Unit 6 Progress Check: MCQ

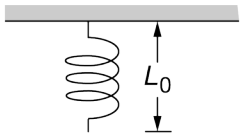


Figure 1. Natural Length of Vertical Spring

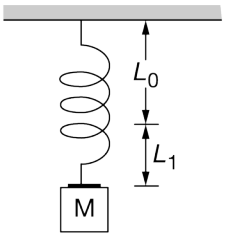


Figure 2. Equilibrium Position of Block-Spring System

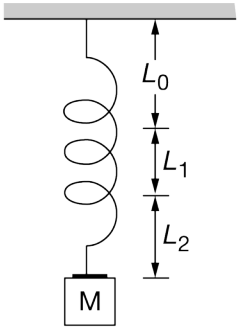


Figure 3. Release Position of Block-Spring System

In experiment 1, a block of mass M is attached to the end of vertical spring of spring constant k_0 with its free end at vertical position L_0, as shown in Figure 1. The mass of the spring is considered to be negligible. When the block is attached to the spring and is at rest at the block-spring's equilibrium position, the spring is stretched so that its end is at a new position L_1, as shown in Figure 2. The block is then pulled down to a new vertical position L_2 and then released from rest so that the block-spring system oscillates. Assume that the reference line for zero gravitational potential energy of the system is at the lowest point in the system's vertical displacement from equilibrium. The experiment is assumed to be performed near Earth's surface.

1. What is the magnitude of the change in potential energy of the block-spring system when it travels from its lowest vertical position to its highest vertical position?

(A) Zero

(B) $2MgL_1$

(C) $2\mathrm{k}_0L_1L_2$ ✓

(D) $\frac{1}{2}k_0(L_1+L_2)^2$

Unit 6 Progress Check: MCQ

2. The students conduct experiment 2 in which the same block is connected to the same spring on a horizontal surface. The spring is stretched a distance L_2 beyond its natural length and released from rest, allowing the block-spring system to oscillate. Frictional forces are considered to be negligible. Which of the following claims is correct about how the period of oscillation for the block-spring system in experiment 2 compares with the period of oscillation for the system in experiment 1, and what evidence supports the claim?

(A) The period of oscillation for experiment 2 is larger than that of experiment 1, because the spring is stretched a distance $L_1 + L_2$ from its natural length in experiment 1 and only stretched a distance L_2 beyond its natural length in experiment 2.

(B) The period of oscillation for experiment 2 is larger than that of experiment 1, because some of the kinetic energy of the block-spring system is converted into spring potential energy in experiment 1, whereas all of the kinetic energy is converted into spring potential energy in experiment 2.

(C) The period of oscillation for experiment 2 is smaller than that of experiment 1, because the force due to gravity is an external force on the block-spring system in experiment 1 that increases the net restoring force on the block.

(D) The periods of oscillation for experiment 2 and experiment 1 are the same, because the block and the spring used in both experiments are identical. ✓

3.

Trial	Mass of Block (kg)	Period of Oscillation (s)
1	0.4	0.56
2	0.5	0.63
3	0.7	0.74
4	1.0	0.89

A student is asked to perform experiment 1, but with a spring of an unknown spring constant. The student performs four trials of the experiment with blocks of different mass and collects the data that are shown in the table. How should the student graphically analyze the data in order to determine the spring constant of the spring?

(A) Create a graph with the period of oscillation plotted on the vertical axis and the mass of the block plotted on the horizontal axis. Use the slope of the best-fit line to determine the spring constant.

(B) Create a graph with the period of oscillation plotted on the vertical axis and the square root of the mass of the block plotted on the horizontal axis. Use the slope of the best-fit line to determine the spring constant. ✓

(C) Create a graph with the period of oscillation plotted on the vertical axis and the square of the mass of the block plotted on the horizontal axis. Use the slope of the best-fit line to determine the spring constant.

(D) The student can only mathematically analyze the data by applying the appropriate equation.

Unit 6 Progress Check: MCQ

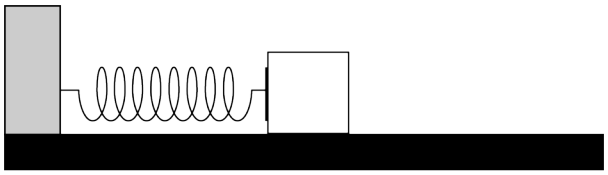


Figure 1. Before the Spring is Stretched

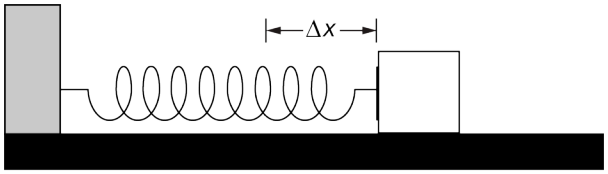


Figure 2. After the Spring is Stretched

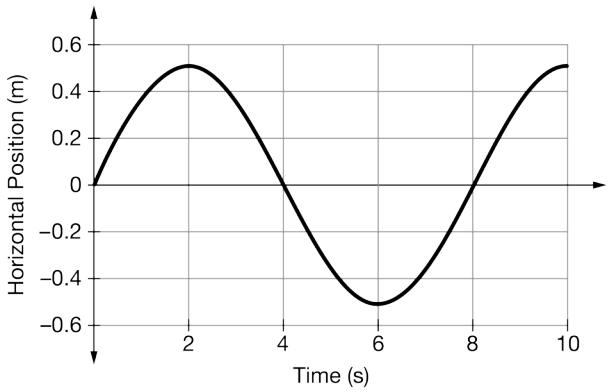


Figure 3

A block on a horizontal surface is attached to a horizontal spring of negligible mass, as shown in Figure 1. The other end of the spring is attached to a wall, and there is negligible friction between the block and the horizontal surface. A group of students wants to investigate how stretching the spring within the block-spring system influences the motion of the system. For each trial of an experiment, the spring is stretched a variable distance Δx from its natural spring length, as shown in Figure 2, and blocks of different mass may be used. The block is then released from rest, and the system is allowed to oscillate. Figure 3 shows the horizontal position of the block as a function of time for one trial of the experiment.

