Unit 4 Progress Check: MCQ Part B

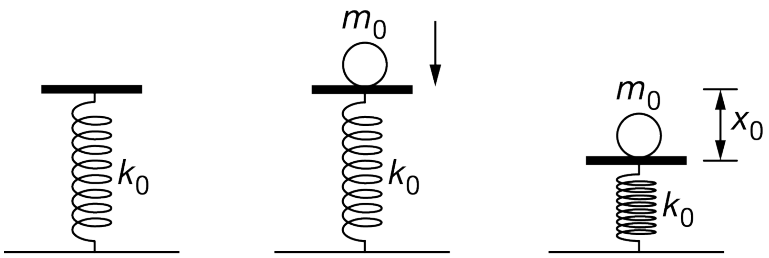

Figure 1 Figure 2 Figure 3

One end of a vertical spring is attached to the ground with the other end above the ground such that the spring is at its equilibrium position. The spring has negligible mass and a spring constant k_0 , as shown in Figure 1. When an object of mass m_0 is released from rest above the spring, the object falls and then makes contact with the top of the spring with a speed v_0 , as shown in Figure 2. The spring then compresses such that the object reaches a position x_0 below the spring's equilibrium position, as shown in Figure 3, where the object comes to rest. The object is then directed upward by the spring until it is no longer in contact with the spring. The object then continues upward. The object-spring-Earth system has zero gravitational potential energy at the instant shown in Figure 2. All frictional forces are considered to be negligible.

1. When the object is located at the position shown in Figure 3, which of the following equations correctly indicates the total mechanical energy of the object-spring-Earth system?

(A) $\frac{1}{2}m_0{v_0}^2 + \frac{1}{2}k_0x_0^2$

(B) $\frac{1}{2}k_0x_0^2$

(C) $\frac{1}{2}k_0x_0^2 + mgx_0$

(D) $\frac{1}{2}k_0x_0^2 - mgx_0$ ✓

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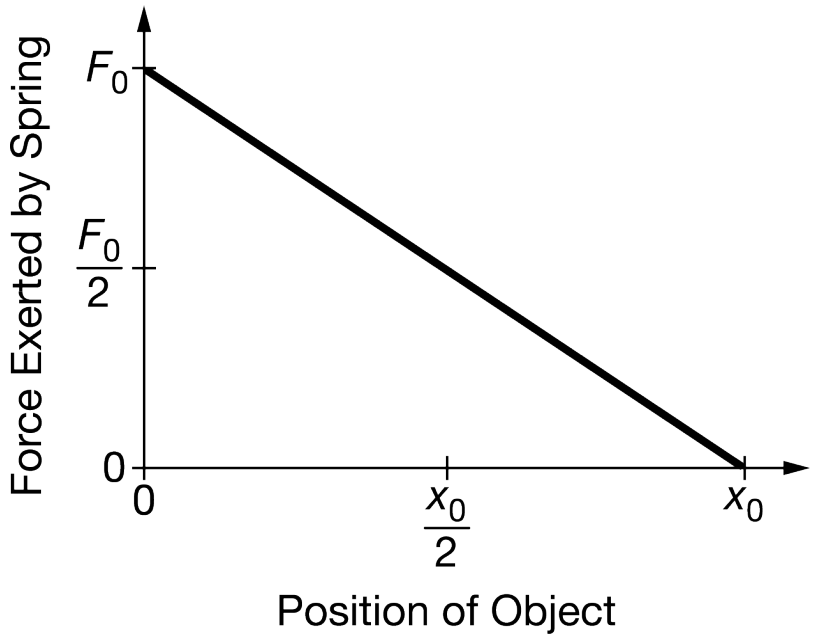
2.



After the object reaches the position in Figure 3, the spring pushes the object upward until the object is no longer in contact with the spring. A graph of the force exerted by the spring on the object as a function of the position of the object is shown. How much work does the spring do on the object as it pushes the object upward until the object is no longer in contact with the spring?

(A) $\frac{F_0 x_0}{2}$ ✓

(B) $F_0 x_0$

(C) $\frac{F_0 x_0}{2} + mgx_0$

(D) $F_0 x_0 + mgx_0$

3. Which of the following describes the total mechanical energy of the object-Earth system during the time in which the object is in the air and the time in which the object is in contact with the spring? Assume all frictional forces are considered to be negligible.

