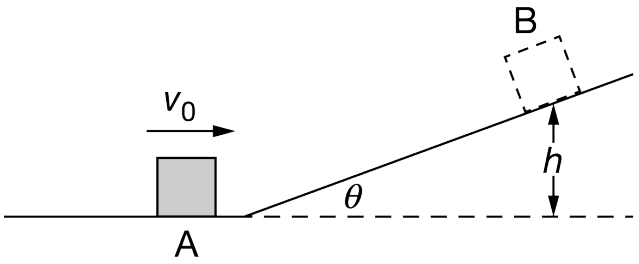
Unit 4 Progress Check: MCQ Part A



Data Table

θ	h (cm)
20°	3.2
30°	3.7
45°	4.2

A student must determine the effect of friction on the mechanical energy of a small block as it slides up a ramp. The block is launched with an initial speed v_0 from point A along a horizontal surface of negligible friction. It then slides up a ramp, where friction is not negligible, that is inclined at angle θ with respect to the horizontal, as shown in the figure. The student measures the maximum vertical height h attained by the block while on the ramp, labeled as point B in the figure. At point B, the block comes to rest. The student performs three trials with the ramp at different angles, launching the block at the same initial speed v_0 for each trial. The results from the trials are displayed in the table.

1. How should the student use the data collected and the known quantities from the experiment to determine the initial total mechanical energy of the block-ramp-Earth system for all trials in the experiment?

(A) Use $\Delta E = W = F_{||}d$ for all trials because the block traveled a different distance up the ramp in each trial.

(B) Use $\Delta U_g = mg\Delta y$ for all trials because the block reaches a different height above the ground in each trial.

(C) Use $W_{F_f} = U_{g_f}$ for one trial because the same amount of work was done by the force of friction in each trial.

(D) Use $K = \frac{1}{2}mv^2$ with the block's initial speed for one trial because the initial speed is the same in all trials.

2. Consider the trial with the 45° ramp. Suppose the block is launched up the ramp such that it comes to rest at point B and then travels down the ramp. Which of the following best describes the block's kinetic energy K_A when it again reaches point A at the bottom of the ramp in comparison to the initial kinetic energy K_0 before it travels up the ramp?

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(A) $K_A > K_0$, because the object will have a higher speed at the bottom of the ramp after sliding down the ramp than its original launch speed.

(B) $K_A < K_0$, because the force of friction removes mechanical energy from the block-ramp-Earth system on its way up the ramp and back down the ramp.

(C) $K_A = K_0$, because the law of the conservation of energy states that mechanical energy must be conserved for a closed system.

(D) It is impossible to predict how the kinetic energy of the block at point A will compare to the original kinetic energy without knowing the magnitude of the force of friction that is exerted on the block as it travels up and back down the ramp.

3. Consider the trial in which the ramp is at a 20° angle with the horizontal. The surface of the ramp has been replaced with a surface in which frictional forces are considered to be negligible. If the mass of the block is doubled and the initial launch speed is doubled, how could the student predict the new vertical of the block at point B?

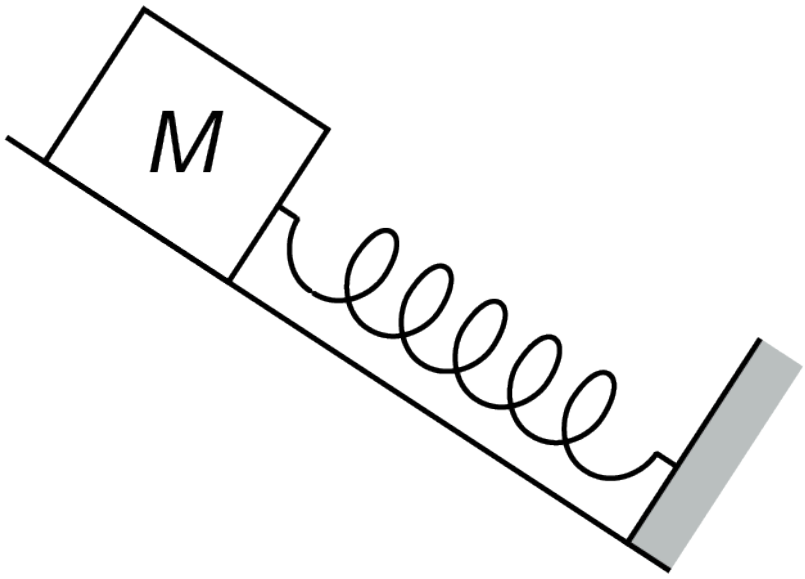
(A) Use $W_{Gravity} = \Delta K = \frac{1}{2}m\Delta v^2$ because the work done by gravity is equal to the change in kinetic energy of the block from the bottom of the ramp to point B.