4. The students must conduct an experiment to determine the magnitude of the force exerted on the block when the block is at a position of $\frac{A}{2}$, where A is the amplitude of oscillation for the block-spring system. For each trial, the students attach blocks of different mass m to the spring, stretch the spring a known distance A, release the system from rest, measure the period of oscillation T, and then measure the maximum velocity v of the system. How should students use a graph to determine the magnitude of the force under consideration?

Unit 6 Progress Check: MCQ

(A) Determine the magnitude of the slope of the best-fit line of v as a function of $\frac{1}{m}$ and use that to find k. Then multiply by A.

(B) Determine the magnitude of the slope of the best-fit line of v^2 as a function of m and use that to find k. Then multiply k by $\frac{A}{2}$.

(C) Determine the magnitude of the slope of the best-fit line of T^2 as a function of m and use that to find k. Then multiply k by $\frac{A}{2}$. ✓

(D) Determine the magnitude of the slope of the best-fit line of T as a function of m and use that to find k. Then multiply k by A.

5. In one experiment, the students allow the block to oscillate after stretching the spring a distance A. If the potential energy stored in the spring is U_0, then what is the change in kinetic energy of the block after it is released from rest and has traveled a distance of $\frac{A}{2}$?

(A) U_0

(B) $\frac{3}{4}U_0$ ✓

(C) $\frac{1}{2}U_0$

(D) $\frac{1}{4}U_0$

6. At which of the following times does the spring exert its maximum force on the block?

(A) 0.0 s

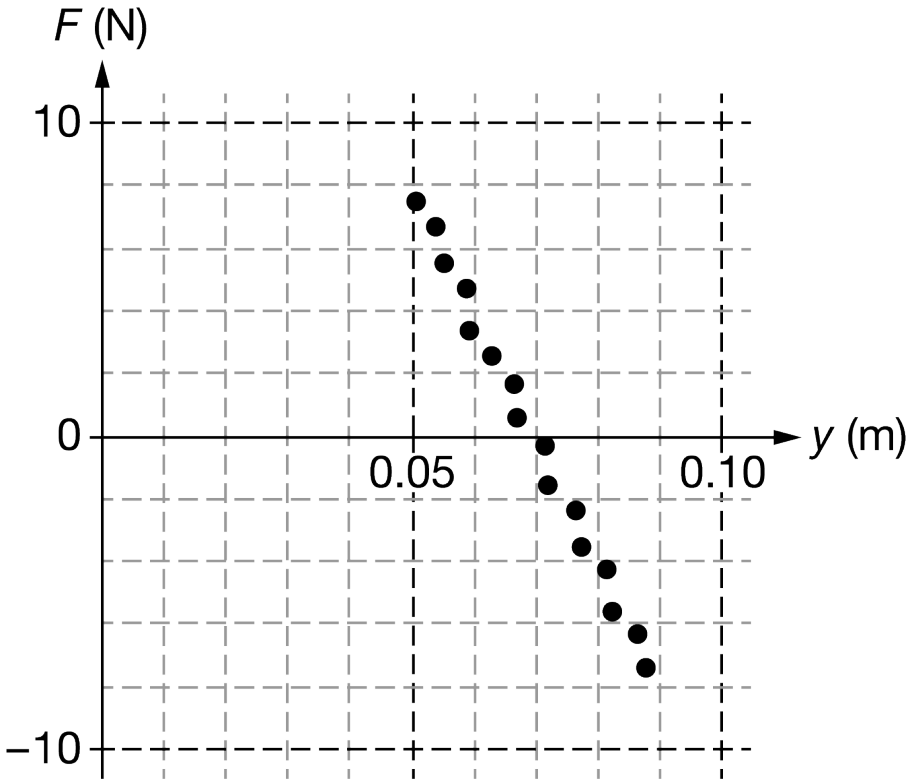
(B) 2.0 s ✓

(C) 4.0 s

(D) 8.0 s

Unit 6 Progress Check: MCQ

7.



A $4.0\,\text{kg}$ cube is placed in a container of water. A student observes that the cube floats. The net force exerted on the cube F represents the sum of the force due to gravity and the force exerted on the cube by the water. A force probe is used to measure F as a function of the cube's distance y from the bottom of the container. The graph shows F as a function of y, where the positive direction is upward. Which of the following statements is correct about the motion of the cube if it is released from rest at a vertical position of $y = 0.05\,\text{m}$?

(A) The cube will have a constant upward acceleration of $2.0\,\text{m/s}^2$.

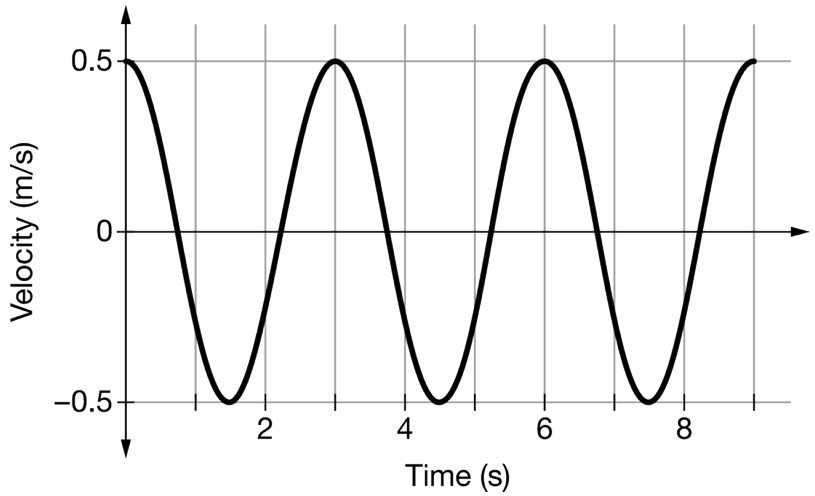
(B) The cube will have a constant downward acceleration of $2.0\,\text{m/s}^2$.

(C) The cube will travel upward with a changing acceleration until it comes to rest at a position of $y = 0.07\,\text{m}$.

(D) The cube will oscillate between $y = 0.05\,\text{m}$ and $y = 0.09\,\text{m}$. ✓

Unit 6 Progress Check: MCQ

8.



