CHAPTER6

1. A block attached to the lower end of a vertical spring oscillates up and down. If the spring obeys Hooke's law, the period of oscillation depends on which of the following?

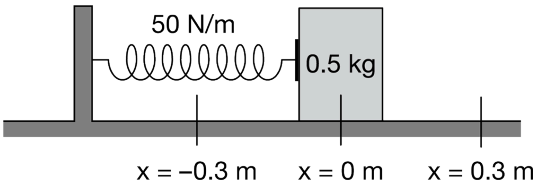
I. Mass of the block

II. Amplitude of the oscillation

III. Force constant of the spring

(A) I only
(B) II only
(C) III only
(D) I and II
(E) I and III

2.



A block of mass $0.5\ \text{kg}$ on a horizontal surface is attached to a horizontal spring of negligible mass and spring constant $50\ \text{N/m}$. The other end of the spring is attached to a wall, and there is negligible friction between the block and the horizontal surface. When the spring is unstretched, the block is located at $x = 0\ \text{m}$. The block is then pulled to $x = 0.3\ \text{m}$ and released from rest so that the block-spring system oscillates between $x = -0.3\ \text{m}$ and $x = 0.3\ \text{m}$. What is the magnitude of the acceleration of the block and the direction of the net force exerted on the block when it is located at $x = 0.3\ \text{m}$?

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(A)

Magnitude of Acceleration	Direction of Net Force
$30\ \mathrm{m/s^2}$	Positive

(B)

Magnitude of Acceleration	Direction of Net Force
$30\ \mathrm{m/s^2}$	Negative

(C)

Magnitude of Acceleration	Direction of Net Force
$0\ \mathrm{m/s^2}$	Positive

(D)

Magnitude of Acceleration	Direction of Net Force
$0\ \mathrm{m/s^2}$	Negative

3. An object is in simple harmonic motion. Of the following quantities related to the object, which set of three can have maximum magnitudes at the same instant of time?

I. Displacement

II. Velocity

III. Acceleration

IV. Kinetic energy

V. Potential energy

(A) I, II, and III
(B) I, II, and IV
(C) I, III, and V
(D) II, III, and IV
(E) II, III, and V

4. An object moves up and down the *y*-axis with an acceleration given as a function of time *t* by the expression $a = A \sin \omega t$, where A and ω are constants. What is the period of this motion?

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(A) ω
(B) $2\pi\omega$
(C) $\omega^2 A$
(D) $2\pi/\omega$
(E) $\omega/2\pi$

5. An object of mass m attached to a spring with constant k oscillates with amplitude A. Assuming air resistance and the mass of the spring to be negligible, which of the following changes alone would cause the period of this oscillation to increase?

I. Increasing m

II. Increasing A

III. Using a spring with greater k

(A) I only
(B) II only
(C) I or III only
(D) II or III only
(E) I, II or III

6. A pendulum consisting of a sphere suspended from a light string is oscillating with a small angle with respect to the vertical. The sphere is then replaced with a new sphere of the same size but greater density and is set into oscillation with the same angle. How do the period, maximum kinetic energy, and maximum acceleration of the new pendulum compare to those of the original pendulum?

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(A)

Period	Maximum Kinetic Energy	Maximum Acceleration
Larger	Larger	Smaller

(B)

Period	Maximum Kinetic Energy	Maximum Acceleration
Smaller	Larger	Smaller

(C)

Period	Maximum Kinetic Energy	Maximum Acceleration
The same	The same	The same

(D)

Period	Maximum Kinetic Energy	Maximum Acceleration
The same	Larger	The same

7. A pendulum has a length l and a bob of mass m. Which of the following is true of the linear momentum of the bob as it swings from its highest to lowest point?

(A) It remains constant because momentum is always conserved.
(B) It increases in magnitude and changes direction.
(C) It decreases in magnitude and does not change direction.
(D) It is converted to angular momentum.
(E) It is converted to kinetic energy.

8. A simple pendulum and a mass hanging on a spring both have a period of 1 s when set into small oscillatory motion on Earth. They are taken to Planet *X*, which has the same diameter as Earth but twice the mass. Which of the following statements is true about the periods of the two objects on Planet *X* compared to their periods on Earth?

(A) Both are shorter.
(B) Both are the same.
(C) Both are longer.
(D) The period of the mass on the spring is shorter; that of the pendulum is the same.
(E) The period of the pendulum is shorter; that of the mass on the spring is the same.

9. A simple pendulum consisting of a small object of mass *m* attached to a string of length *l* has a period *T*. A pendulum with which of the following combinations of object mass and string length will also have period *T* ?

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(A)

Object Mass	String Length
$m/2$	l

(B)

Object Mass	String Length
m	$l/4$

(C)

Object Mass	String Length
$\sqrt{2}m$	$l/\sqrt{2}$

(D)

Object Mass	String Length
$2m$	$4l$

(E)

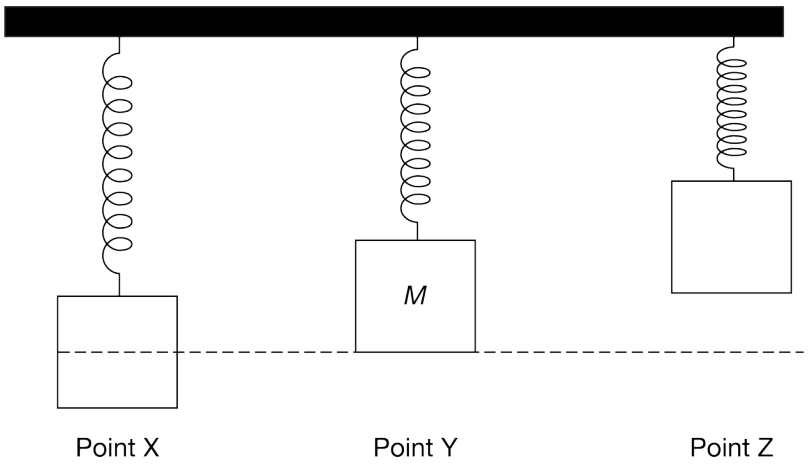
Object Mass	String Length
$4m$	$2l$

10. A simple pendulum is used to determine the acceleration due to gravity at the surface of a planet. The pendulum has a length of 2 m and its period is measured to be 2 s. The value of g obtained in this investigation is most nearly

(A) 1 m/s^2
(B) 2 m/s^2
(C) 5 m/s^2
(D) 10 m/s^2
(E) 20 m/s^2

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11.



A student attaches a block of mass M to a vertical spring so that the block-spring system will oscillate if the block-spring system is released from rest at a vertical position that is not the system's equilibrium position. The figure shows three positions of the spring as it travels from point X to point Y and then from point Y to point Z. Point X is the lowest point of the center of mass of the block as it oscillates. Point Y is the equilibrium position of the block-spring system. Point Z is the highest point of the center of mass of the block as it oscillates. The gravitational potential energy of the block-spring-Earth system is considered to be zero at point X.

Which of the following claims is correct about the block-spring-Earth system?

(A) The gravitational potential energy of the block-spring-Earth system is the same at point X as it is at point Z.

(B) The spring potential energy of the block-spring-Earth system is the same at point X as it is at point Z.

(C) The block-spring-Earth system does not have spring potential energy at point Y.

(D) The block-spring-Earth system has minimum potential energy at point Y.

12.

Spring	Mass of Block (kg)	Change in Length of Spring (cm)
A	0.10	5.0
B	0.20	4.0
C	0.15	6.0
D	0.12	3.0

Four springs, A, B, C, and D, with the same unstretched length are attached to the ceiling, and a block is attached to each spring. The mass of each block and the resulting change in length of the spring as each block hangs in equilibrium are shown in the table. Each block is then pulled down a small distance y and released. Which spring will oscillate with the highest frequency?

(A) Spring A

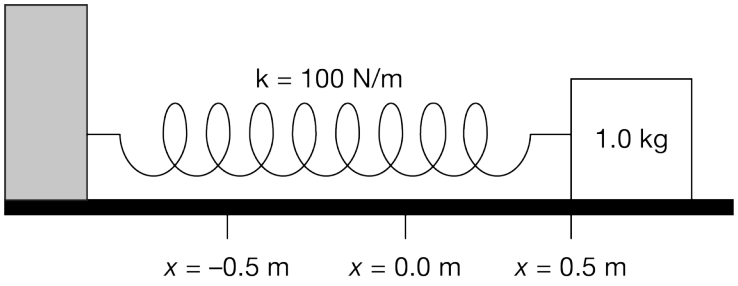
(B) Spring B

(C) Spring C

(D) Spring D

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13.



A block of mass $1.0\ \text{kg}$ on a horizontal surface is attached to a horizontal spring of negligible mass and spring constant $100\ \text{N/m}$. The other end of the spring is attached to a wall, and there is negligible friction between the block and the horizontal surface. When the spring is unstretched, the block is located at $x = 0\ \text{m}$. The block is then pulled to $x = 0.5\ \text{m}$ and released from rest so that the block-spring system oscillates between $x = -0.5\ \text{m}$ and $x = 0.5\ \text{m}$, as shown in the figure.

Which of the following descriptions about the system are correct? Select two answers.

A The kinetic energy of the block and the spring potential energy of the system at $x = 0.25\ \text{m}$ are both half of the total mechanical energy of the system.

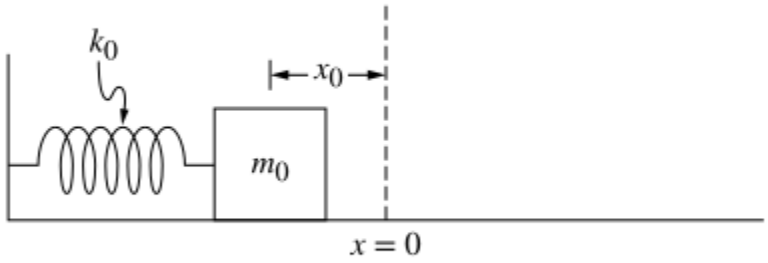
B The spring potential energy of the system at $x = 0.25\ \text{m}$ is nearly $3.13\ \text{J}$.