(B) Use $\frac{1}{2}mv_{initial}^2 = mgy_{final}$ to solve for y_f.

(C) The height will still be $3.2\ \text{cm}$ because the angle of the ramp is constant and the increase in the block's speed is offset by the increase in the block's mass.

(D) The height cannot be predicted without knowing the mass of the block.

4.



A block of mass M on an inclined surface is attached to a spring of negligible mass, as shown. The other end of the spring is attached to a wall, and there is negligible friction between the block and the incline. The block is pulled to a position such that the spring is stretched from its equilibrium position. The block is then released from rest. Which of the following systems can be classified as a closed system?

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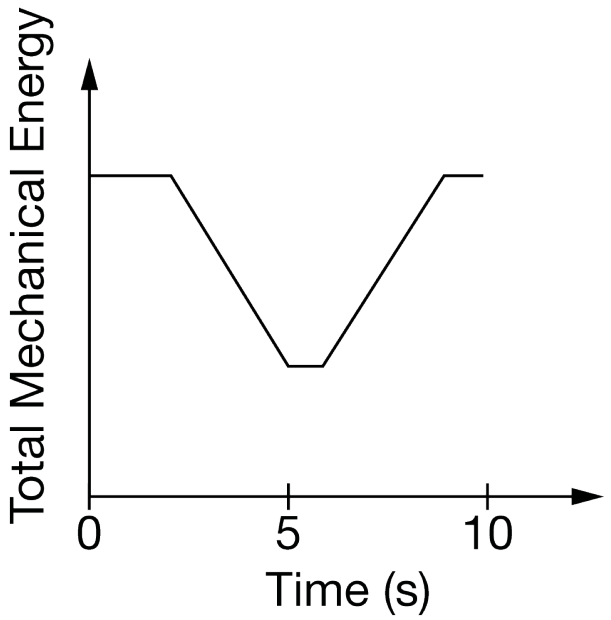
(A) A system consisting of the block only

(B) A system consisting of the spring and Earth

(C) A system consisting of the block and spring

(D) A system consisting of the block, spring, and Earth

5.



The total mechanical energy of a system as a function of time is shown in the graph. Which of the following statements is true regarding the system?

(A) The system should be classified as a closed system because the total mechanical energy lost from $t = 3\,\text{s}$ to $t = 5\,\text{s}$ was gained from $t = 6\,\text{s}$ to $t = 9\,\text{s}$.

(B) The system should be classified as an open system because mechanical energy can be added and removed from the system.

(C) The system should be classified as an open system because the curve in the graph is symmetrical.

(D) The system should be classified as a closed system because the system's total mechanical energy does not change from $t = 0\,\text{s}$ to $\text{t} = 10\,\text{s}$.