A student attaches a $0.6\ \text{kg}$ block to a vertical spring so that the block-spring system will oscillate if the block-spring system released from rest at a vertical position that is not the system's equilibrium position. The student measures the velocity of the block as a function of time as the system oscillates, as shown in the graph. The spring constant of the spring is most nearly

(A) $0.3\ \text{N/m}$

(B) $2.6\ \text{N/m}$ ✓

(C) $7.9\ \text{N/m}$

(D) $10.5\ \text{N/m}$

9. A student must use an object attached to a string to graphically determine the gravitational field strength near Earth's surface. The student attaches the free end of the string to the ceiling and pulls the object-string system so that the string makes an angle of 5 degrees from the object's vertical hanging position. The student then releases the object from rest and uses a stopwatch to measure the time it takes for the object to make one complete oscillation. Which of the following is the next step that will allow the student to determine the gravitational field strength?

(A) Repeat the experiment by adding additional mass to the object for multiple trials.

(B) Repeat the experiment by changing the length of the string for multiple trials. ✓

(C) Repeat the experiment by changing the angle that the string makes with the object's vertical hanging position.

(D) Repeat the experiment by measuring the time it takes to make two oscillations, three oscillations, and additional oscillations for multiple trials.

10. Student X attaches an object of mass M to the end of a string of length L so that a pendulum is constructed. Student Y attaches an object of mass M to a string of length $4L$ to construct a second pendulum. Which of the following claims correctly compares the period of Student X's pendulum with the period of Student Y's pendulum?

(A) The period of Student X's pendulum is the same as the period of Student Y's pendulum.

(B) The period of Student X's pendulum is four times the period of Student Y's pendulum.

(C) The period of Student X's pendulum is twice the period of Student Y's pendulum.

(D) The period of Student X's pendulum is half the period of Student Y's pendulum. ✓

Unit 6 Progress Check: MCQ

11. The gravitational field strength near Jupiter's surface is nearly 2.53 times greater than the gravitational field strength near Earth's surface. Which of the following claims is correct about the period of a pendulum if it oscillates near Jupiter's surface and near Earth's surface?

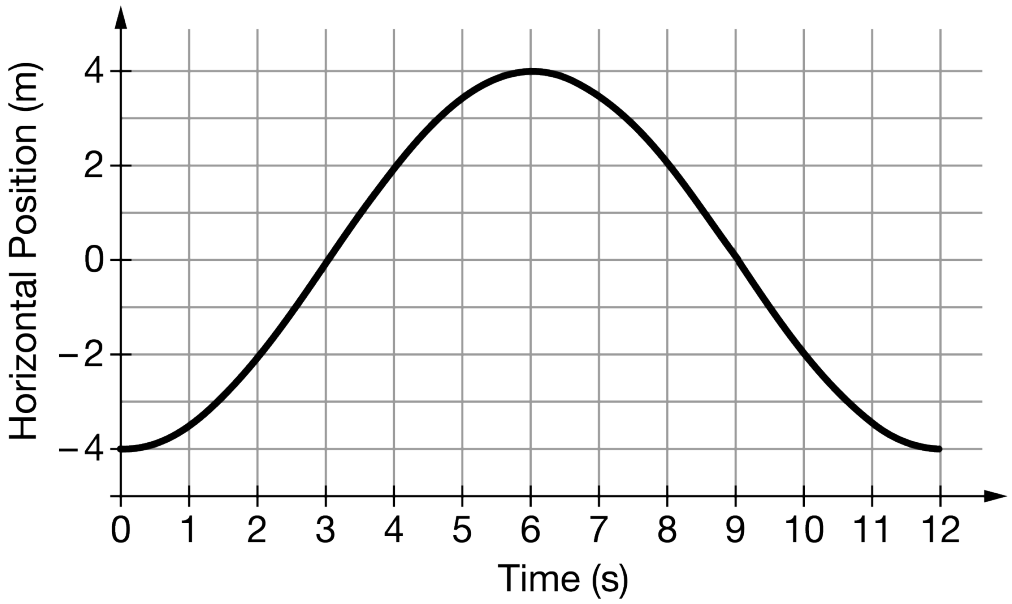
(A) The period of the pendulum will be greater on Jupiter.

(B) The period of the pendulum will be greater on Earth. ✓

(C) The period of the pendulum is the same on both planets.

(D) A comparison of the period of the pendulum for both planets cannot be made without more information about the length of the pendulum.

12.



A block on a horizontal surface is attached to a horizontal spring of negligible mass and spring constant $30\ \mathrm{N/m}$. The other end of the spring is attached to a wall, and there is negligible friction between the block and the horizontal surface. The block-spring system experiences simple harmonic motion, as shown in the graph.

What is the change in spring potential energy of the block-spring system from when the block is released to when the block has its greatest speed?

