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1. [5 pts] The position of a particle undergoing simple harmonic motion is described by the equation $x(t) = A\sin\left(Bt + \frac{\pi}{3}\right)$, where $A = 7.50\text{ m}$ and $B = 4.00\text{ s}^{-1}$. What is the velocity of the particle at $t = 0$?

   A) 3.75 m/s
   B) 6.50 m/s
   C) 15.0 m/s
   D) 26.0 m/s
   E) 30.0 m/s

2. [5 pts] An ideal spring is suspended from the ceiling. When no mass is attached, its length is 10.0 cm. A 5.00 kg mass is then hung from the spring. When the 5.00 kg mass is at rest, the spring has a length of 12.0 cm. The mass is then pulled down slightly and released, setting it into vertical oscillation. What is the period of this oscillation?

   A) 0.284 s
   B) 0.631 s
   C) 0.700 s
   D) 1.26 s
   E) 2.00 s

3. [5 pts] The pendulum outside the physics classroom has a period of 7.90 s. Now it is moved to the surface of Jupiter where the gravity is 2.50 times stronger than the gravity on the surface of earth. What is the new period?

   A) 19.8 s
   B) 12.5 s
   C) 7.90 s
   D) 5.00 s
   E) 3.20 s

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4. [5 pts] A block attached to an ideal spring oscillates horizontally on a frictionless surface. Consider a system consisting of the spring and block. If the amplitude of oscillation is doubled, what happens to the total mechanical energy of the system?

   A) It becomes half as large.
   B) It is unchanged.
   C) It becomes four times larger.
   D) It becomes two times larger.
   E) More information is required to answer.

5. [5 pts] A traveling pulse is described by the time-dependent wave function $y(x, t) = \frac{A}{1+(Bx-Ct)^2}$ where $A = 5.0$ m , $B = 0.20\ \text{m}^{-1}$; $C = 2.5\ \text{s}^{-1}$. What is the wave speed of this pulse?

   A) 0.10 m/s
   B) 0.50 m/s
   C) 2.5 m/s
   D) 5.0 m/s
   E) 12.5 m/s

6. [5 pts] A small speaker emits sound waves equally in all directions. The sound intensity level at 2.00 m from the speaker is 80.0 dB. At what distance from the speaker would the sound intensity level drop to 60.0 dB?

   A) 4.00 m
   B) 10.0 m
   C) 20.0 m
   D) 40.0 m
   E) 60.0 m

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7. [5 pts] The electric bells at your school buzz with a frequency of 450 Hz. If you are late for class and riding your bike down a hill toward the school at a constant speed of 4.47 m/s, what is the frequency of the sound you hear? Assume that the speed of sound is 343 m/s.

   A) 438 Hz
   B) 444 Hz
   C) 450 Hz
   D) 456 Hz
   E) 462 Hz

8. [5 pts] A standing wave with three antinodes is established in a closed-closed pipe when the air inside is vibrated at a frequency of 300 Hz. What is the smallest frequency at which the air can be vibrated to produce any standing wave in the pipe?

   A) 50 Hz
   B) 100 Hz
   C) 150 Hz
   D) 200 Hz
   E) 300 Hz

9. [5 pts] A thin film of soap ($n = 1.55$) with a thickness, t, floats on water ($n = 1.33$). Which condition leads to constructive interference for reflected light of wavelength λ in the film?

   A) $2t = \frac{m\lambda}{n_{film}}$ for $m = 0, 1, 2..$
   B) $2t = \frac{\left(m+\frac{1}{2}\right)\lambda}{n_{film}}$ for $m = 0, 1, 2..$
   C) The path difference must be zero.
   D) Constructive interference is impossible in this situation.

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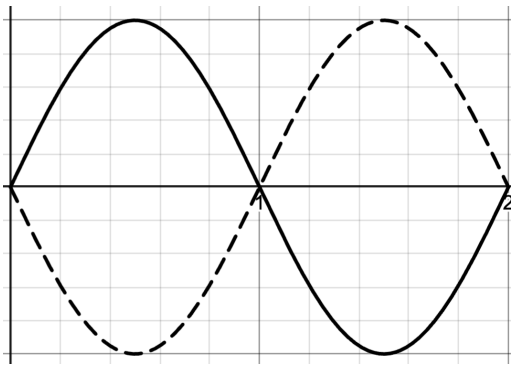
Lab Multiple Choice Questions

10. [5 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 $\sqrt{2}f_0$.

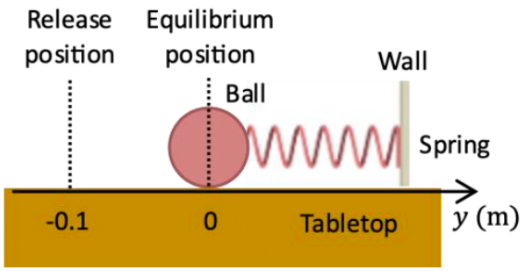
B) Group 1 should increase the frequency to $4f_0$, and group 2 should decrease the frequency to $f_0/\sqrt{2}$.