C The kinetic energy of the system at $x = 0.3\ \text{m}$ is nearly $4.5\ \text{J}$.

D The sum of the spring potential energy of the system and the kinetic energy of the block at $x = 0.4\ \text{m}$ is nearly $12.5\ \text{J}$.

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14.



A block of mass m_0 on a horizontal surface is attached to a light spring of spring constant k_0 that is initially compressed a distance x_0 from its relaxed length, as shown. When the block is released from rest, the block-spring system oscillates with total mechanical energy E_0. Which combination of spring constant, initial compression length, and mass would result in the total mechanical energy of the block-spring system being equal to $2E_0$?

	Spring Constant	Initial Compression Length	Mass
A	$\frac{1}{4}k_0$	$2x_0$	$2m_0$
B	$\frac{1}{2}k_0$	$2x_0$	$2m_0$
C	$4k_0$	$\frac{1}{2}x_0$	m_0
D	$8k_0$	x_0	m_0

(A) A

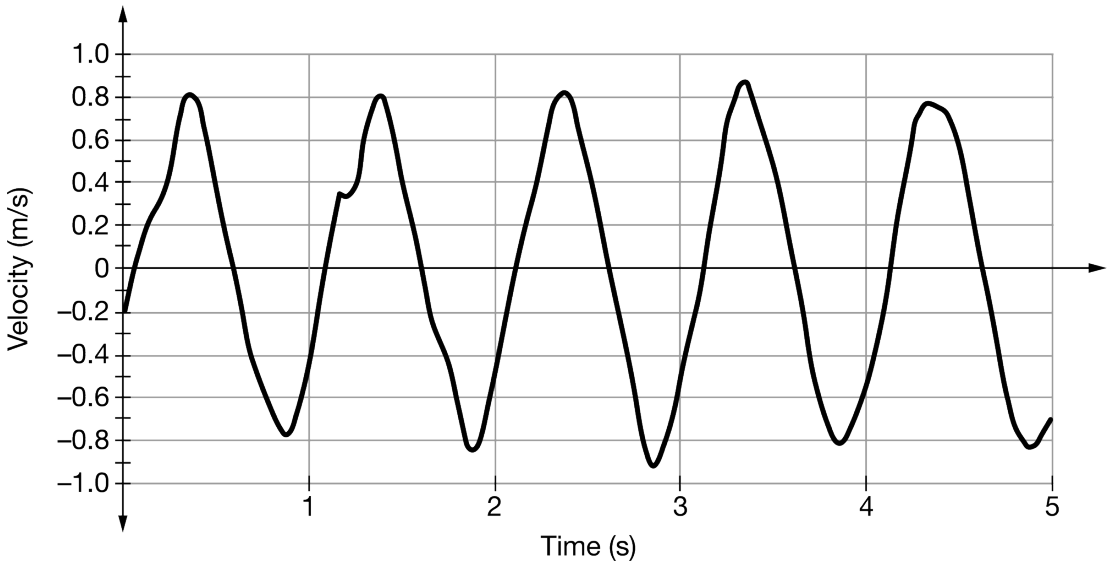
(B) B

(C) C

(D) D

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15.



A cart of mass $2.0\ \text{kg}$ on a horizontal surface is attached to a horizontal spring of negligible mass. A $1.0\ \text{kg}$ block is secured on top of the of the $2.0\ \text{kg}$ cart. The other end of the spring is attached to a wall, and there is negligible friction between the cart-block-spring system and the horizontal surface. The cart-block-spring system then experiences simple harmonic motion as described by the graph that shows the velocity of the cart-block system as a function of time. The maximum spring potential energy of the cart-block-spring system is most nearly

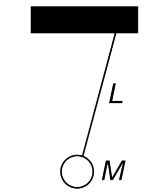
(A) $0.32\ \text{J}$

(B) $0.64\ \text{J}$

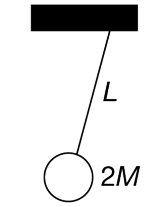
(C) $0.96\ \text{J}$

(D) $1.92\ \text{J}$

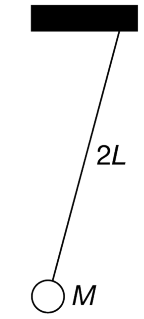
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Experiment 1



Experiment 2



Experiment 3

Three different experiments are conducted that pertain to the oscillatory motion of a pendulum. For each experiment, the length of the pendulum and the mass of the pendulum are indicated. In all experiments, the pendulum is released from the same angle with respect to the vertical.

16. The pendulum in Experiment 2 is released from rest at an angle of θ_0 with respect to the vertical. What is the magnitude of the change in kinetic energy of the pendulum from its lowest point to the highest point along its arc?

(A) Zero

(B) $2MgL$

(C) $2MgL\cos\theta_0$

(D) $2Mg(L - L\cos\theta_0)$

17. If the students collect data about the kinetic energy of the pendulum as a function of time for each experiment, which of the following claims is true?

(A) The data collected from Experiment 1 will be the same as the data collected from Experiment 2.

(B) The data collected from Experiment 1 will be the same as the data collected from Experiment 3.

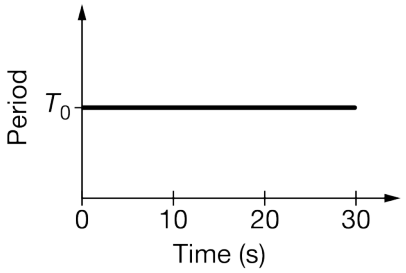
(C) The data collected from Experiment 2 will be the same as the data collected from Experiment 3.

(D) The data collected from each experiment will be different.

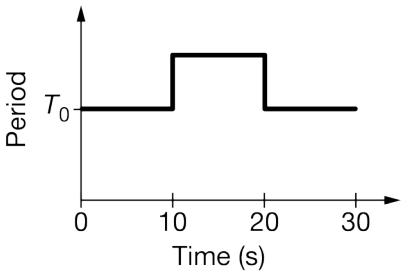
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18. The pendulum from Experiment 1 has been experimentally determined to have a period of T_0 when released from an angle θ_0. The pendulum is then attached to the ceiling of an elevator that travels upward. The pendulum is released from rest at an angle θ_0 at $t = 0$ s. From $t = 0$ s to $t = 10$ s, the elevator travels with a constant speed. From $t = 10$ s to $t = 20$ s, the elevator decreases its speed with a constant acceleration. From $t = 20$ s to $t = 30$ s, the elevator remains at rest. Which of the following graphs represents the period of the pendulum as a function of time?

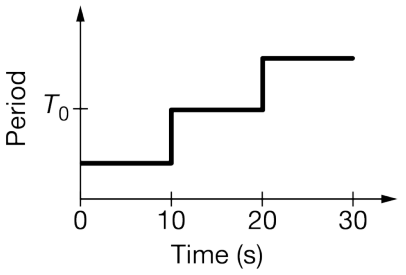
(A)



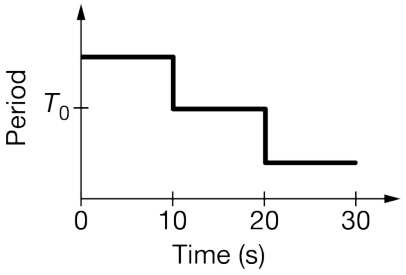
(B)



(C)



(D)



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19.

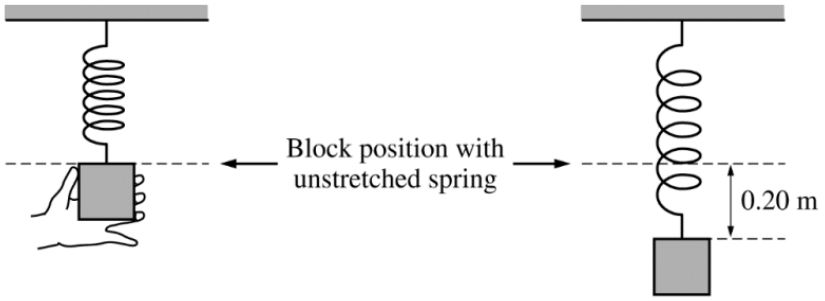


Figure 1 Figure 2

A 1.0 kg block is attached to an unstretched spring of spring constant 50 N/m and released from rest from the position shown in Figure 1 above. The block oscillates for a while and eventually stops moving 0.20 m below its starting point, as shown in Figure 2. What is the change in potential energy of the block-spring-Earth system between Figure 1 and Figure 2 ?

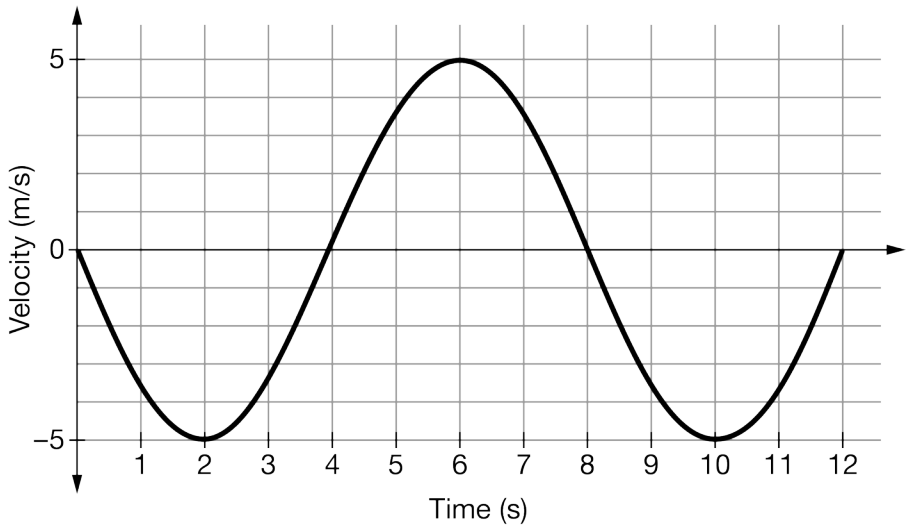
(A) −1.0 J

(B) 0 J

(C) 1.0 J

(D) 3.0 J

20.