(A) $0\ \mathrm{J}$

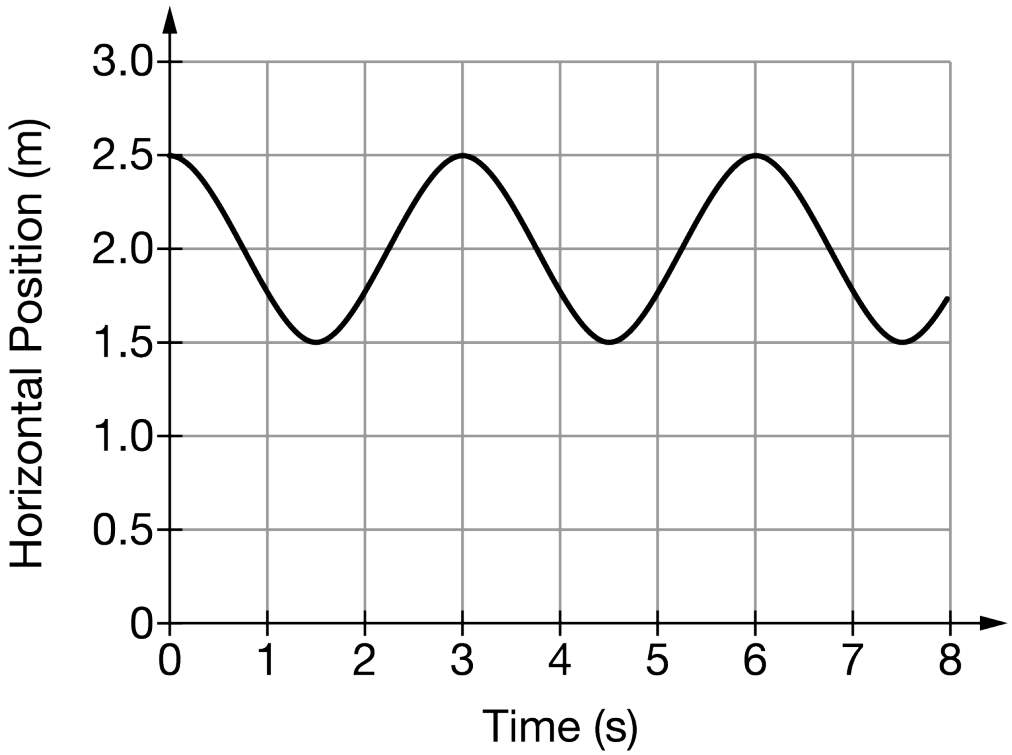
(B) $120\ \mathrm{J}$

(C) $240\ \mathrm{J}$ ✓

(D) $480\ \mathrm{J}$

Unit 6 Progress Check: MCQ

13.



A block of mass 0.4 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 then experiences simple harmonic motion as described by the graph. The maximum spring potential energy of the block-spring system is most nearly

(A) 0.2 J ✓

(B) 0.9 J

(C) 2.0 J

(D) 5.5 J

Unit 6 Progress Check: MCQ

14.

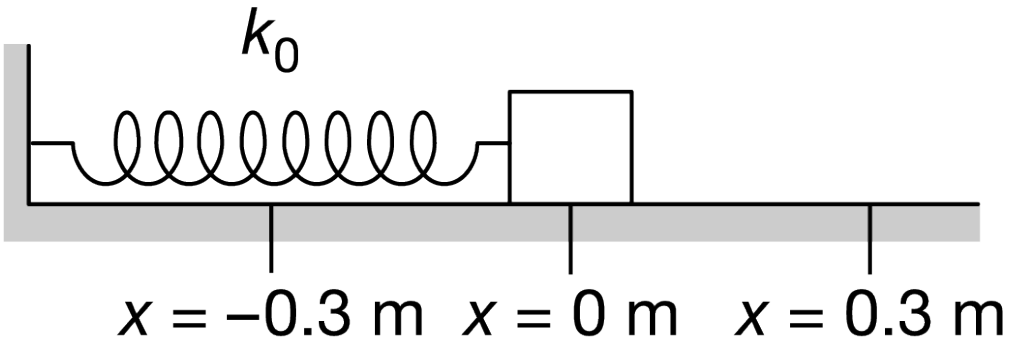


Figure 1

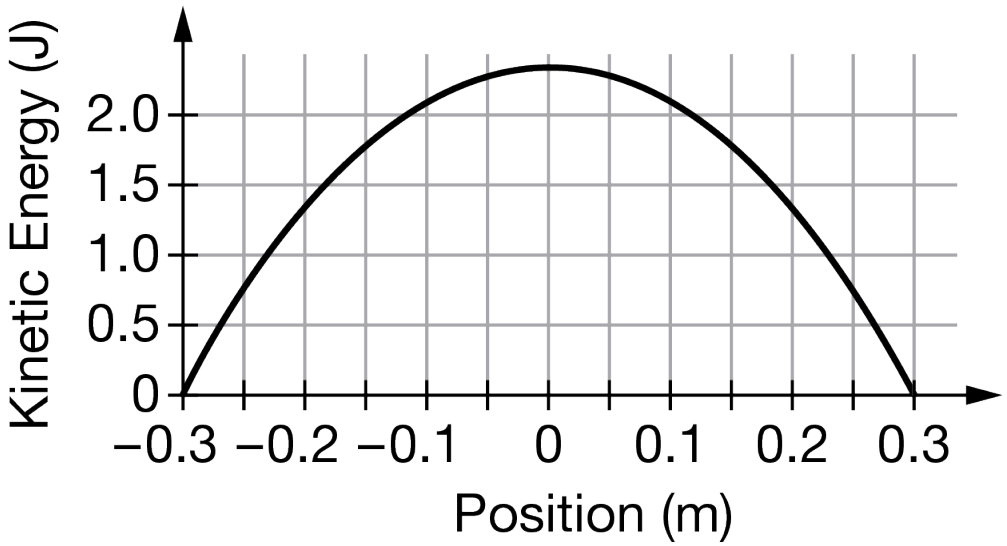


Figure 2

A block on a horizontal surface is attached to a horizontal spring of negligible mass and spring constant k_0. The other end of the spring is attached to a wall. When the spring is unstretched, the block is located at $x = 0$ m, as shown in Figure 1. The block is then pulled to $x = 0.3$ m and released from rest so that the block-spring system oscillates between $x = -0.3$ m and $x = 0.3$ m. A student creates the graph shown in Figure 2, which shows the kinetic energy of the block-spring system as a function of the block's position. Which of the following mathematical routines can a student use, if at all, to determine the approximate change in the spring potential energy of the block-spring system when the block is moved from a position of $x = 0.00$ m to $x = 0.02$ m ?

(A) Subtract the kinetic energy of the block at $x = 0.02$ m from the kinetic energy of the block at $x = 0.00$ m. ✓

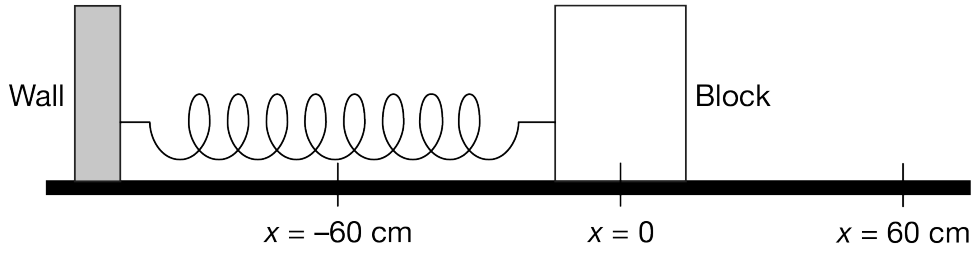
(B) Subtract the kinetic energy of the block at $x = 0.00$ m from the kinetic energy of the block at $x = 0.02$ m.