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

11. [5 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 4.000 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) -0.09980 m

B) -0.09984 m

C) -0.09987 m

D) -0.09990 m

E) -0.09992 m

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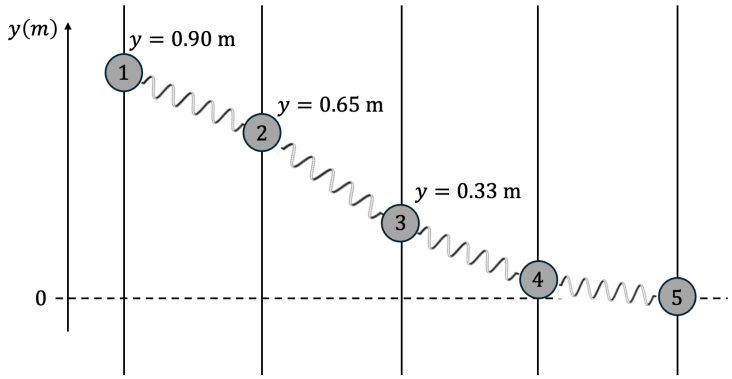
12. [5 pts] For the simulation of the five balls in Lab A2, balls 2, 3, and 4 are free to move and the net force on each of these balls is due to the springs to the left and right. For this question, **use the following assumption which is the same as that in the lab**:



> 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 Q11, the balls have a mass of 0.250 kg, and the spring constant of each spring is 4.00 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) $1.1\ \mathrm{m/s^2}$

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

Consider the following scenario for the next three questions.
You attach one end of a thin string firmly to a pole at x = 0.0 m and hold the other end at x = 3.0 m so that the string is along the x-direction. At t = 0.0 s, you start moving the end of the string you are holding vertically. The graph below shows the history graph of a point P, which is at x = 1.2 m.

13. [5 pts] What is the wave speed of this string? Show your work.

14. [5 pts] On the graph below, draw the snapshot graph at t = 1.0 s. Be sure to include the entire pulse and label the tick marks on the horizontal axis such that we can determine the scale.

15. [5 pts] Suppose that the tension in the string is decreased by a factor of four ($T_{new} = T_{original}/4$). The student generates the pulse in exactly the same way. On the graph below, draw the snapshot graph of point P at t = 1.0 s. Be sure to to include the entire pulse and label the tick marks on the horizontal axis such that we can determine the scale.

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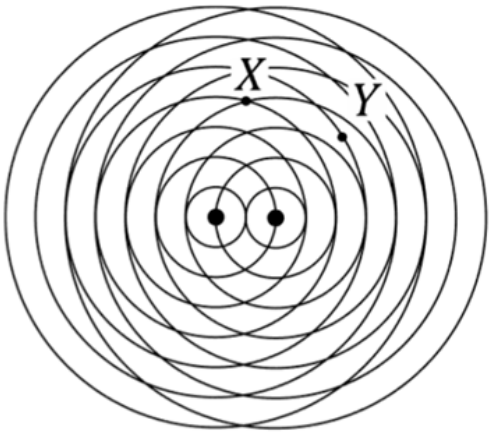
Consider the following scenario for the next two questions.
Surface waves are generated from two coherent sources separated by a small distance. The figure shows the crests of the waves at $t = 0$.



16. [5 pts] Draw all the antinodal lines on the figure.

17. [5 pts] On the axes below sketch the displacement curve at point X and Y as a function of time starting at $t = 0$. Indicate which curve is which. Indicate the time corresponding to the period, T, on your graph.

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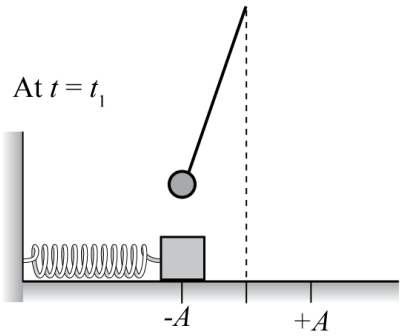
Tutorial Free Response Questions

18. [5 pts] A pendulum is hung directly above a block that is connected to an ideal spring. The surface is frictionless, and the block and pendulum bob have the same mass, m. At $t = t_1$, the pendulum bob and block are both instantaneously at rest.

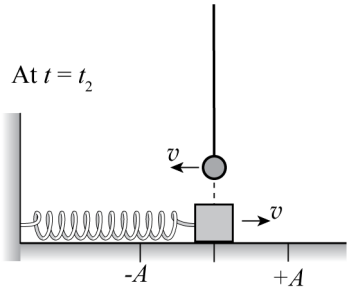


Consider the following systems:

- System 1: Pendulum and Earth
- System 2: Block and Spring

For which of these systems, if any, can the total energy be determined without knowing the value of m? Explain.

19. [5 pts] A short time later, at $t = t_2$, the block has reached its equilibrium position for the first time, and the pendulum bob has reached its equilibrium position for the second time.



When the pendulum reaches its rightmost position for the second time, what is the position of the block and in what direction is it moving? Explain.

20. [5 pts] A student wants to alter the experiment such that the bob is always directly over the block as they oscillate. They determine that increasing the length of the pendulum by a factor x produces the desired result. Which of the choices at right (A to D) would alternatively provide the same result (assuming the pendulum remains at its original length)? Explain.

A. Increase the spring constant by the same factor x.
B. Increase the mass of the block by the same factor x.
C. Increase the mass of the bob by the same factor x.
D. More than one of these.