A 2 kg block on a horizontal surface is attached to a horizontal spring of negligible mass. The other end of the spring is attached to a wall, and there is negligible friction between the block and the horizontal surface. The block is released from rest after the spring is stretched such that the block-spring system experiences simple harmonic motion, as shown in the graph that represents the block's velocity as a function of time.

How could a student use the known information and the graph to determine the magnitude of the change in spring potential energy of the system from the release point of the block to the moment when the system's spring potential energy is zero?

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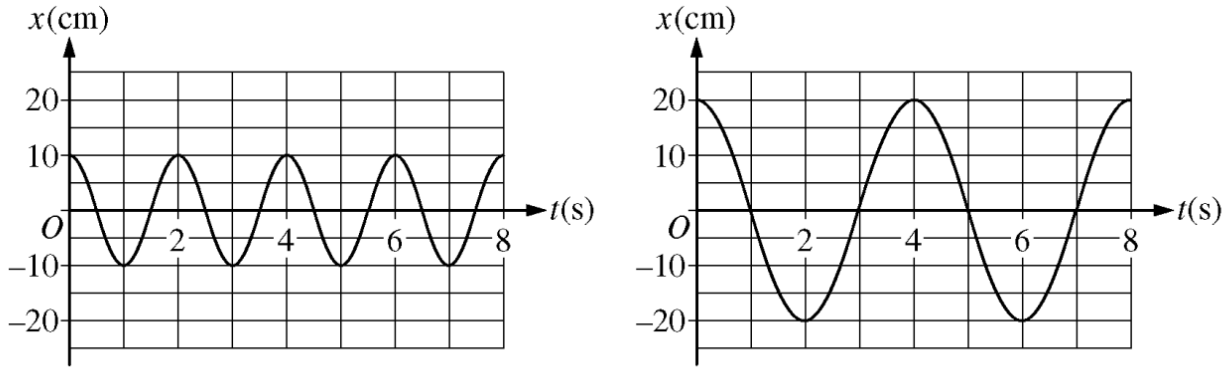
(A) By determining the kinetic energy of the block at 8 s by using $K = \frac{1}{2}mv^2$.

(B) By determining the kinetic energy of the block at 2 s by using $K = \frac{1}{2}mv^2$.

(C) By determining the kinetic energy of the block at 2 s and 6 s by using $K = \frac{1}{2}mv^2$ and adding the two values of kinetic energy together.

(D) By determining the kinetic energy of the block at 2 s and 6 s by using $K = \frac{1}{2}mv^2$, subtracting the two values of kinetic energy, and determining the magnitude of the result.

21.



Block *A* Block *B*

Two blocks are connected to identical ideal springs and are oscillating on a horizontal frictionless surface. Block A has mass m, and its motion is represented by the graph of position as a function of time shown above on the left. Block B's motion is represented above on the right. Which of the following statements comparing block B to block A is correct?

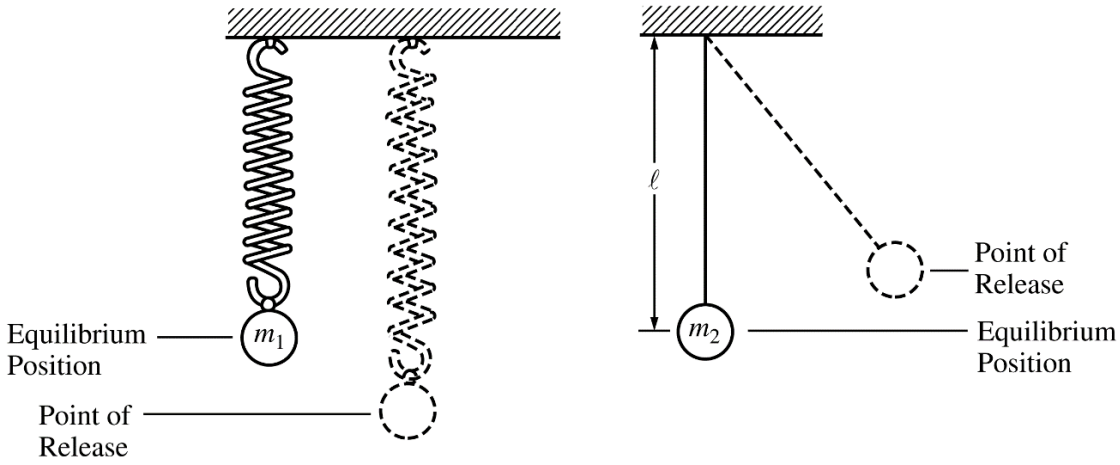
(A) Because block B covers more distance per cycle than block A, block B takes more time to complete each cycle.

(B) Because the spring attached to block B is initially stretched a greater distance, the spring constant is smaller and therefore block B has a slower average speed than block A does.

(C) Because block B has more mass, it has a slower average speed than block A does.

(D) Because block B has more mass, its acceleration is smaller than that of block A at any given displacement from the equilibrium position.

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A sphere of mass m_1, which is attached to a spring, is displaced downward from its equilibrium position as shown above left and released from rest. A sphere of mass m_2, which is suspended from a string of length l is displaced to the right as shown above right and released from rest so that it swings as a simple pendulum with small amplitude. Assume that both spheres undergo simple harmonic motion

22. If both spheres have the same period of oscillation, which of the following is an expression for the spring constant?

(A) $l / m_1 g$

(B) $g / m_2 l$

(C) $m_1 l / g$

(D) $m_2 g / l$

(E) $m_1 g / l$

23. Which of the following is true for both spheres?

(A) The maximum kinetic energy is attained as the sphere passes through its equilibrium position.

(B) The maximum kinetic energy is attained as the sphere reaches its point of release.

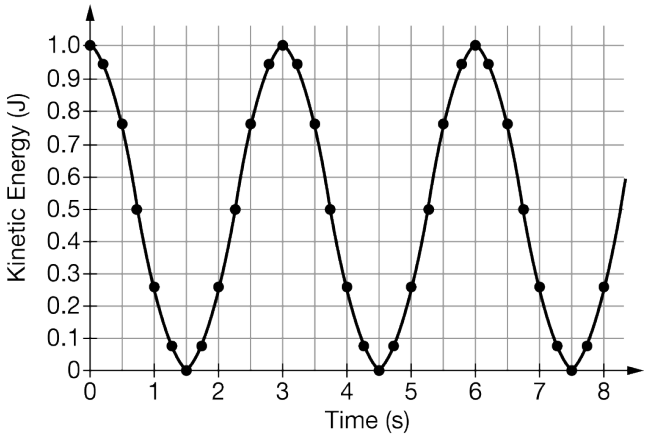
(C) The minimum gravitational potential energy is attained as the sphere passes through its equilibrium position.

(D) The maximum gravitational potential energy is attained when the sphere reaches its point of release.

(E) The maximum total energy is attained only as the sphere passes through its equilibrium position.

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24.



A student attaches a block to a horizontal spring so that the block-spring system will oscillate if the block-spring system released from rest at a horizontal position that is not the system's equilibrium position. The student creates a graph of the block-spring system's kinetic energy as a function of time, as shown. The spring potential energy of the block-spring system at $5.0\ \text{s}$ is most nearly

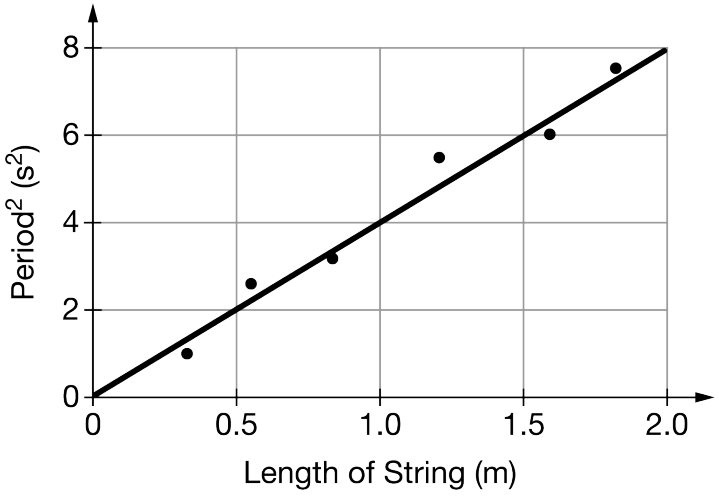
(A) $0.0\ \text{J}$

(B) $0.27\ \text{J}$

(C) $0.73\ \text{J}$

(D) $1.0\ \text{J}$

25.



In an experiment, one end of a string is attached to an object of mass M, and the other end of the string is secured so that the object is at rest as it hangs from the string. When the object is raised to a height above its lowest point, the object undergoes simple harmonic motion. Data collected from the experiment is graphed and linearized, as shown. What information from the graph can be used to determine the acceleration due to gravity for an object that is released from rest near Earth's surface and allowed to fall to the ground?

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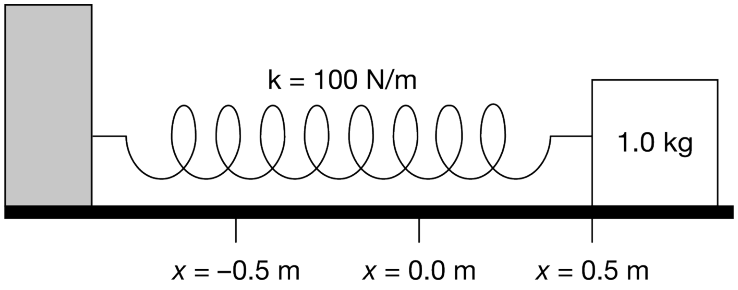
(A) The slope of the graph represents $\frac{1}{\sqrt{g}}$.

(B) The slope of the graph represents the quantity $\frac{2\pi}{\sqrt{g}}$.

(C) The slope of the graph represents the quantity $\frac{4\pi^2}{g}$.

(D) The graph cannot be used to determine the acceleration due to gravity for an object that is released from rest and allowed to fall to the ground.

