Practice exam for 5B midterm I

1. A mass on a spring undergoes simple harmonic motion. When the mass is at maximum displacement from its equilibrium position in the positive direction, then which one of the following statements about the mass is true?

(a) The velocity is nonzero.

(b) The kinetic energy is at its maximum.

(c) The acceleration is positive and its magnitude at its maximum.

(d) The acceleration is negative and its magnitude is at its maximum.

(e) The acceleration is zero.

2. Consider a damped harmonic oscillator subject to an oscillating external driving force. Suppose we double the magnitude of the driving force. How does this affect the natural resonant frequency of the oscillator?

(a) The natural resonant frequency is increased by a factor of four.

(b) The natural resonant frequency is increased by a factor of two.

(c) The natural resonant frequency is unchanged.

(d) The natural resonant frequency is reduced by a factor of two.

(e) The natural resonant frequency is reduced by a factor of four.

3. A pendulum is made by suspending a hoop of radius R and mass m from a pivot point located on the hoop, such that the plane of the hoop lies in the vertical plane, as shown in the figure below. The period of this pendulum is T. If a hoop with the same radius but a mass four times as great is suspended in the same way, what will be its period of oscillation?

(a) $4T$

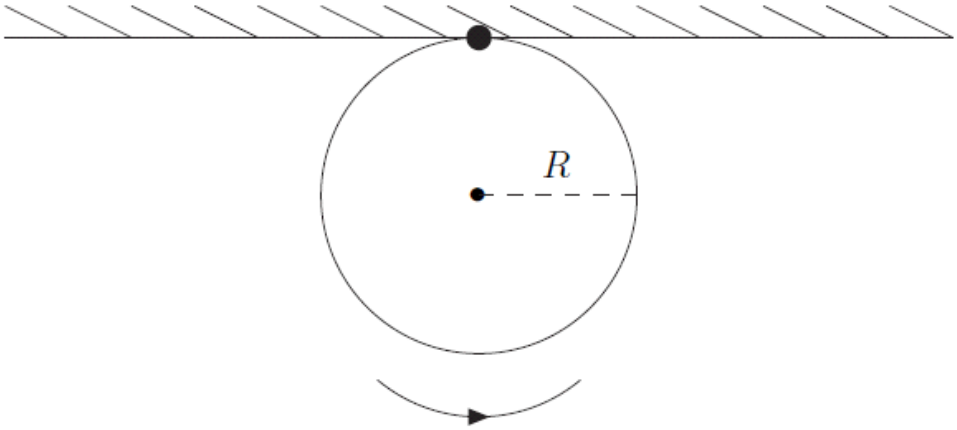
(b) $2T$

(c) T

(d) $T/2$

(e) $T/4$

(e) $I/4$



4. The speed of transverse waves on a thin wire is 150 m/s. The density of the material that the wire is made of is 5000 kg/m^3. The wire has a 0.5 mm diameter circular cross-section. What is the tension that the wire is under?

(a) 76.2 N

(b) 22.1 N

(c) 88.4 N

(d) 0.147 N

(e) 56.7 N

5. Two identical pulses of opposite amplitude travel along a stretched string and interfere destructively. The ends of the string are not fixed. Which of the following statements is true?

(a) There is no instant at which the string is completely straight.

(b) When the two pulses interfere, the energy of the pulses is momentarily zero.

(c) There is exactly one point on the string that does not move up or down.

(d) There are several points on the string that do not move up or down.

(e) After the pulses pass each other, their shapes are distorted.

6. A stone is thrown into a quiet pool of water, creating outgoing circular waves from the point of impact. Ignoring the friction of the fluid, the amplitude of the waves falls off with distance r from the impact point as

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(a) $1/r^2$

(b) $1/r^{3/2}$

(c) $1/r$

(d) $1/r^{1/2}$

(e) The amplitude remains constant as r increases.

7. The radio station KPIG announces their broadcast frequency as "107 oink 5" (that is, 107.5 on your FM dial). What is the corresponding wavelength of the waves they use to broadcast their signal?