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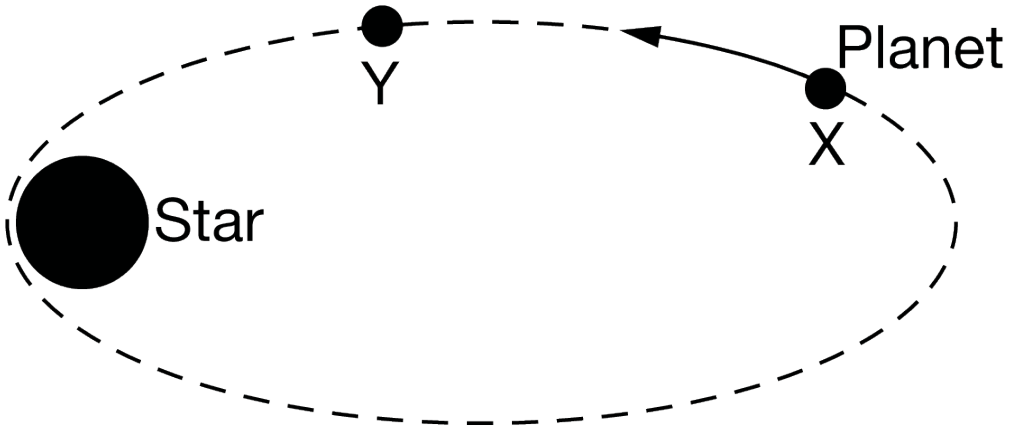
6.



A planet orbits a star along an elliptical path from point X to point Y, as shown in the figure. In which of the following systems does the total mechanical energy of the system remain constant?

(A) The open system containing the planet

(B) The open system containing the planet and the star

(C) The closed system containing the planet

(D) The closed system containing the planet and the star

7. A $5\ \mathrm{kg}$ object near Earth's surface is released from rest such that it falls a distance of $10\ \mathrm{m}$. After the object falls $10\ \mathrm{m}$, it has a speed of $12\ \mathrm{m/s}$. Which of the following correctly identifies whether the object-Earth system is open or closed and describes the net external force?

(A) The system is closed, and the net external force is zero.

(B) The system is open, and the net external force is zero.

(C) The system is closed, and the net external force is nonzero.

(D) The system is open, and the net external force is nonzero.

8. A toy car has an initial acceleration of $2\ \mathrm{m/s^2}$ across a horizontal surface after it is released from rest. After the car travels for a time $t = 5$ seconds, the speed of the car is $25\ \mathrm{m/s}$. Is the system consisting of only the car an open system or a closed system, and why?

(A) Open system, because the acceleration of the car is not constant.

(B) Open system, because an external force is applied to the car that causes it to accelerate.

(C) Closed system, because the speed of the car is as expected in the case where an object has uniform acceleration for a time t.

(D) Closed system, because mechanical energy was not removed from the system as a result of a net force.

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9.