26.



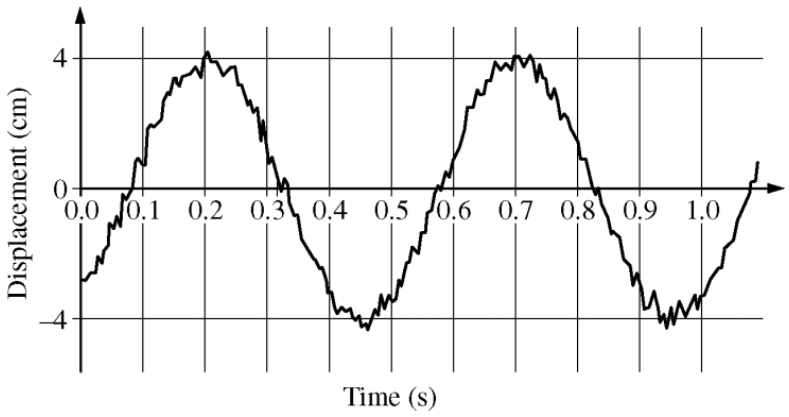
A block of mass $2.0\ \text{kg}$ on a horizontal surface is attached to a horizontal spring of negligible mass and spring constant $100\ \frac{\text{N}}{\text{m}}$. The other end of the spring is attached to a wall, and there is negligible friction between the block and the horizontal surface. When the spring is unstretched, the block is located at $x = 0\,\text{m}$. The block is then pulled to $x = 0.5\,\text{m}$ and released from rest so that the block-spring system oscillates between $x = -0.5\,\text{m}$ and $x = 0.5\,\text{m}$, as shown in the figure. Which of the following predictions is correct regarding the energy of the system?

(A) If the mass of the block is changed to $0.5\ \text{kg}$ and all other quantities are held constant, the maximum kinetic energy of the system will be half of the value from the original situation.

(B) If the spring is changed so that its spring constant is $200\ \frac{\text{N}}{\text{m}}$ and all other quantities are held constant, the maximum kinetic energy of the system will be twice the value from the original situation.

(C) If the block is pulled to $x = 2.0\,\text{m}$ and released from rest and all other quantities are held constant, the maximum kinetic energy of the system will be four times the value from the original situation.

(D) If the mass of the block is changed to $1.0\ \text{kg}$ and the spring is changed to so that its spring constant is $50\ \frac{\text{N}}{\text{m}}$, the maximum kinetic energy of the system will be the same as the value from the original situation.



A student sets an object attached to a spring into oscillatory motion and uses a position sensor to record the displacement of the object from equilibrium as a function of time. A portion of the recorded data is shown in the figure above.

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27. The frequency of oscillation is most nearly

(A) 0.5 Hz

(B) 0.7 Hz

(C) 1.4 Hz

(D) 2.0 Hz

28. The speed of the object at time $t = 0.65$ s is most nearly equal to which of the following?

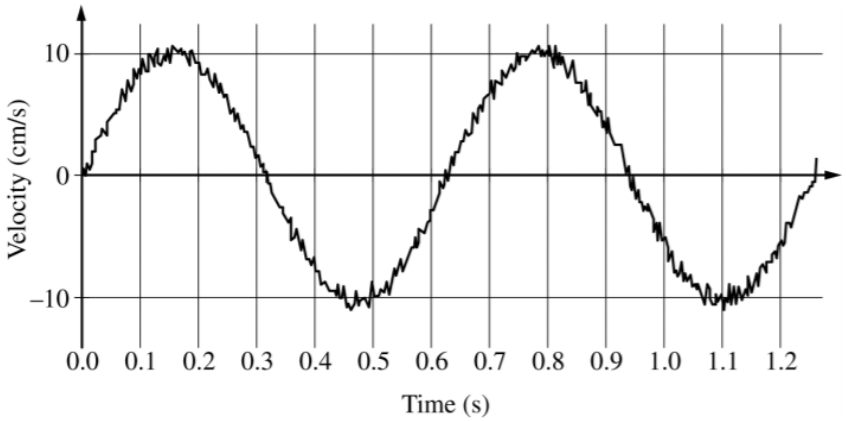
(A) The value of the graph at 0.65 s

(B) The slope of the line connecting the origin and the point on the graph at 0.65 s

(C) The slope of the line connecting the point where the graph crosses the time axis near 0.57 s and the point on the graph at 0.65 s

(D) The slope of the tangent to a best-fit sinusoidal curve at 0.65 s

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A student sets an object attached to a spring into oscillatory motion and uses a motion detector to record the velocity of the object as a function of time. A portion of the recorded data is shown in the figure above.

29. The frequency of oscillation is most nearly

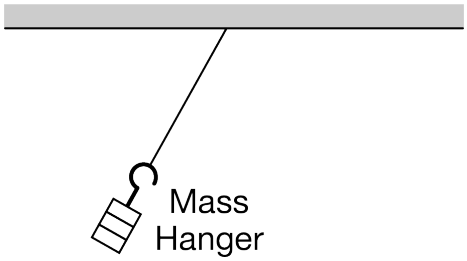
(A) 0.63 Hz

(B) 0.80 Hz

(C) 1.25 Hz

(D) 1.60 Hz

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A group of students must study the oscillatory motion of a pendulum. One end of a light string is attached to the ceiling, and the other end of the string is attached to a mass hanger so that small disks of various masses may be stacked on the hanger, as shown in the figure.

30. Students are provided with data in which an experiment was conducted to determine the relationship between the length of the pendulum and the period of oscillation. The data include a pendulum of length $0.5\ \text{m}$, for which it took $81\ \text{s}$ for the pendulum bob to oscillate 10 times. However, the experiment was conducted at a location that is not near Earth's surface. The gravitational field strength where the experiment was conducted is most nearly

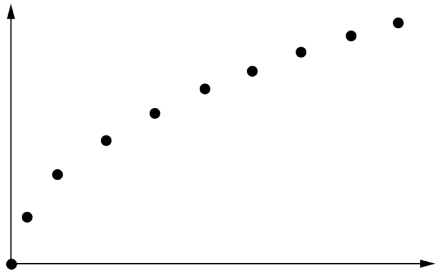
(A) $0.003\ \text{N/kg}$

(B) $0.024\ \text{N/kg}$

(C) $0.30\ \text{N/kg}$

(D) $2.40\ \text{N/kg}$

31.



The students perform four experiments, as described.

Experiment 1: Determine the relationship between the mass of the pendulum and the period of oscillation.

Experiment 2: Determine the relationship between the displacement of the pendulum and the period of oscillation.

Experiment 3: Determine the relationship between the period of oscillation and the length of the pendulum.

Experiment 4: Determine the relationship between the vertical release height of the hanger-disk system and its speed at the lowest point of its arc.

The students collect data to create the graph that is shown, but the horizontal and vertical axes are not labeled. Which experiments could be represented by the graph?

CHAPTER6

(A) Experiment 1 and Experiment 2

(B) Experiment 1 and Experiment 3

(C) Experiment 2 and Experiment 3

(D) Experiment 3 and Experiment 4

32. The students want to determine how the length of the pendulum affects the period of the pendulum. Which of the following procedures should the students use to conduct the experiment?

(A) Measure the length of the string with a meterstick. Place two disks on the hanger. Raise the hanger-disk system to a vertical position above its lowest point. Release the system from rest. Use a stopwatch to determine how long it takes the system to make ten oscillations. Repeat the experiment for different vertical heights.

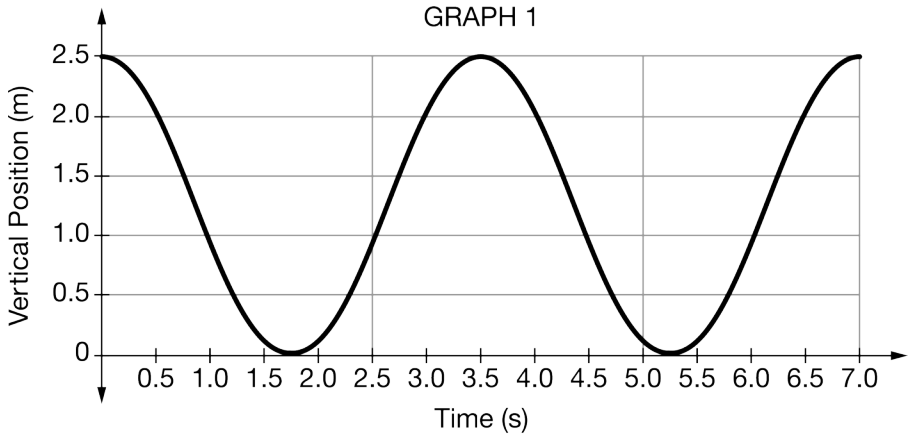
(B) Measure the length of the string with a meterstick. Place two disks on the hanger. Raise the hanger-disk system to a vertical position above its lowest point. Release the system from rest. Use a stopwatch to determine how long it takes the system to make ten oscillations. Repeat the experiment for different string lengths.

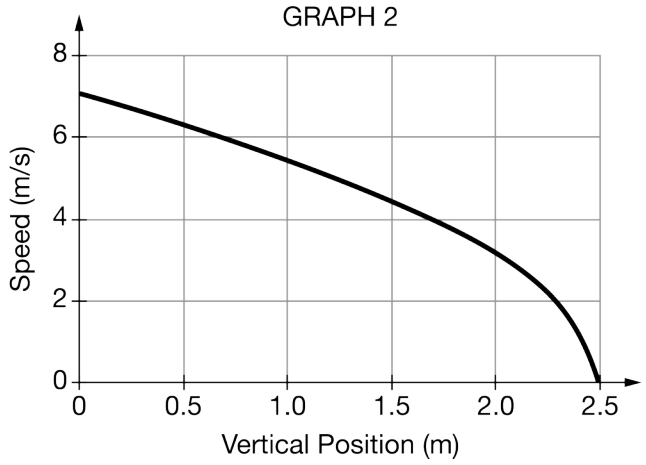
(C) Measure the length of the string with a meterstick. Place two disks on the hanger. Raise the hanger-disk system to a vertical position above its lowest point. Release the system from rest. Use a stopwatch to determine how long it takes the system to make ten oscillations. Repeat the experiment for different vertical heights and string lengths.