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(A)

In Air	Contact with Spring
constant	constant

(B) ✓

In Air	Contact with Spring
constant	not constant

(C)

In Air	Contact with Spring
not constant	constant

(D)

In Air	Contact with Spring
not constant	not constant

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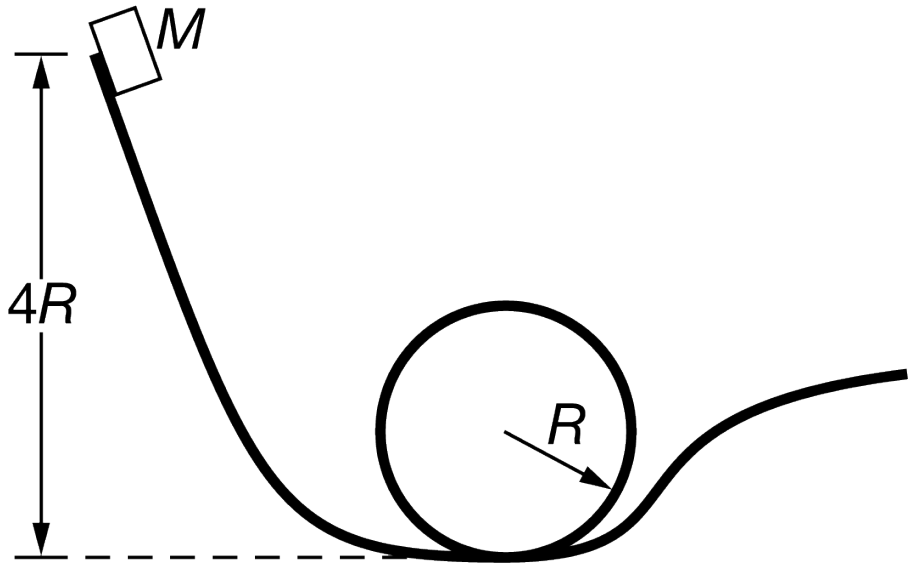
4.



A roller coaster track at a park includes a loop of radius R. A cart of mass M is located at the peak of the track, which has a height of $4R$. The cart is subsequently released from rest such that it can slide down the track and go around the loop, as shown in the figure above. All frictional forces are considered to be negligible. Which of the following expressions for the cart's initial and final kinetic energy KE and the cart-Earth system's initial and final gravitational potential energy U_g could be used to determine the speed v_f of the cart when it reaches the top of the loop?

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(A)

Initial Energy	Final Energy
$U_{g^0} = 4MgR\ KE_0 = 0$	$U_{gf} = MgR\ KE_f = \frac{1}{2}mv^2{}_f$

(B) ✓

Initial Energy	Final Energy
$U_{g^0} = 4MgR\ KE_0 = 0$	$U_{gf} = 2MgR\ KE_f = \frac{1}{2}mv^2{}_f$

(C)

Initial Energy	Final Energy
$U_{g^0} = 2MgR\ KE_0 = 0$	$U_{gf} = 2MgR\ KE_f = \frac{1}{2}mv^2{}_f$

(D)

Initial Energy	Final Energy
$U_{g^0} = 2MgR\ KE_0 = 0$	$U_{gf} = MgR\ KE_f = \frac{1}{2}mv^2{}_f$