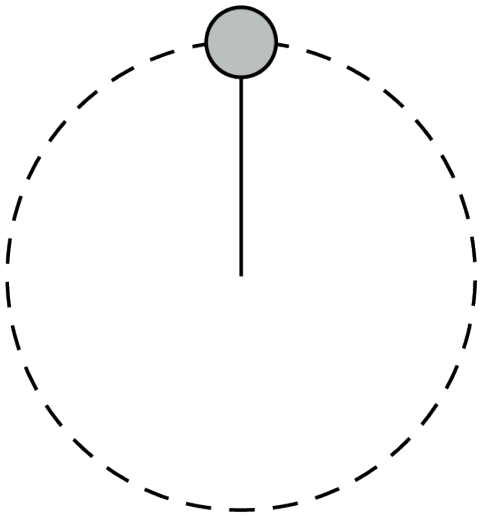

Figure 1.
Top View

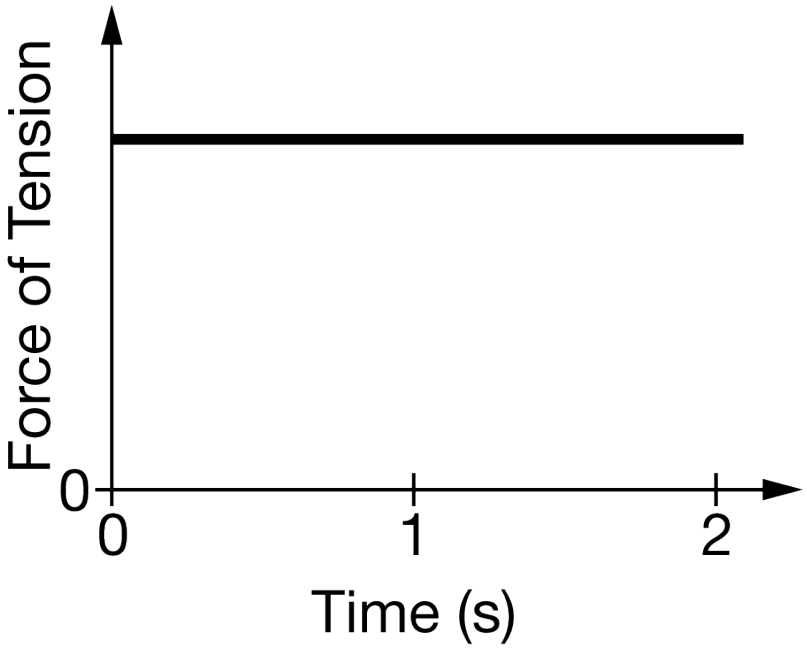

Figure 2

A student performs an experiment in which a ball travels in a perfect circle. The ball is attached to a string and travels in the horizontal, circular path, as shown in Figure 1. At time t_0, the ball has a speed v_0. During the time

interval of 0 s to 2 s, the force of tension in the string is recorded and graphed, as shown in Figure 2. Is the system consisting of the ball, string, and student an open system or closed system, and why?

(A) Open system, because a net centripetal force of tension is exerted on the ball that changes the direction of the ball.

(B) Open system, because the force due to gravity from Earth is an external force that is exerted on the ball-string-student system

(C) Closed system, because the force of tension remains constant and does not change the tangential speed of the ball as it travels in its circular path

(D) Closed system, because the ball travels in a closed circular path

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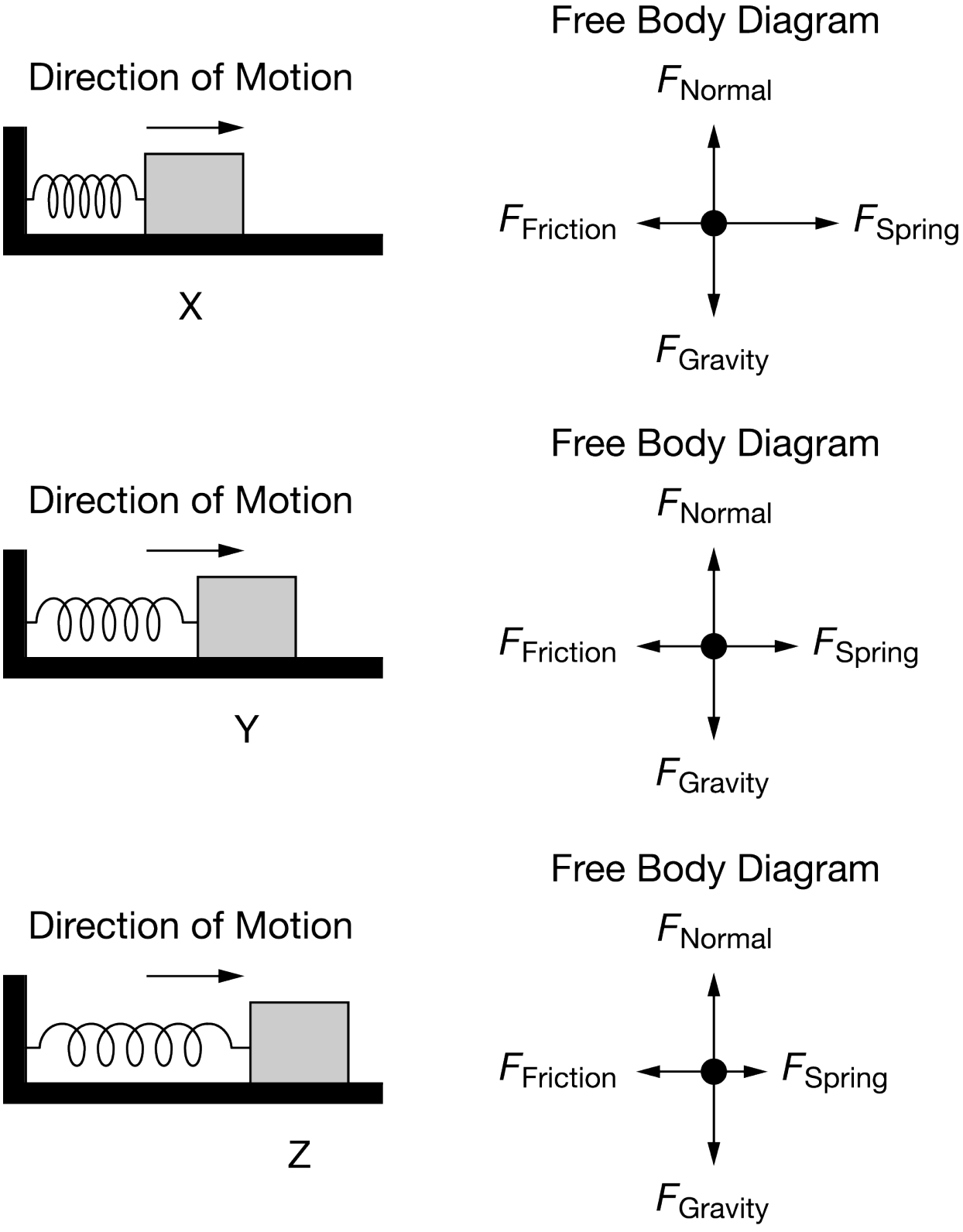
10.