(D) Measure the length of the string with a meterstick. Place two disks on the hanger. Raise the hanger-disk system to a vertical position above its lowest point. Release the system from rest. Use a stopwatch to determine how long it takes the system to make ten oscillations. Repeat the experiment for different string lengths and number of disks attached to the hanger.

CHAPTER6

33.





A rope hangs from a tree that is on Earth's surface. Student X holds on to the end of a rope and hangs from rest. Student Y exerts a force onto student X so that student X undergoes simple harmonic motion while hanging onto the rope. Air resistance is considered to be negligible. Graph 1 shows the vertical position of student X as a function of time. Graph 2 shows the speed of student X as a function of the student's vertical position.

What is the approximate length of the rope and the mass of the student if the maximum gravitational potential energy of the student-Earth system is 2000 J?

CHAPTER6

(A)

Length of Rope (m)	Mass of Student (kg)
2.5	41

(B)

Length of Rope (m)	Mass of Student (kg)
2.5	82

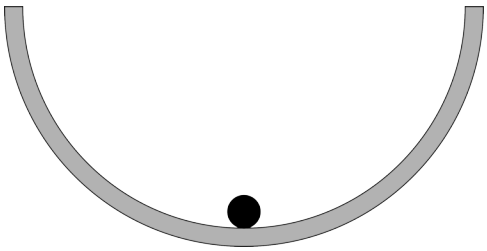
(C)

Length of Rope (m)	Mass of Student (kg)
3.1	41

(D)

Length of Rope (m)	Mass of Student (kg)
3.1	82

34.



A marble is placed at the bottom of a semi-spherical bowl, as shown in the figure. The marble is then displaced from the bottom of the bowl to a position about halfway from the top of the bowl. The marble is then released from rest such that the marble always remains in contact with the bowl. Students observe that the marble rolls back and forth as it oscillates about the bottom of the bowl. Which of the following statements best explains why the marble undergoes oscillatory motion?

(A) The sides of the bowl become steeper at positions farther from the bottom of the bowl.

(B) The net force exerted on the marble always has a component directed toward the bottom of the bowl.

(C) The normal force exerted on the marble decreases with increasing distance from the bottom of the bowl.

(D) The gravitational force exerted on the marble is constant in magnitude and direction.

CHAPTER6

35. A student must determine how the mass of a block affects the period of oscillation when the block is attached to a vertical spring. The value of the spring constant is known. The student writes the following experimental procedure.

1. Use an electronic balance to measure the mass of the block.
2. Attach the block to the vertical spring.
3. Displace the block from the system's equilibrium position to a new vertical position.
4. Release the block from rest.
5. Use a meterstick to measure the vertical displacement of the center of mass of the block from the system's equilibrium position to its maximum vertical position above the equilibrium position.
6. Use a stopwatch to measure the time it takes for the system to make ten complete oscillations.
7. Repeat the experiment for different vertical displacements and block masses.

Which of the following steps of the procedure should the student revise to make the determination? Justify your selection.

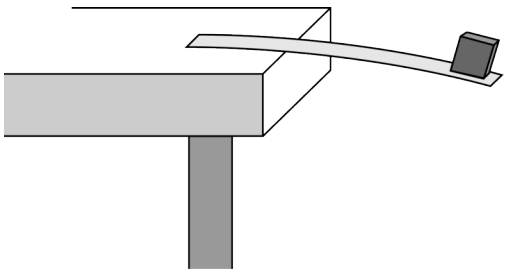
(A) Step 3, because the student must specify whether the new vertical position should be above or below the system's equilibrium position.

(B) Step 5, because the meterstick should be used to measure total displacement of the system from its lowest vertical position to its highest vertical position.

(C) Step 6, because the stopwatch should be used only to measure the time it takes for the system to make 1 complete oscillation.

(D) Step 7, because the experiment should not be repeated for different vertical displacements and block masses.

36.



Students attach a thin strip of metal to a table so that the strip is horizontal in relation to the ground. A section of the strip hangs off the edge of the table. A mass is secured to the end of the hanging section of the strip and is then displaced so that the mass-strip system oscillates, as shown in the figure. Students make various measurements of the net force F exerted on the mass as a result of the force due to gravity and the normal force from the strip, the vertical position y of the mass above and below its equilibrium position y, and the period of oscillation T when the mass is displaced by different amplitudes A. Which of the following explanations is correct about the evidence required to conclude that the mass undergoes simple harmonic motion?

(A) The period T of oscillation depends on the amplitude A of the mass, because the students can directly change this value during the experiment.

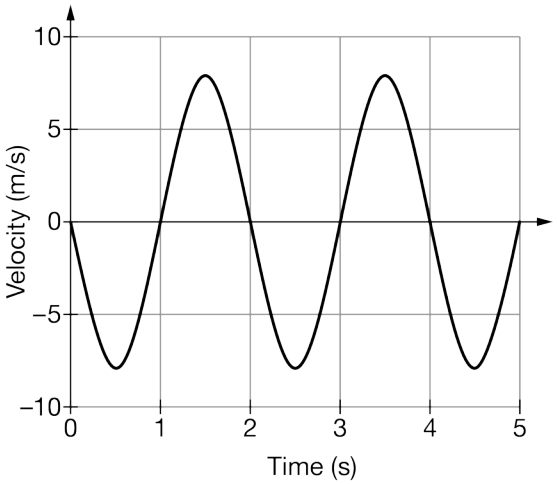
(B) The net force F exerted on the mass must be directly proportional to the vertical position y, because the net force exerted on the mass is the restoring force.

(C) The mass's acceleration is proportional to the square of the vertical position y, because the elastic potential energy of the mass-strip system can be modeled by the equation for spring potential energy.

(D) The motion of the mass repeats after a specific time interval, because total mechanical energy is considered to be conserved in simple harmonic motion.

CHAPTER6

37.

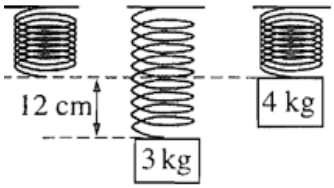


A block on a horizontal surface is attached to a horizontal spring of negligible mass. The other end of the spring is attached to a wall, and there is negligible friction between the block and the horizontal surface. The block-spring system is then placed into simple harmonic motion. The figure shows a graph of the velocity of the block as a function of time.

At which of the following times does the block-spring system have maximum spring potential energy?

(A) 1.5 s
(B) 2.0 s
(C) 3.5 s
(D) 4.5 s

38.

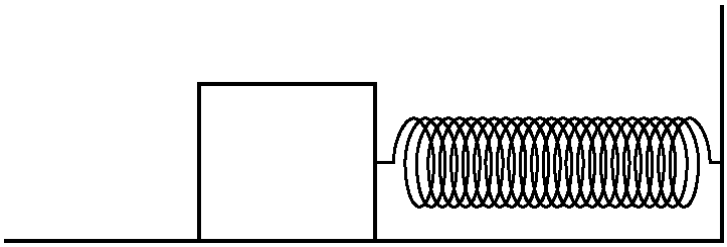


A block of mass 3.0 kg is hung from a spring, causing it to stretch 12 cm at equilibrium, as shown above. The 3.0 kg block is then replaced by a 4.0 kg block, and the new block is released from the position shown above, at which the spring is unstretched. How far will the 4.0 kg block fall before its direction is reversed?

(A) 9 cm
(B) 18 cm
(C) 24 cm
(D) 32 cm
(E) 48 cm

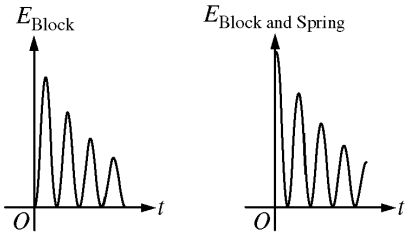
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39.

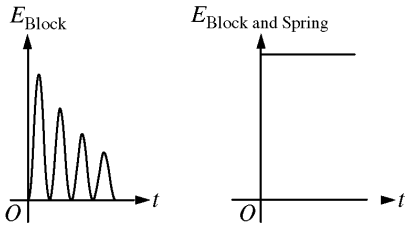


A block on a level surface is attached to one end of a spring, as shown in the figure above. The other end of the spring is attached to a wall. There is friction between the block and the surface. A person displaces the block from its equilibrium position and releases it. Which of the following shows the mechanical energy E as a function of time t for the system that includes only the block and the system that includes the block and spring?

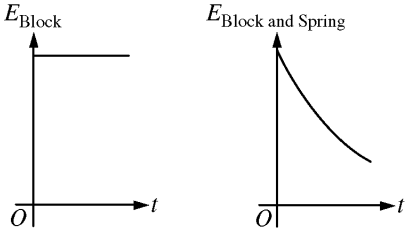
(A)



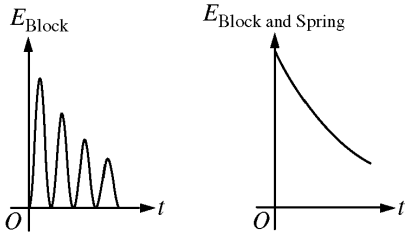
(B)



(C)

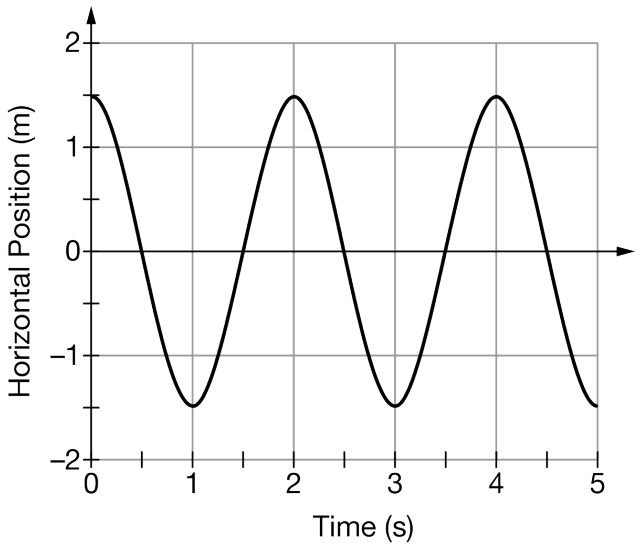


(D)



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40.