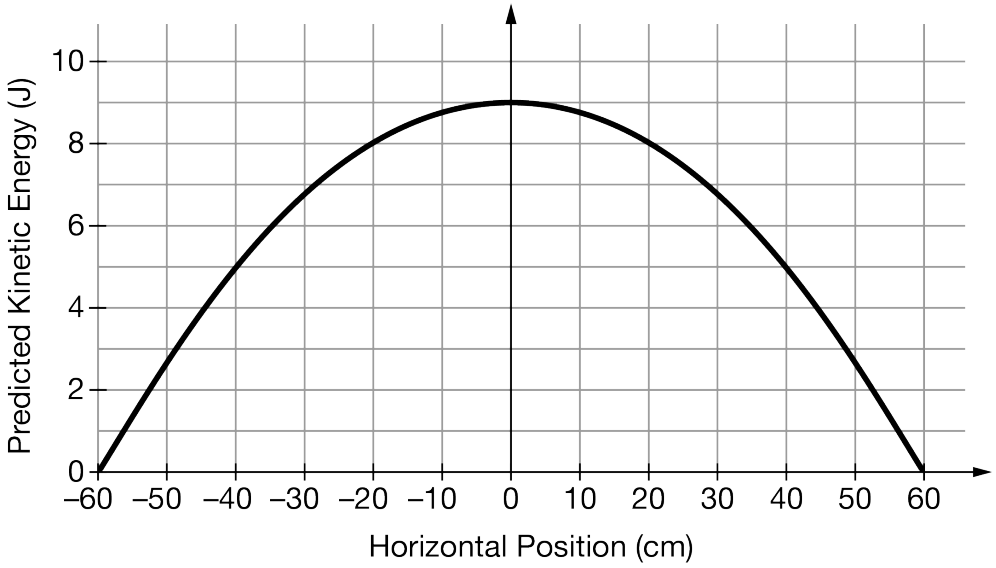
(C) Add the kinetic energy of the block at $x = 0.00$ m to the kinetic energy of the block at $x = 0.02$ m.

(D) The mathematical routines listed cannot be used to make the determination.

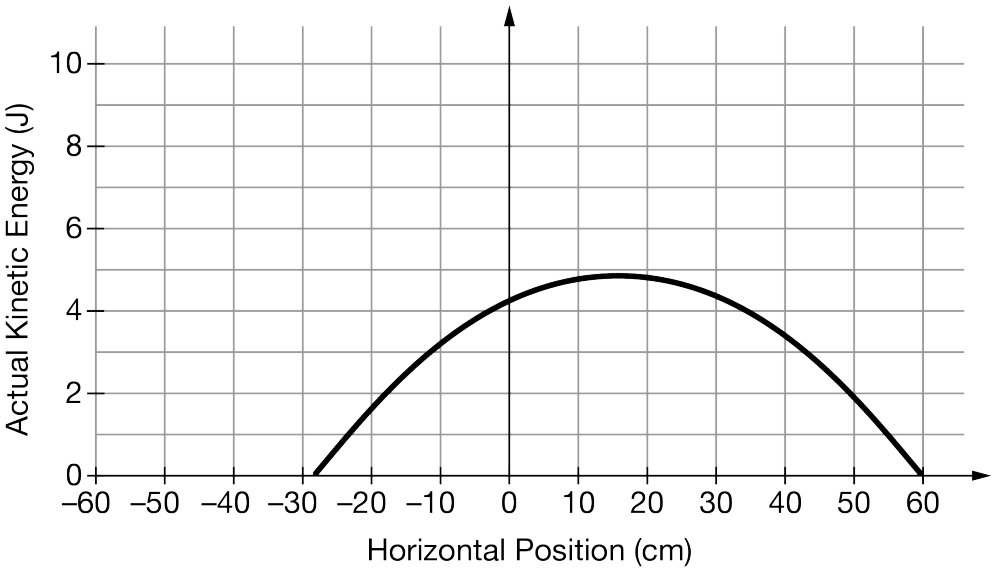
Unit 6 Progress Check: MCQ

15.





Graph 1



Graph 2

Unit 6 Progress Check: MCQ

A block on a horizontal surface is attached to a horizontal spring of spring constant $50\ \mathrm{N/m}$. The other end of the spring is attached to a wall. The block is initially at the equilibrium position of the block-spring system, as shown in the figure. The block is then moved to a position of $x = 60\ \mathrm{cm}$ and released from rest so that the system oscillates. A student predicts the kinetic energy of the block-spring system as a function of the block's horizontal position as shown in Graph 1. When an experiment is conducted, the block does not make a complete oscillation because frictional forces were not considered in the student's prediction. Data is collected about the actual kinetic energy of the block-spring system as a function of the block's horizontal position and is used to create Graph 2.

How can the student use one or both graphs to determine how much mechanical energy is converted to nonmechanical energy from the instant the block is released from rest to the instant that the block is no longer in motion?

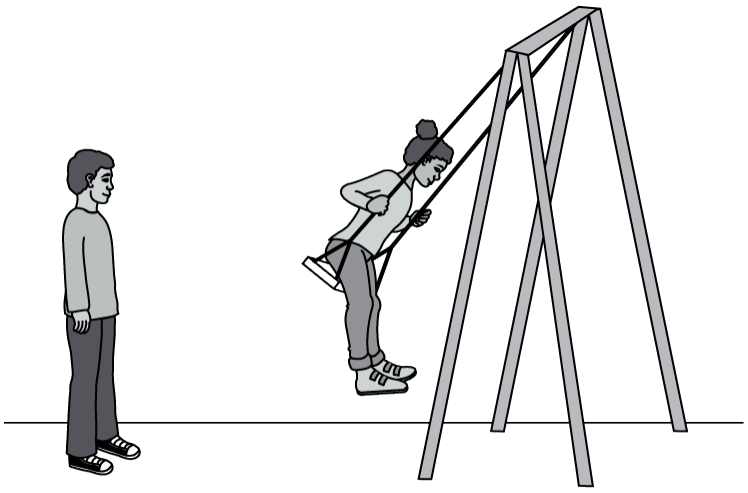
(A) Use Graph 1 to determine the maximum predicted kinetic energy of the block. This is how much energy is removed from the system.