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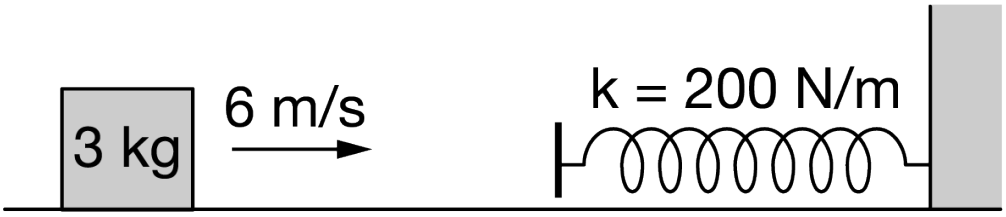
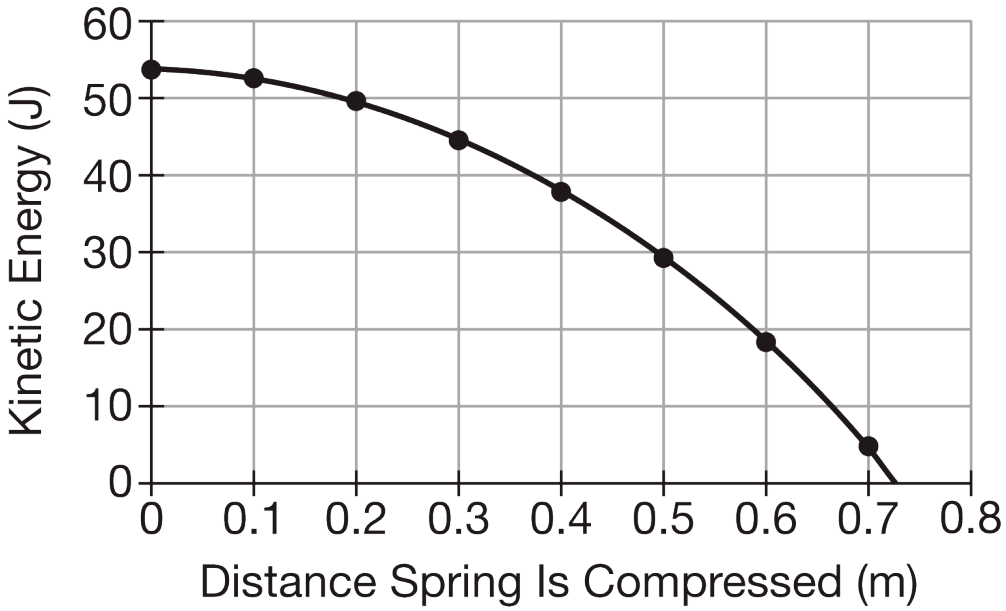
5.





A block of mass $3\ \text{kg}$ on a horizontal surface travels at $6\ \text{m/s}$ toward the free end of a horizontal spring of negligible mass and spring constant $k = 200\ \text{N/m}$, as shown in the figure. 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 comes into contact with the free end of the spring such that the block remains fixed to the spring as the spring is compressed. A graph of the kinetic energy of the block as a function of the distance the spring is compressed is shown that was collected from experimental data. Which of the following data tables could best represent the spring potential energy of the block-spring system as a function of the distance that the spring is compressed?

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(A)

Distance Spring Is Compressed (m)	Spring Potential Energy (J)
0.0	0
0.3	9
0.6	36

(B)

Distance Spring Is Compressed (m)	Spring Potential Energy (J)
0.0	0
0.3	9
0.6	27

(C)

Distance Spring Is Compressed (m)	Spring Potential Energy (J)
0.0	54
0.3	45
0.6	18

(D)

Distance Spring Is Compressed (m)	Spring Potential Energy (J)
0.0	54
0.3	54
0.6	54

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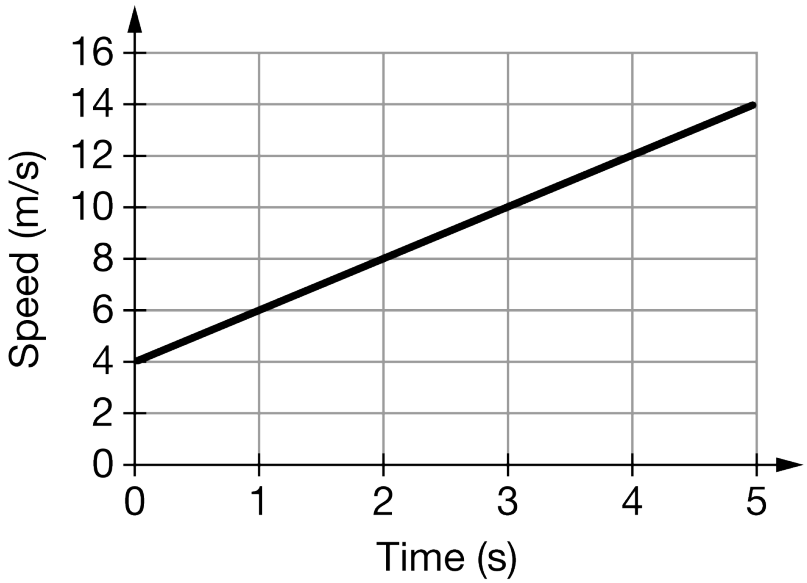
6.