A block of mass $0.3\ \text{kg}$ on a horizontal surface is attached to a horizontal spring of negligible mass. The other end of the spring is attached to a wall, and there is negligible friction between the block and the horizontal surface. The block-spring system is released from rest and undergoes simple harmonic motion. The graph shows the horizontal position of the block as a function of time.

How could the student estimate the total mechanical energy of the system by using the graph and the known information about the system?

(A) Determine the slope of the curve between 0.0 s and 1.0 s. This value represents the average speed of the block between these instants in time. Then use $K = \frac{1}{2}mv^2$.

(B) Determine the slope of the curve between 0.2 s and 0.8 s. This value represents the average speed of the block between these instants in time. Then use $K = \frac{1}{2}mv^2$.

(C) Determine the slope of the curve between 0.4 s and 0.6 s. This value represents the average speed of the block between these instants in time. Then use $K = \frac{1}{2}mv^2$.

(D) Determine the slope of the curve between 0.45 s and 0.55 s. This value represents the average speed of the block between these instants in time. Then use $K = \frac{1}{2}mv^2$.

41. One end of a string is attached to an object of mass M, and the other end of the string is secured so that the object is at rest as it hangs from the string. When the object is raised to a position X that is a height H above its lowest point and released from rest, the object undergoes simple harmonic motion. When the object passes through the equilibrium position Y, it has a speed v_0.

Which of the following methods could a student use to determine the total mechanical energy E at position Y, and why? Select two answers.

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A $E = \frac{1}{2}Mv_0^2 - MgH$, because energy changes from kinetic energy to gravitational potential energy as the pendulum swings from position X to position Y.

B $E = MgH - \frac{1}{2}Mv_0^2$, because energy changes from gravitational potential energy to kinetic energy as the pendulum swings from position X to position Y.

C $E = \frac{1}{2}Mv_0^2$, because this equation represents the maximum kinetic energy of the pendulum at position Y if the system has zero gravitational potential energy at position Y.

D $E = MgH$, because this equation represents the maximum gravitational potential energy of the system at position X if the system has zero gravitational potential energy at position Y.

42. One end of a string is attached to an object of mass M, and the other end of the string is secured so that the object is at rest as it hangs from the string. When the object is raised to a height above its lowest point and released from rest, the object undergoes simple harmonic motion with a frequency f_0. In a second scenario, the length of the string is cut in half before the object undergoes simple harmonic motion again. What is the new frequency of oscillation of the object in terms of f_0?

(A) $\frac{1}{2}f_0$

(B) $\frac{1}{\sqrt{2}}f_0$

(C) $\sqrt{2}f_0$

(D) $2f_0$

43. Two systems are in oscillation: a simple pendulum swinging back and forth through a very small angle and a block oscillating on a spring. The block-spring system takes twice as much time as the pendulum to complete one oscillation. Which of the following changes could make the two systems oscillate with the same period?

(A) Increasing the mass of the pendulum bob

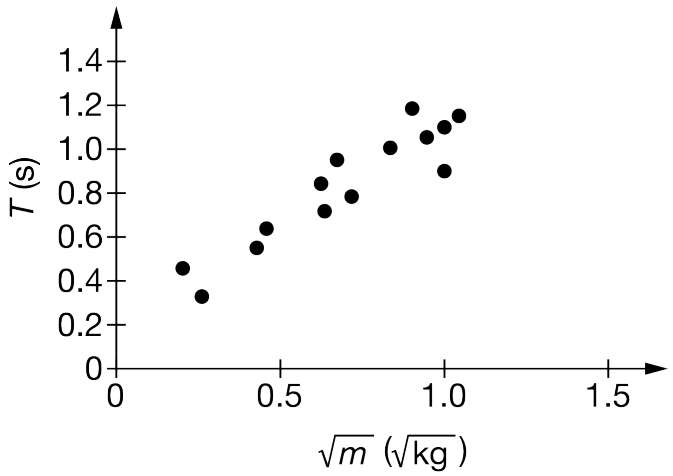
(B) Increasing the angle through which the pendulum swings by a small amount

(C) Decreasing the mass of both the block and the pendulum bob

(D) Shortening the pendulum

CHAPTER6

44.



A student attaches a block to a vertical spring of unknown spring constant k_0 so that the block-spring system will oscillate if the block-spring system is released from rest at a vertical position that is not the system's equilibrium position. The student varies the object's mass and uses a stopwatch to determine the time it takes the object to make one oscillation. The student creates the graph that is shown. The slope of the line of best fit is equal to which of the following quantities?

(A) $2\pi k_0$

(B) $\frac{2\pi}{k_0}$

(C) $2\pi\sqrt{k_0}$

(D) $\frac{2\pi}{\sqrt{k_0}}$

45. A student performs an experiment that involves the motion of a pendulum. The student attaches one end of a string to an object of mass M and secures the other end of the string so that the object is at rest as it hangs from the string. When the student raises the object to a height above its lowest point and releases it from rest, the object undergoes simple harmonic motion. As the student collects data about the time it takes for the pendulum to undergo one oscillation, the student observes that the time for one swing significantly changes after each oscillation. The student wants to conduct the experiment a second time. Which two of the following procedures should the student consider when conducting the second experiment? Select two answers.

A Make sure that the length of the string is not too long.

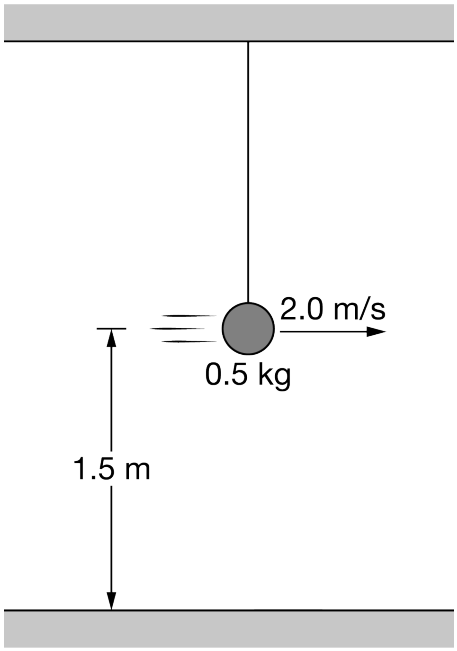
B Make sure that the mass of the pendulum is not too large.

C Make sure that the difference in height between the pendulum's release position and rest position is not too large.

D Make sure that the experiment is conducted in an environment that has minimal wind resistance.

CHAPTER6

46.



One end of a string is attached to an object of mass $0.5\ \text{kg}$, and the other end of the string is secured so that the object is at rest as it hangs from the string $1.5\ \text{m}$ above the ground, as shown in the figure. The object is then pulled to an unknown height above the ground. The object is then released from rest. The speed of the pendulum at the position shown in the figure is $2.0\ \text{m/s}$ when it undergoes simple harmonic motion. What is the approximate change in the gravitational potential energy of the pendulum-Earth system from the pendulum's maximum height to the position where its speed is $2.0\ \text{m/s}$?

(A) $1.0\ \text{J}$

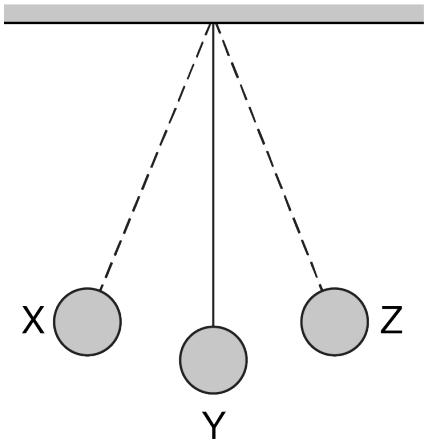
(B) $2.0\ \text{J}$

(C) $7.5\ \text{J}$

(D) $8.5\ \text{J}$

CHAPTER6

47.



One end of a string is attached to an object of mass M, and the other end of the string is secured so that the object is at rest as it hangs from the string. When the object is raised to a height above its lowest point and released from rest, the object undergoes simple harmonic motion. Three possible positions of the pendulum, X, Y, and Z, are shown in the figure. Which of the following claims is correct regarding the mechanical energy of the pendulum?

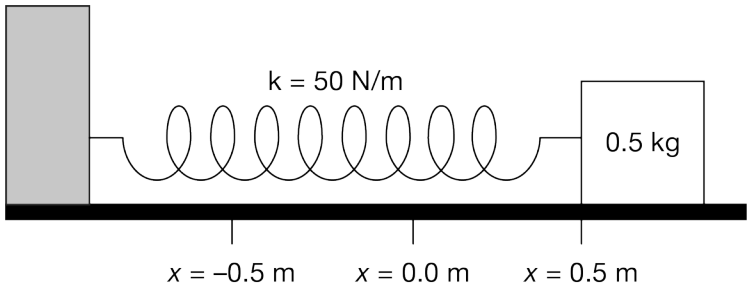
(A) The magnitude of the change in gravitational potential energy from point X to point Y is the same as from point Y to point Z.

(B) The pendulum has half of its maximum speed whenever it is at a vertical position that is halfway between point X and point Y.

(C) A pendulum with twice the mass will have twice the speed at the lowest point along the pendulum's arc when compared to the pendulum that is shown in the figure.

(D) A pendulum that is released at an angular amplitude that is twice what is shown in the figure will have the same total mechanical energy as the pendulum shown in the figure.

48.