(a) 140 nm

(b) 4.2 cm

(c) 2.8 m

(d) 42 m

(e) 2.8 km

8. When light is either reflected or refracted, the quantity that does not change in either process is its

(a) direction of travel

(b) dispersion

(c) frequency

(d) speed

(e) wavelength

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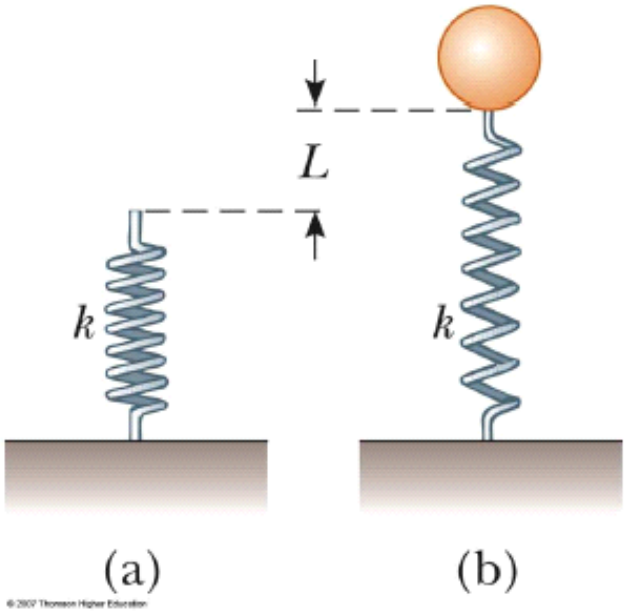
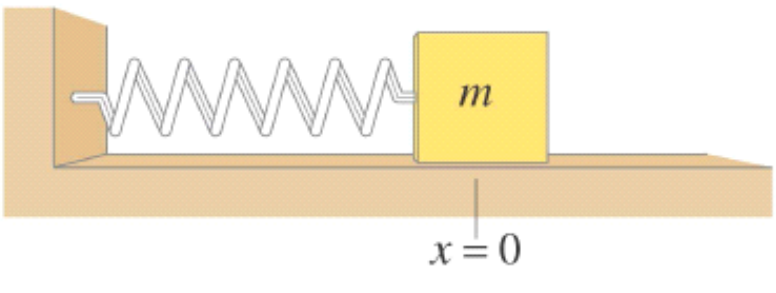


A 2 g balloon is filled with helium to a volume of $5\,\text{m}^3$ and is then connected to the spring, causing the spring to stretch as shown in figure (b) above. Compute the extension distance L (shown in the figure above) when the balloon is in equilibrium. You may neglect the weight of the spring.

DATA: The density of helium is $\rho_{He} = 0.179\,\text{kg/m}^3$. The density of air is $\rho_{air} = 1.29\,\text{kg/m}^3$. These data are given for standard temperature and pressure (0°C and 1 atm pressure), which you can assume for this problem.

10. A block with a mass of $m = 0.5$ kg is attached to a spring with a spring constant $k = 50\,\text{N/m}$. Let x be the displacement from the equilibrium position. You may neglect the mass of the spring. At equilibrium, the center-of-mass of the block is located at $x = 0$, as shown in the figure below.



Suppose that at time $t = 0$, the block has its maximum speed of 20 m/s and is moving to the left.

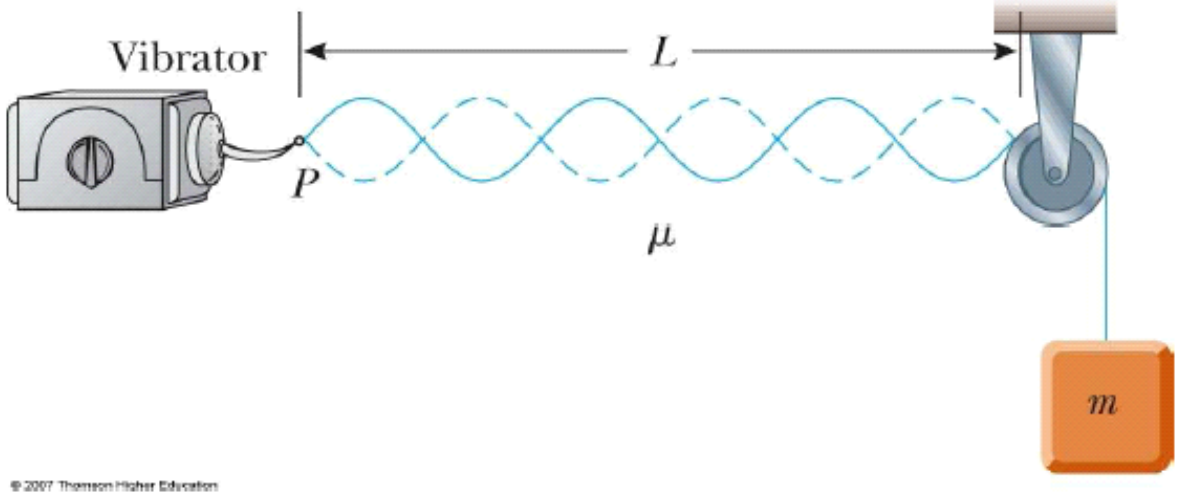
(a) Write down an equation for the displacement of the center-of-mass of the block as a function of time, $x(t)$. Determine the numerical values of the amplitude and the angular frequency of the oscillation.

(b) Find the minimum time interval required for the center-of-mass of the block to move from its location at $t = 0$ to a point 1 m to the left of its equilibrium point.

(c) For what values of x is the potential energy three times the kinetic energy?

HINT: Use the conservation of energy to write the square of the velocity v^2 directly in terms of x^2 by comparing the total energy at any point of the oscillation with the total energy at the point of maximal displacement. You can then immediately solve for x (without ever specifying the time t).

11. In the arrangement shown in the figure below, a block is hung from a string (with linear mass density $\mu = 2$ g/m) that passes over a fixed pulley (whose mass is negligible). The string is connected to a vibrator (of constant frequency f), and the length of the string between point P and the pulley is $L = 2$ m. When the mass m of the block is either 16 kg or 25 kg, standing waves are observed. However, no standing waves are observed with any mass between these values.



NOTE: The shape of the standing wave shown above is for illustrative purposes only and does not necessarily correspond to any of the masses given in this problem.

(a) What is the frequency f of the vibrator?

HINT: The hanging block provides tension for the string. The greater the tension of the string, the smaller the number of nodes in the standing wave. Assume that a node exists at the location of the vibrator.

(b) What is the mass of the heaviest block for which standing waves could be observed?