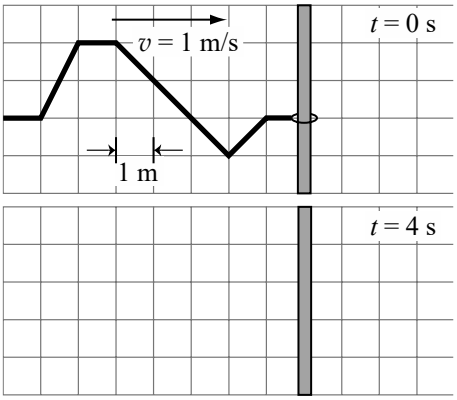
26. [4 pts] Two rows of cups are aligned on either side of a spring with a *fixed* end. The top figure at right shows the shape of the spring before the pulse reaches the fixed end.



Will cups from the *top row, bottom row, both rows,* or *neither row* be knocked over? [*Note:* You do not need to indicate precisely which cups are knocked over, only from which rows, if any. Space has been provided to sketch the spring if you wish to do so.]

Explain your reasoning.

27. [4 pts] A pulse traveling at 1 m/s approaches the *free* end of a spring, as shown in the top figure at right.



Sketch the shape of spring at time $t = 4$ s in the space provided.

Explain your reasoning.

Sketch shape of spring at time $t = 4$ s