A student uses a motion detector to record the speed of a 2 kg object as a function of time as it travels across a horizontal surface of negligible friction. Data from the experiment are shown in the graph. In addition to the known mass, how can a student use the graph to determine the work done on the object from 0 s to 5 s ?

(A) Use $K = \frac{1}{2}mv^2$ with v equal to the speed of the object at 5 s.

(B) Use $K = \frac{1}{2}mv^2$ with v equal to the average speed of the object.

(C) Use $\Delta K = \frac{1}{2}m\Delta v^2$ with v_0 equal to the speed of the object at 0 s and v_f equal to the speed of the object at 5 s. ✓

(D) A graph of the force exerted on the object as a function of time is required to determine the work done on the object.

7. A student must determine the work done on an object when an external force is exerted on it after it travels a specific distance. An external force F is exerted on an object at position $x = 0$ by a string as the object moves a distance D across a horizontal surface for a time t_{f} . The force changes such that it decreases as the object moves. Which procedure could be used to determine the work done on the object by the external force?

(A) Use a spring scale that is tied to the free end of the string and a stopwatch to measure the force exerted on the object and the corresponding time for several positions until time t_{f} . Graph the force on the vertical axis and the time on the horizontal axis. Determine the area bound by the curve and the horizontal axis.

(B) Use a meterstick and a stopwatch to measure the object's position and the corresponding time for several positions until time t_{f} . Graph the position on the vertical axis and the time on the horizontal axis. Determine the area bound by the curve and the horizontal axis.

(C) Use a motion detector to measure the velocity of the object as a function of time until time t_{f} . Graph the velocity on the vertical axis and the time on the horizontal axis. Determine the area bound by the curve and the horizontal axis.

(D) Use a spring scale that is tied to the free end of the string and a meterstick to measure the force exerted on the object and the corresponding position for several positions until the object travels a distance D . Graph the force on the vertical axis and the position on the horizontal axis. Determine the area bound by the curve and the horizontal axis. ✓

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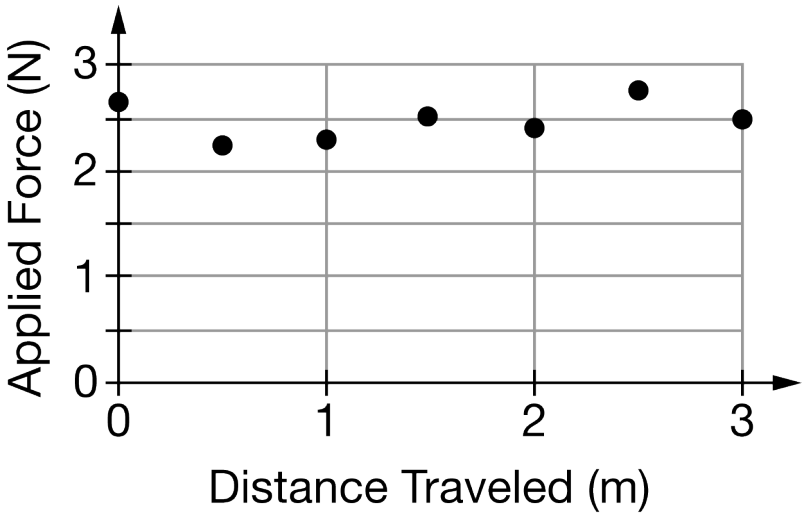
8.



An experiment is conducted such that an applied force is exerted on an object as it travels across a horizontal surface with a constant speed. A graph of the applied force exerted on the object as a function of the object's distance traveled is shown. Which of the following claims is correct regarding the work done on the object by the applied force from one data point to the next data point?