(B) Use Graph 1 to determine the maximum predicted kinetic energy of the block. Subtract the actual kinetic energy of the block at a position of $x = 0\ \mathrm{cm}$.

(C) Use Graph 2 to determine the spring potential energy stored in the system at the instant the block is no longer in motion. Subtract this value from the maximum predicted kinetic energy of the block that can be determined from Graph 1. ✓

(D) The student cannot use the graphs to make this determination, because the student does not know the mass of the block nor the coefficient of friction between the block and the horizontal surface.

16.



Student Y is at rest while sitting on a swing. Student X stands behind student Y and provides an initial applied force on student Y. Student Y's position on the swing then oscillates.

Which of the following claims is correct about student Y?

Unit 6 Progress Check: MCQ

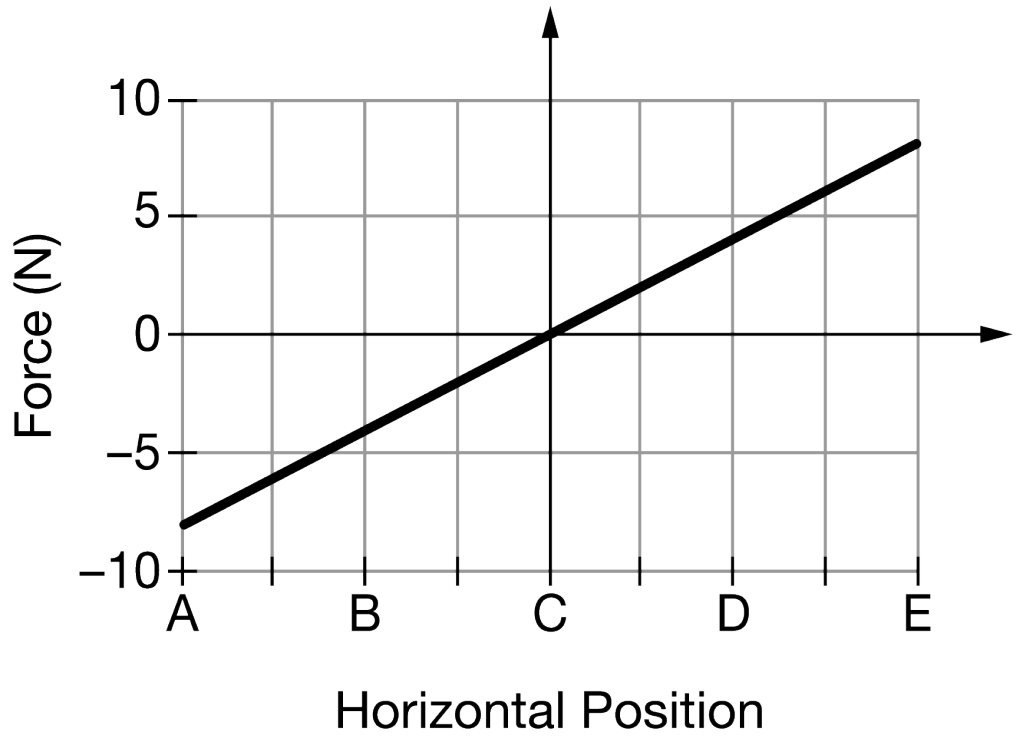
(A) If student X applies a greater force on student Y, the period of oscillation for student Y will decrease compared to the original situation.

(B) If student X applies a greater force on student Y, the frequency of oscillation for student Y will decrease compared to the original situation.

(C) If student X applies a greater force on student Y, the total mechanical energy of the student Y-Earth system will increase compared to the original situation. ✓

(D) If student X applies a greater force on student Y, the maximum gravitational potential energy of the student Y-Earth system will be the same as in the original situation.

17.



A block of mass M on a horizontal surface is attached to a horizontal spring of negligible mass and spring constant $20\ \mathrm{N/m}$. 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 block is pulled to a position beyond the spring's natural length and released from rest, the block experiences simple harmonic motion. A graph of the force exerted on the spring as a function of the block's position is shown.

What is the spring potential energy stored in the spring-block system at position B?

(A) $0.1\ \mathrm{J}$

(B) $0.4\ \mathrm{J}$ ✓

(C) $0.9\ \mathrm{J}$

(D) $1.6\ \mathrm{J}$

Unit 6 Progress Check: MCQ

18. A student attaches a block to a vertical spring so that the block-spring system will oscillate in simple harmonic motion if the system is released from rest at a vertical position that is not the system's equilibrium position. Which of the following explanations is correct about why the system oscillates in simple harmonic motion about the block-spring system's equilibrium position?

(A) The system oscillates in simple harmonic motion because the block's velocity is directly proportional to and opposite in direction to the block's displacement from the system's equilibrium position.

(B) The system oscillates in simple harmonic motion because the block's acceleration is directly proportional to and opposite in direction to the block's displacement from the system's equilibrium position. ✓

(C) The system oscillates in simple harmonic motion because the block's acceleration is directly proportional to and opposite in direction to the block's velocity.

(D) The system oscillates in simple harmonic motion because the net force exerted on the block is directly proportional to and opposite in direction to the block's acceleration.

Unit 6 Progress Check: MCQ

19.