A block of mass $0.5\ \mathrm{kg}$ on a horizontal surface is attached to a horizontal spring of negligible mass and spring constant $50\ \mathrm{N/m}$. The other end of the spring is attached to a wall, and there is negligible friction between the block and the horizontal surface. When the spring is unstretched, the block is located at $x = 0\ \mathrm{m}$. The block is then pulled to $x = 0.5\ \mathrm{m}$ and released from rest so that the block-spring system oscillates between $x = -0.5\ \mathrm{m}$ and $x = 0.5\ \mathrm{m}$, as shown in the figure. Which of the following claims is correct about the block's period of oscillation?

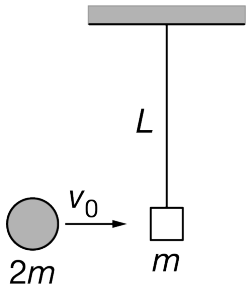
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(A) The period would increase if the block were released from rest at $x = 0.8\ \text{m}$.

(B) The period would increase if the block had a mass of $1.2\ \text{kg}$.

(C) The period would increase if the spring had a spring constant of $75\ \text{N/m}$.

(D) The period would increase if the block-spring system was oriented vertically so that the block-spring system oscillates between $y = -0.5\ \text{m}$ and $y = 0.5\ \text{m}$, the mass of the block is $0.5\ \text{kg}$, and the spring constant is $50\ \text{N/m}$.



A clay ball of mass $2m$ is moving horizontally with speed v_0 just before colliding with a block of mass m, as shown above. The block is suspended from a light string with length L. The clay sticks to the block, and the block swings up to a maximum height h_0 above the block's initial position (where $h_0 << L$). The block then oscillates about its lowest position with period T_0.

49. If the experiment is repeated, but the initial speed of the clay ball is $2v_0$, the period of oscillation of the block would be most nearly

(A) $T_0/2$

(B) T_0

(C) $\sqrt{2}\,T_0$

(D) $2T_0$

---

50. A student attaches a block to a vertical spring so that the block-spring system will oscillate if the block-spring system is released from rest at a vertical position that is not the system's equilibrium position. The system oscillates near Earth's surface. The system is then taken to the Moon's surface, where the gravitational field strength is nearly $\frac{1}{6}$ that of the gravitational field strength near Earth's surface. Which of the following claims is correct about the period of oscillation for the system?

(A) The system has a longer period on Earth than on the Moon.

(B) The system has a shorter period on Earth than on the Moon.

(C) The system has the same period on Earth as the Moon.

(D) The period of oscillation cannot be determined without knowledge of the spring constant, the mass of the block, and the exact gravitational field strength near Earth's surface and the Moon's surface.

51. A student attaches a block of mass M to a horizontal spring so that the block-spring system will oscillate if the block-spring system is released from rest at a horizontal distance D below the system's equilibrium position. The student measures the period of oscillation for the system to be P. What is the maximum spring potential energy of the system U_s in terms of D, M, and P ?

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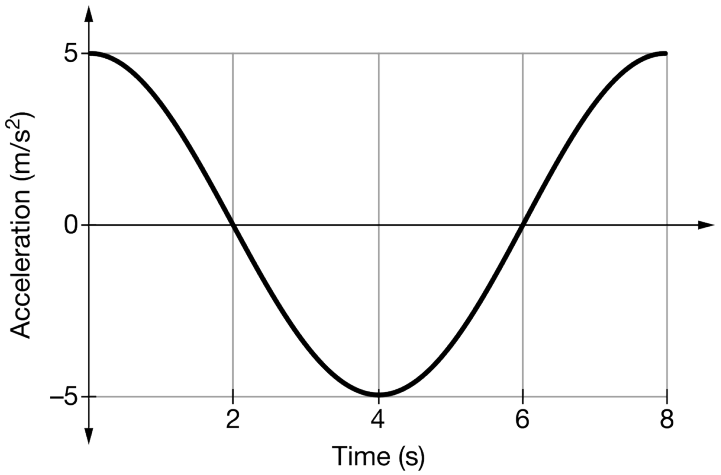
(A) $\frac{M\pi^2D^2}{2P^2}$

(B) $\frac{M\pi^2D^2}{P^2}$

(C) $\frac{2M\pi^2D^2}{P^2}$

(D) $\frac{4M\pi^2D^2}{P^2}$

52.



A student attaches a block to a horizontal spring so that the block-spring system will oscillate if the block-spring system is released from rest at a horizontal position that is not the system's equilibrium position. The oscillatory motion of the system is described by the graph of the block's acceleration as a function of time. An identical experiment is conducted except that a new spring is used that has a spring constant that is twice the value of that of the original spring. Which two of the following predictions are correct about the system when it undergoes simple harmonic motion? Select two answers.

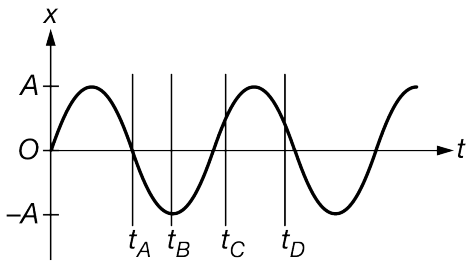
A The amplitude of oscillation will be increased by a factor of 2.

B The maximum acceleration of the system will be $10\ \mathrm{m/s^2}$.

C The period of oscillation for the system will be nearly $5.7\ \mathrm{s}$.

D The maximum spring potential energy of the system will be increased by a factor of 4.

53.

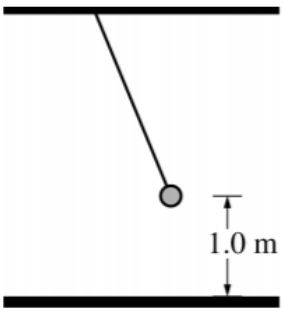


A block attached to a spring is oscillating in simple harmonic motion between $x = +A$ and $x = -A$. A graph of position x as a function of time t for the block is shown above. At which of the labeled times is negative work being done on the block by the spring?

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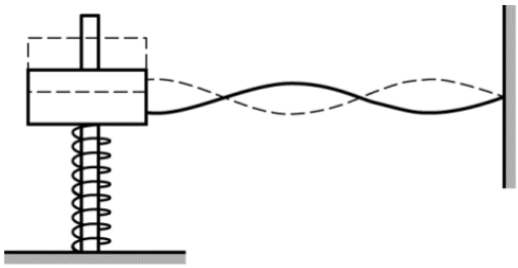
(A) t_A
(B) t_B
(C) t_C
(D) t_D

54.



A 0.5 kg pendulum bob is raised to 1.0 m above the floor, as shown in the figure above. The bob is then released from rest. When the bob is 0.8 m above the floor, its speed is most nearly

(A) 5 m/s
(B) 4 m/s
(C) 2 m/s
(D) 1 m/s



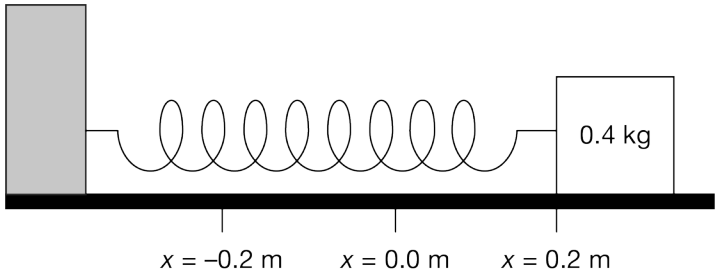
The figure above shows a pole with a spring around it and a 0.10 kg block with a hole in the middle on top of the spring. A light horizontal string is attached to the block and a wall. When the block is oscillating at 5.0 Hz, the standing wave shown is formed.

55. The spring constant of the spring is approximately which of the following?

(A) 100 N/m
(B) 10 N/m
(C) 1.0 N/m
(D) 0.1 N/m

CHAPTER6

56.



A block of mass $0.4\ \text{kg}$ on a horizontal surface is attached to a horizontal spring of negligible mass and unknown spring constant. The other end of the spring is attached to a wall, and there is negligible friction between the block and the horizontal surface. When the spring is unstretched, the block is located at $x = 0\ \text{m}$. The block is then pulled to $x = 0.2\ \text{m}$ and released from rest so that the block-spring system oscillates between $x = -0.2\ \text{m}$ and $x = 0.2\ \text{m}$. The block-spring system undergoes 5 oscillations in $8\ \text{s}$.

How could a student determine the change in spring potential energy of the system from $x = 0.2\ \text{m}$ to $x = 0.1\ \text{m}$ by using the diagram and the known information?

(A) By dividing 5 oscillations by $8\ \text{s}$ to determine the period of the system, using $T_s = 2\pi\sqrt{\frac{m}{k}}$ to determine the spring constant of the spring, using $U_s = \frac{1}{2}kx^2$ to determine the spring potential energy at $x = 0.2\ \text{m}$ and $x = 0.1\ \text{m}$, and determining the magnitude of the difference of these two values.

(B) By dividing 5 oscillations by $8\ \text{s}$ to determine the period of the system, using $T_s = 2\pi\sqrt{\frac{m}{k}}$ to determine the spring constant of the spring, using $U_s = \frac{1}{2}kx^2$ to determine the spring potential energy at $x = 0.2\ \text{m}$ and $x = 0.1\ \text{m}$, and determining the sum of these two values.

(C) By dividing $8\ \text{s}$ by 5 oscillations to determine the period of the system, using $T_s = 2\pi\sqrt{\frac{m}{k}}$ to determine the spring constant of the spring, using $U_s = \frac{1}{2}kx^2$ to determine the spring potential energy at $x = 0.2\ \text{m}$ and $x = 0.1\ \text{m}$, and determining the magnitude of the difference of these two values.

(D) By dividing $8\ \text{s}$ by 5 oscillations to determine the period of the system, using $T_s = 2\pi\sqrt{\frac{m}{k}}$ to determine the spring constant of the spring, using $U_s = \frac{1}{2}kx^2$ to determine the spring potential energy at $x = 0.2\ \text{m}$ and $x = 0.1\ \text{m}$, and determining the sum of these two values.