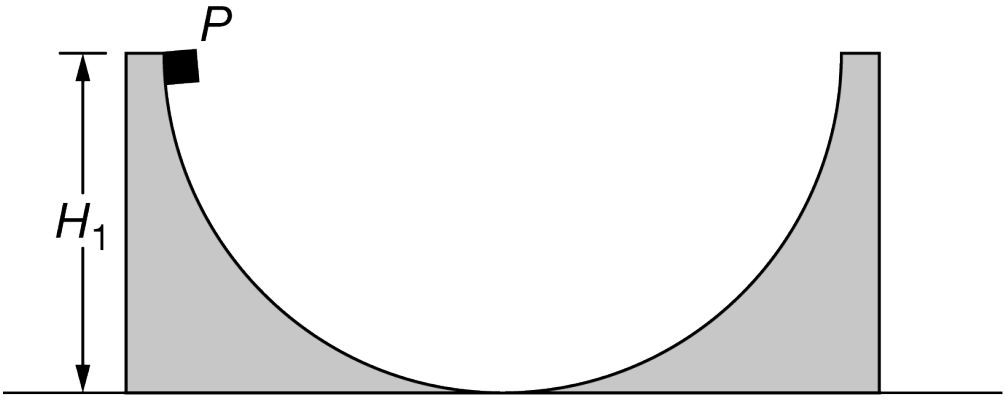
(A) The work done remains nearly constant for all displacements. ✓

(B) The work done increases for all displacements.

(C) The work done decreases for all displacements.

(D) The work done is zero for all displacements because the speed of the object remains constant.

9.



A block of mass M is placed on a semicircular track and released from rest at point P, which is at vertical height H_1 above the track's lowest point. The surfaces of the track and block are considered to be rough such that a coefficient of friction exists between the track and the block. The block slides to a vertical height H_2 on the other side of the track. How does H_2 compare to H_1?

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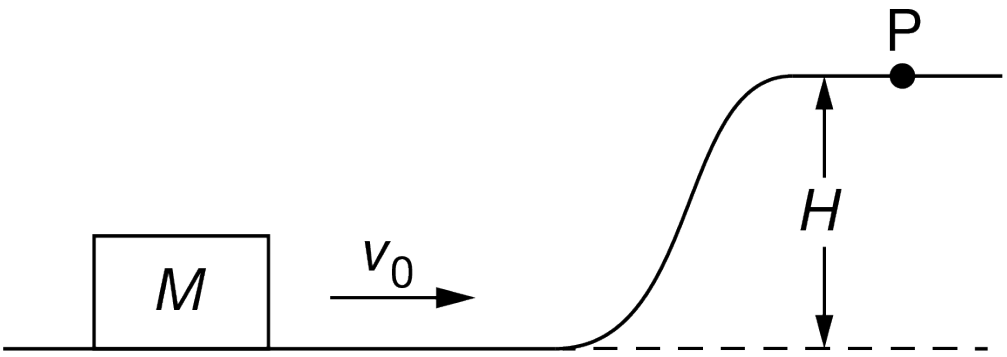
(A) $H_2 = H_1$

(B) $H_2 > H_1$

(C) $H_2 < H_1$ ✓

(D) A determination of how H_2 compares to H_1 cannot be made without knowing the radius of the track.

10.



A block of mass M slides with speed v_0 at the bottom of a ramp of negligible friction that has a height H, as shown. How do the total mechanical energy of the block alone and the total mechanical energy of the block-Earth system change when the block slides up the ramp to point P?

(A)

Mechanical Energy of Block	Mechanical Energy of Block-Earth System
Increases	Remains constant

(B)

Mechanical Energy of Block	Mechanical Energy of Block-Earth System
Increases	Increases

(C) ✓

Mechanical Energy of Block	Mechanical Energy of Block-Earth System
Decreases	Remains constant

(D)

Mechanical Energy of Block	Mechanical Energy of Block-Earth System
Decreases	Increases