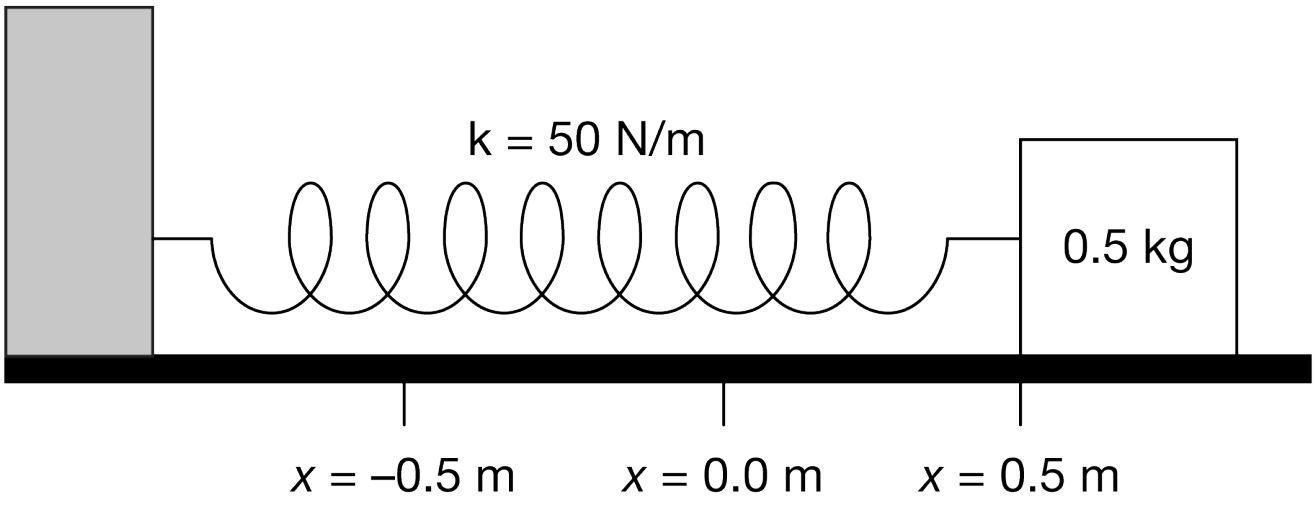


Figure 1

Unit 6 Progress Check: MCQ

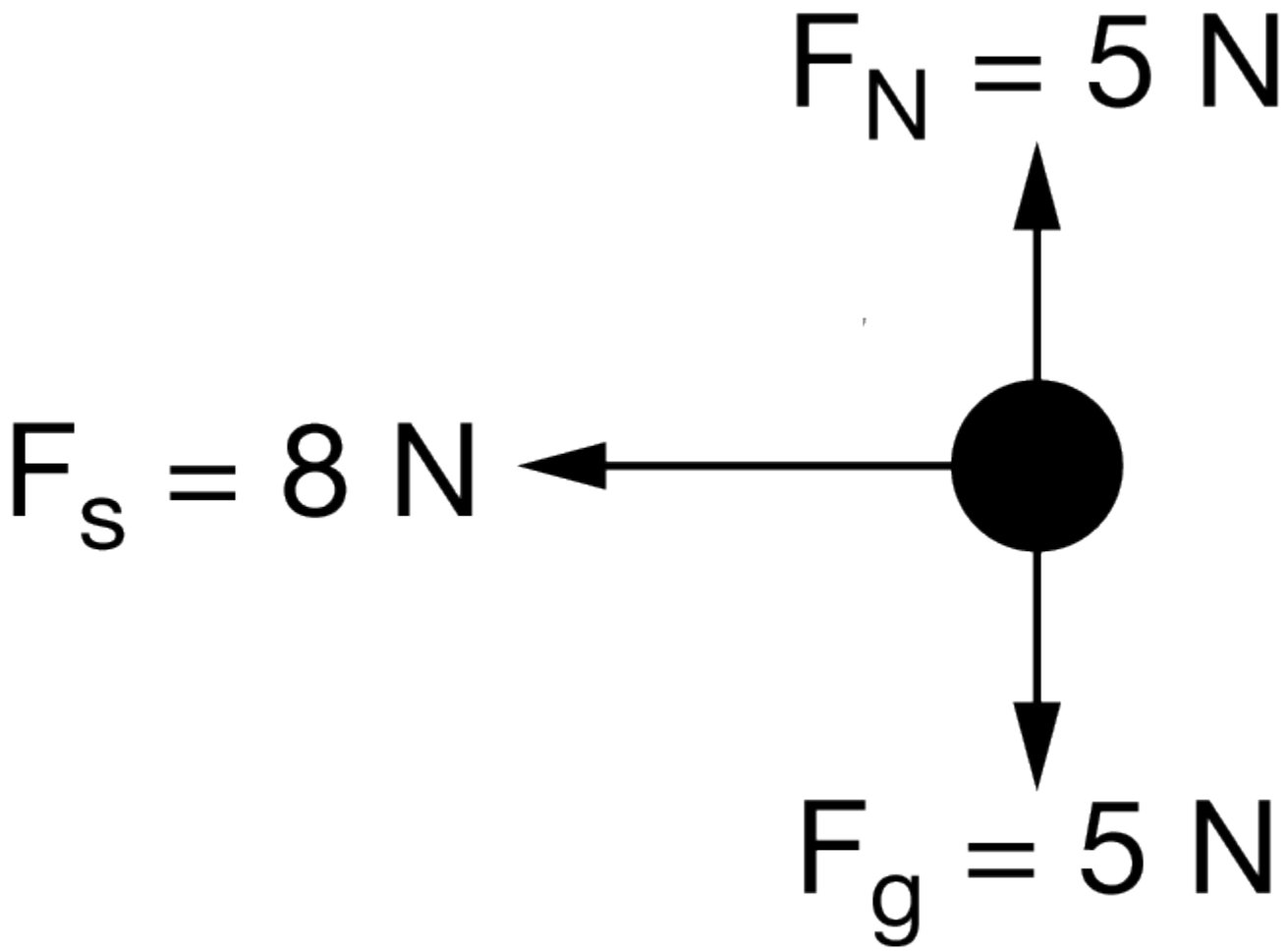


Figure 2

A block of mass 0.5 kg on a horizontal surface is attached to a horizontal spring of negligible mass and spring constant 50 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 $x = 0.0$ m. The block is then pulled to $x = 0.5$ m and released from rest so that the block-spring system oscillates between $x = -0.5$ m and $x = 0.5$ m, as shown in figure 1. A free-body diagram of the object at a particular location is shown in figure 2. Based on the free-body diagram, at which of the following locations could the block be?