57. The displacement x with respect to time t of a particle moving in simple harmonic motion is given by $x = 5\cos(16\pi t)$, where x is in millimeters and t is in seconds. If the particle starts at $x = 5$ mm and $t = 0$ s, at what time t does it first pass through its equilibrium position?

(A) $\frac{1}{32}\ s$

(B) $\frac{1}{16}\ s$

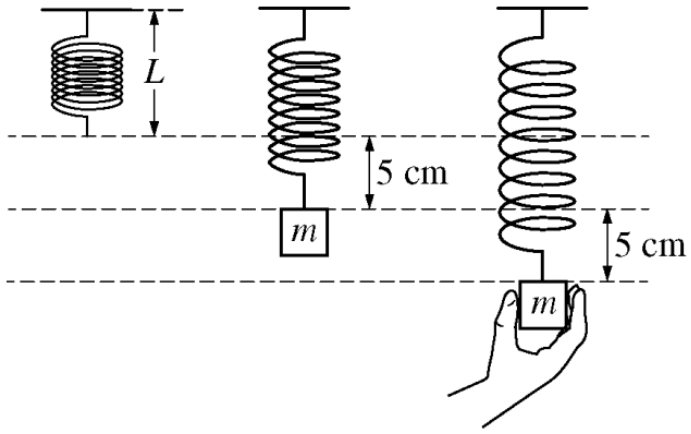
(C) $\frac{1}{5}\ s$

(D) 4 s

(E) 8 s

CHAPTER6

58.



An object with mass m is suspended at rest from a spring with a spring constant of 200 N/m . The length of the spring is 5.0 cm longer than its unstretched length *L*, as shown above. A person then exerts a force on the object and stretches the spring an additional 5.0 cm. What is the total energy stored in the spring at the new stretched length?

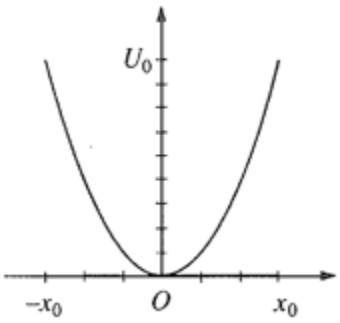
(A) 0.25 J

(B) 1.0 J

(C) 10 J

(D) 20 J

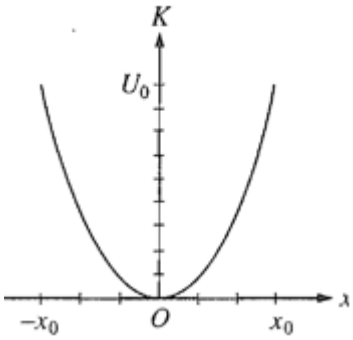
59.



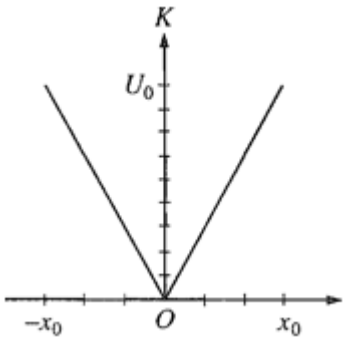
The graph above represents the potential energy *U* as a function of displacement *x* for an object on the end of a spring oscillating in simple harmonic motion with amplitude x_0. Which of the following graphs represents the kinetic energy *K* of the object as a function of displacement *x*?

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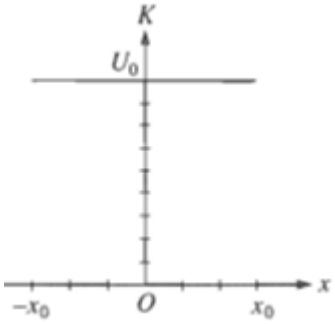
(A)



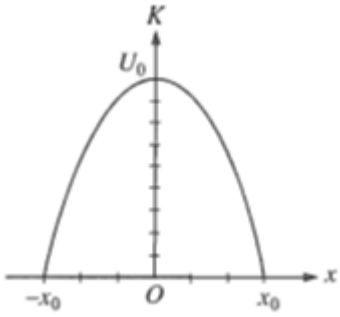
(B)



(C)

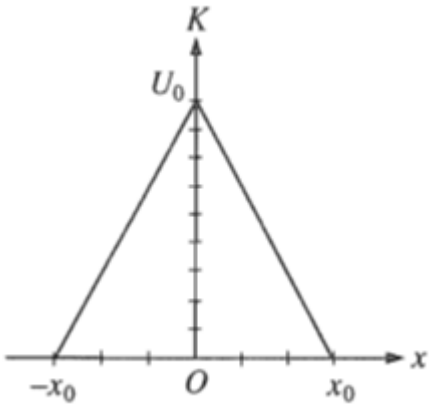


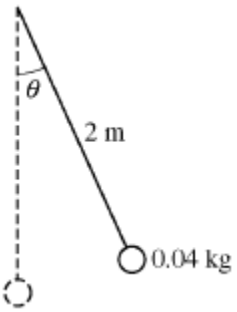
(D)



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(E)





The pendulum illustrated above has a length of 2 m and a bob of mass 0.04 kg. It is held at an angle Θ, as shown, where $\cos\Theta = 0.9$.

60. The frequency of oscillation is most nearly

(A) 4π Hz

(B) $2\pi\sqrt{0.2}$ Hz

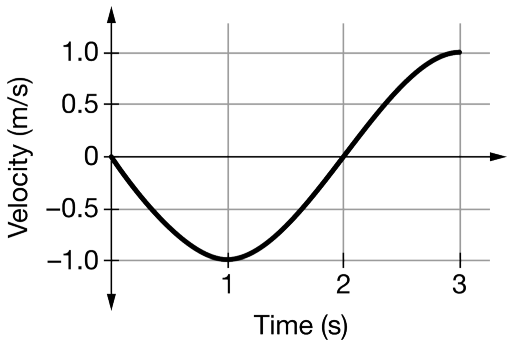
(C) $(0.25 / \pi)$ Hz

(D) $(\sqrt{0.2}/2\pi)$ Hz

(E) $(\sqrt{5}/2\pi)$ Hz

CHAPTER6

61.



A block that is connected to a horizontal spring is allowed to oscillate, and a graph of its velocity as a function of time is shown in the figure. At $t = 7$ s, the block detaches from the spring. All frictional forces are considered to be negligible. What distance will the block travel from $t = 7$ s to $t = 10$ s?

(A) 0.0 m

(B) 1.5 m

(C) 3.0 m

(D) 10.0 m

62. A block is suspended vertically by a spring, and the block-spring system oscillates with a period of 0.50 s. An identical block is attached to a lightweight string to form a pendulum that oscillates with a period of 0.75 s. Which of the following modifications, when implemented on its own, could result in the two periods being more nearly the same? Select two answers.

A Use a spring with a higher spring constant.

B Use a longer string.

C Use heavier blocks.

D Repeat the procedure on a planet with a higher gravitational acceleration.

Refer to the following material to answer the group of questions.

A student is observing an object of unknown mass that is oscillating horizontally at the end of an ideal spring. The student measures the object's period of oscillation with a stopwatch.

63. While the object is continuously oscillating, the student determines the maximum speed of the object during two oscillations. The first speed is 3.5 m / s and the second speed is 2.7 m / s. Which of the following could account for the decrease in the object's maximum kinetic energy?

(A) Energy was transferred from the object to the spring, which increased the maximum potential energy of the spring.

(B) Energy was transferred from the spring to the object, which decreased the maximum potential energy of the spring.

(C) As energy was transferred back and forth between the object and the spring, a greater average share of the energy became potential energy of the spring.

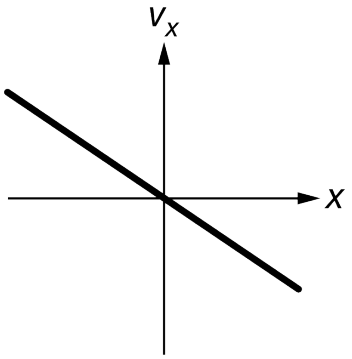
(D) The object-spring system lost energy to its surroundings.

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64. A block of mass M on a horizontal surface is attached to a horizontal spring of negligible mass. The other end of the spring is attached to a wall, and there is negligible friction between the block and the horizontal surface. The object is displaced from the object-spring's equilibrium position and released from rest so that the system oscillates. A student collects data about the object's horizontal displacement x, velocity v_x, acceleration a_x, and the net force F_x exerted on the object as the object oscillates. Which of the following graphs, with appropriate evidence, could the student be able to create from the data to explain that the object undergoes simple harmonic motion?

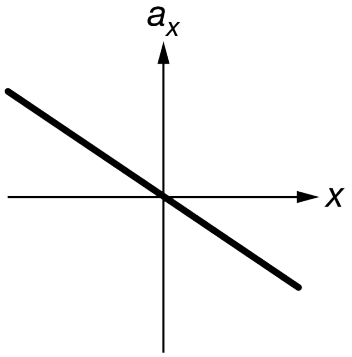
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(A)



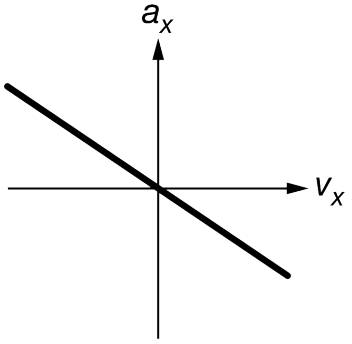
The kinetic energy and the velocity of the object are directly proportional to the displacement of the object.

(B)



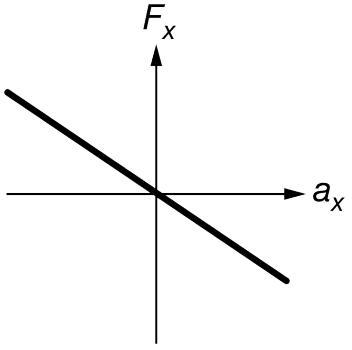
The restoring force and the acceleration of the object are directly proportional to the displacement of the object.

(C)



The restoring force and the acceleration of the object are directly proportional to the velocity of the object.

(D)



The restoring force is directly proportional to the acceleration of the object.