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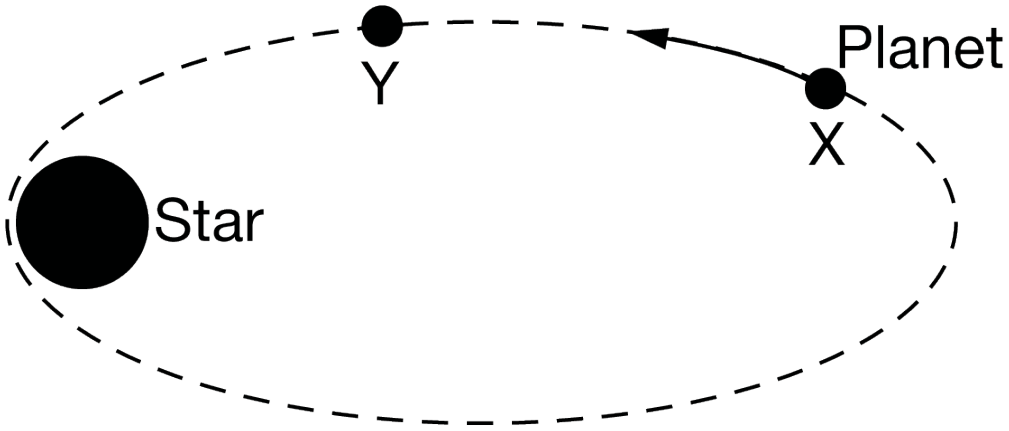
11.



A planet orbits a star along an elliptical path, as shown in the figure. Consider the system consisting of the planet and the star. How do the magnitude of the force exerted on the planet by the star and the total mechanical energy of the system change as the planet moves from point X to point Y?

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(A) ✓

Magnitude of Force Exerted on Planet by Star	Total Mechanical Energy of Planet and Star
Increases	Remains constant

(B)

Magnitude of Force Exerted on Planet by Star	Total Mechanical Energy of Planet and Star
Increases	Increases

(C)

Magnitude of Force Exerted on Planet by Star	Total Mechanical Energy of Planet and Star
Decreases	Remains constant

(D)

Magnitude of Force Exerted on Planet by Star	Total Mechanical Energy of Planet and Star
Decreases	Decreases

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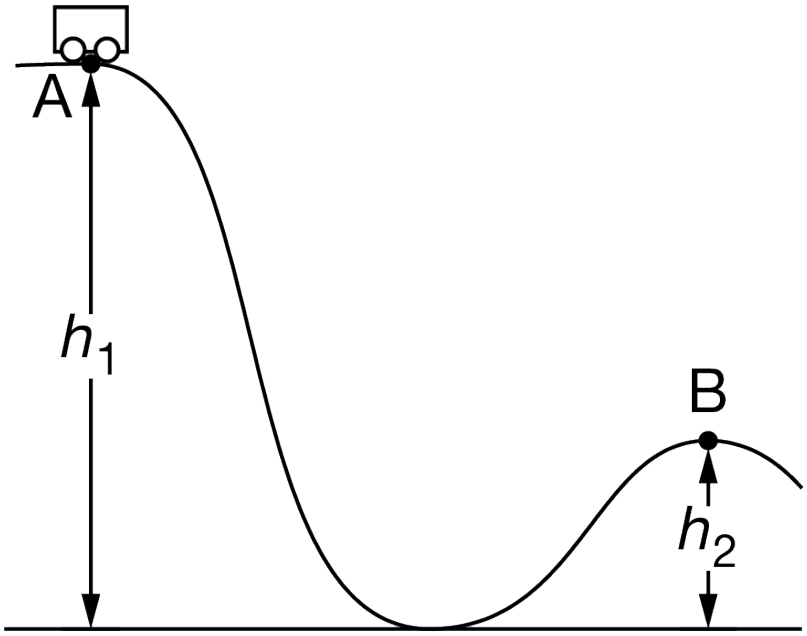
12.



A cart of mass M travels from point A at height h_1 above the ground to point B on a track that is at a height h_2, as shown in the figure. The speed of the cart at point A is nearly zero, and the frictional forces between the wheels, cart, and track are considered to be negligible. Which of the following graphs could represent the potential energy of the cart-Earth system at point A and point B? Select two answers.