(A) At position $x = -0.5$ m

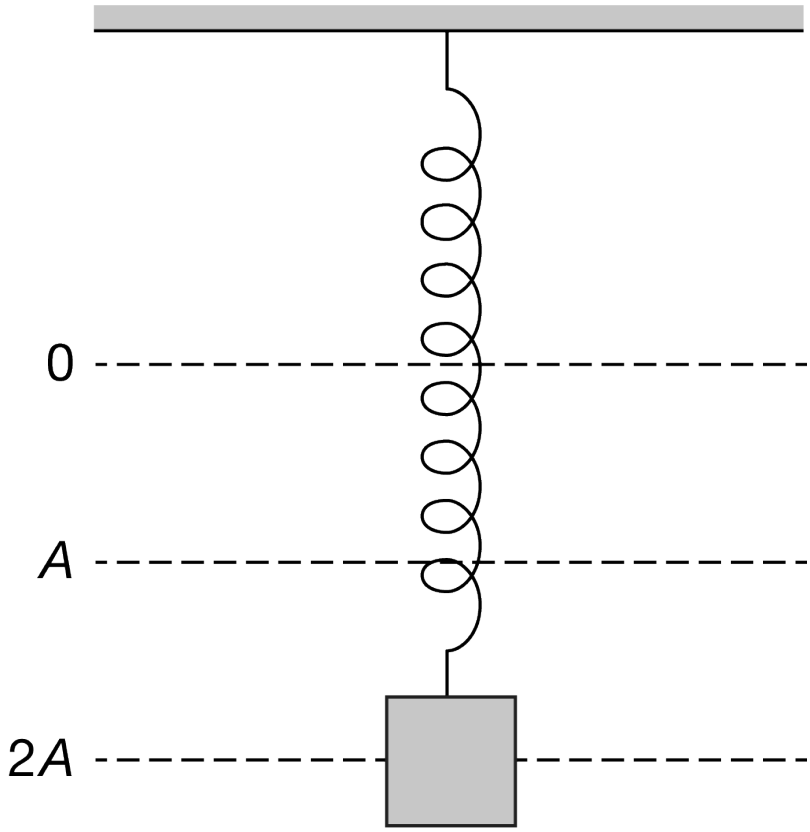
(B) Between positions $x = -0.5$ m and $x = 0.0$ m

(C) Between positions $x = 0.0$ m and $x = 0.5$ m ✓

(D) At position $x = 0.5$ m

Unit 6 Progress Check: MCQ

20.



A block of mass M hangs at rest at the bottom of a stationary spring that stretches a distance A from the spring's unstretched length. The block is then pulled down an additional distance A so the spring is stretched a distance $2A$, as shown in the figure. The block is released from rest, and the center of mass of the block vertically oscillates a displacement of $2A$ from its lowest position to its highest position. The lowest vertical position of the block's center of mass is the location at which the gravitational potential energy of the block-spring-Earth system is zero. Which two of the following claims are correct about the mechanical energy of the system? Select two answers.

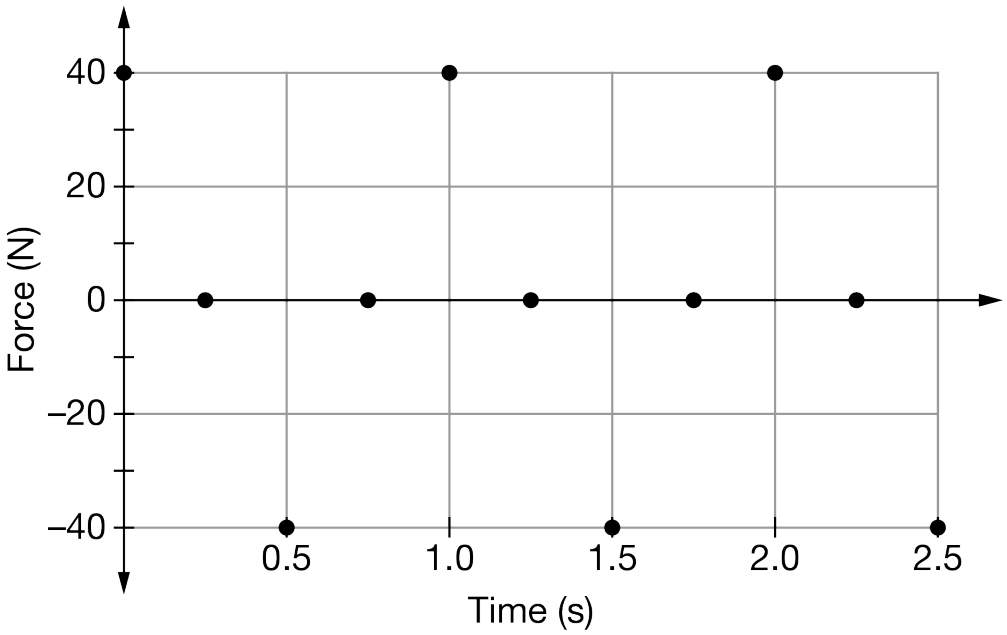
A	At the maximum vertical position of the block's center of mass, the system has spring potential energy and kinetic energy.	
B	The kinetic energy of the block is at its maximum when the spring is stretched a distance A from its unstretched length.	✓
C	The potential energy of the system is at its maximum when spring is stretched a distance $2A$ from its unstretched length.	✓
D	There is at least one vertical position where the system's potential energy is zero.	

21. 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. Which of the following measuring tools, when used together, can be used to determine the spring constant of the spring? Select two answers.

Unit 6 Progress Check: MCQ

A	Meterstick
B	Stopwatch ✓
C	Electronic balance ✓
D	Protractor

22.



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. When the block is pulled to a position beyond the spring's natural length and released from rest, the block experiences simple harmonic motion. A graph of the force exerted on the spring as a function of the block's position is shown. A student collects data such that the force that the spring exerts on the block for every 0.25 s is plotted on the graph that is shown.

Which two of the following claims is correct about the block-spring system during the time in which data were collected? Select two answers.

A	The block has its maximum acceleration at all times $0.5n$, where n is a zero or a whole number. ✓
B	The block has maximum spring potential energy at all times $0.5n$, where n is a zero or a whole number. ✓
C	The block has its maximum speed at all times $0.5n$, where n is a zero or a whole number.
D	The block has its maximum momentum at all times $0.5n$, where n is a zero or a whole number.