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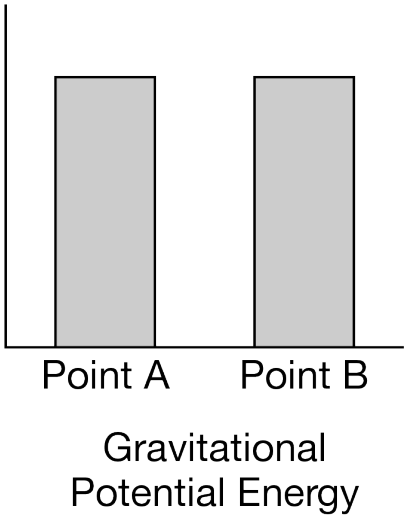
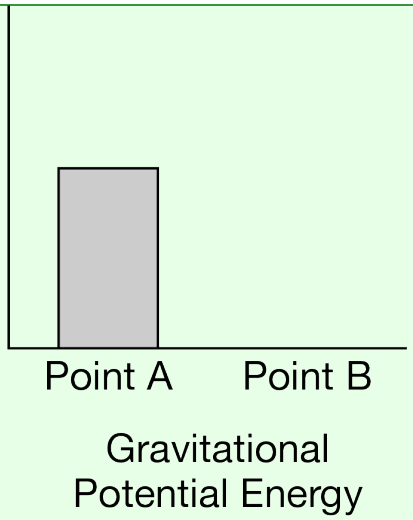
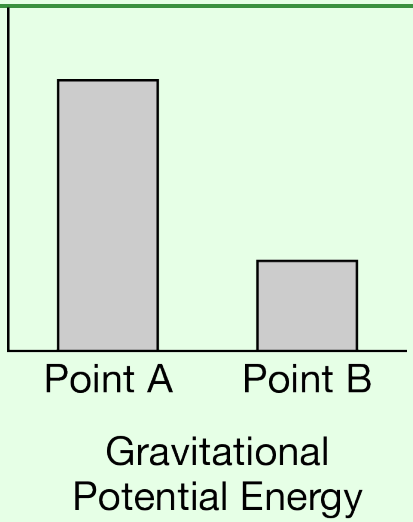
A



B ✓



C ✓



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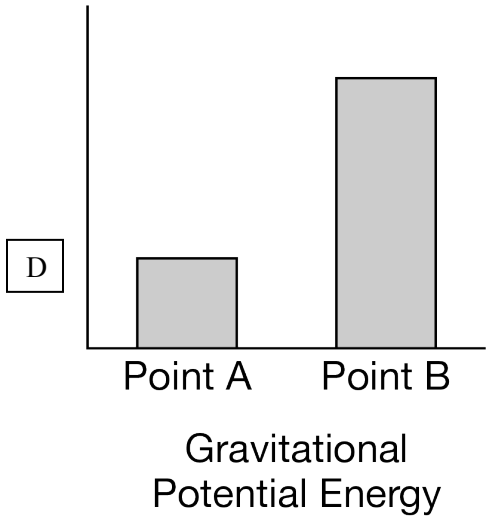
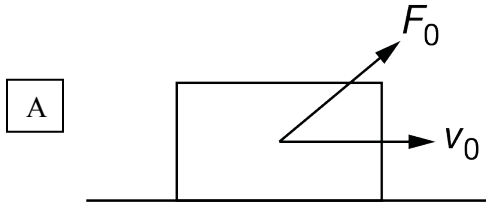
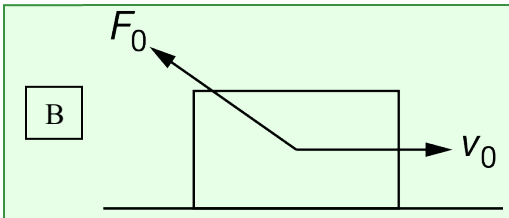
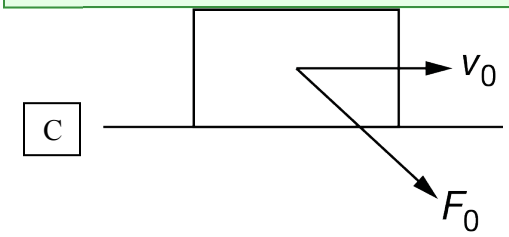
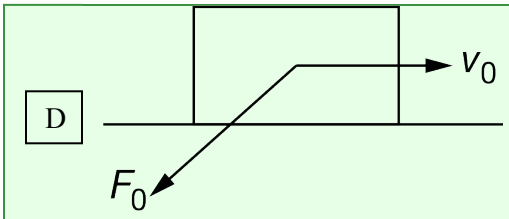


13. A block is initially sliding along a surface of negligible friction with a speed v_0. A constant force F_0 is then exerted on the block. Which of the following figures represents the situations in which the kinetic energy of the block will initially decrease? Select two answers.









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14.

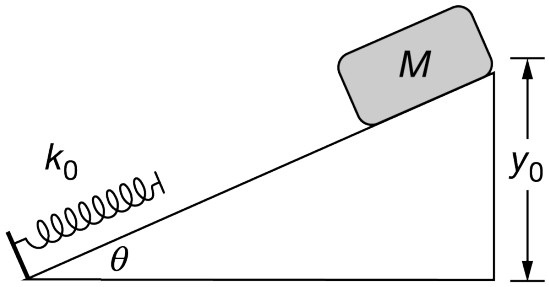

Figure 1

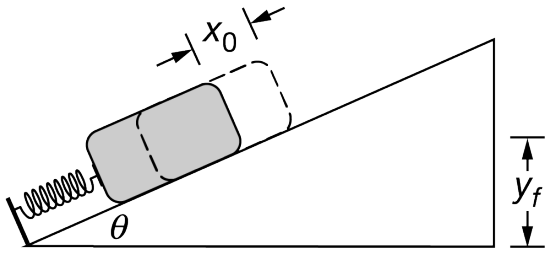

Figure 2

A block of mass M is held at rest on an inclined ramp that can be considered frictionless. The ramp makes an angle θ with the horizontal, as shown in Figure 1. When released, the block slides down the incline and comes into contact with an uncompressed spring with spring constant k_0 . The block slides an additional distance x_0 before it compresses the spring a maximum distance, as shown in Figure 2. A student wants to use the law of conservation of energy to analyze the energies associated with the block-ramp-spring-Earth system. Which of the following equations should the student use to analyze the specific forms of energy in the system from the instant the block is released to the instant that the spring is at its maximum compression? Select two answers.

A ✓ $mg(y_0 - y_f) = \frac{1}{2}kx_0^2$, because the initial gravitational potential energy of the system is converted into spring potential energy.

B ✓ $mgy_0 = mgy_f + \frac{1}{2}kx_0^2$, because some of the initial gravitational potential energy of the system is converted into spring potential energy.

C $mgy_0 = mgy_f + \frac{1}{2}kx_0^2 + \frac{1}{2}mv_f^2$, because some of the initial gravitational potential energy of the system is converted into the kinetic energy of the block and some of the initial gravitational potential energy of the system is converted into spring potential energy.

D $mgy_0 = \frac{1}{2}kx_0^2 + \frac{1}{2}mv_f^2$, because the initial gravitational potential energy of the system is converted into the kinetic energy of the block and into spring potential energy.

15. A student must perform an experiment to determine the work done by a spring as it launches a block across a horizontal surface. The spring is initially compressed and the block is initially held at rest. After the spring is uncompressed, the block is no longer in contact with the spring. The spring constant is unknown, and the student may not use the mass or weight of the block in the experiment for any calculation. Which of the following measuring tools, when used together, can be used to determine the work done by the spring on the block? Select two answers.

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A meterstick ✓

B motion detector

C stopwatch

D force sensor ✓

16.

Applied Force (N)	Distance Traveled (m)	Speed of Object $(\mathrm{m/s})$
10	1	1.0
10	2	1.4
10	3	1.7

A student performs an experiment in which an applied force is exerted on a $4\ \mathrm{kg}$ object that is initially at rest. In the experiment, the applied force is exerted on the object until the object has moved a known distance. In all the experiments the applied force is exerted in the direction of motion. A motion detector measures the speed of the object after it has traveled the distance under consideration for a given trial. The table contains the data that were collected for three trials of the experiment. Which of the following conclusions can be drawn from the data? Select two answers.

A The net work done on the object is the product of the applied force and the distance traveled for each trial.

B The total mechanical energy after a given trial is equal to the kinetic energy of the object at the end of the experiment. ✓

C The change in the kinetic energy of the block from when it was at rest to the moment in which its final speed is measured is equal to the work done by the applied force on the object.

D Another external force must have done work on the object because the final kinetic energy of the object is less than the work done on the object by the applied force. ✓