A block on a rough, horizontal surface is attached to a horizontal spring of negligible mass. The other end of the spring is attached to a wall. The spring is compressed such that the block is located at position X. When the block-

spring system is released, the block travels to the right through position Y and continues to travel to the right through position Z. Free body diagrams for the block at positions X, Y, and Z are shown in the figure. At which position does the block have the greatest kinetic energy?

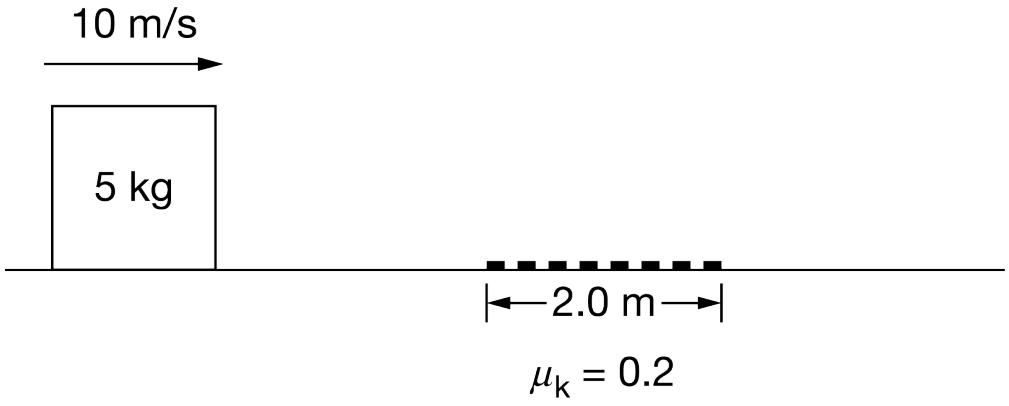
(A) X

(B) Y

(C) Z

(D) The answer cannot be determined without knowing the exact speed of the block at each position.

11.



A $5\ \mathrm{kg}$ block moves with a constant speed of $10\ \frac{\mathrm{m}}{\mathrm{s}}$ to the right on a smooth surface where frictional forces are considered to be negligible. It passes through a $2.0\ \mathrm{m}$ rough section of the surface where friction is not negligible, and the coefficient of kinetic friction between the block and the rough section μ_k is 0.2. What is the change in the kinetic energy of the block as it passes through the rough section?

(A) $20\ \mathrm{J}$ of energy is removed from the block.

(B) $250\ \mathrm{J}$ of energy is removed from the block.

(C) $20\ \mathrm{J}$ of energy is added to the block.

(D) $250\ \mathrm{J}$ of energy is added to the block.

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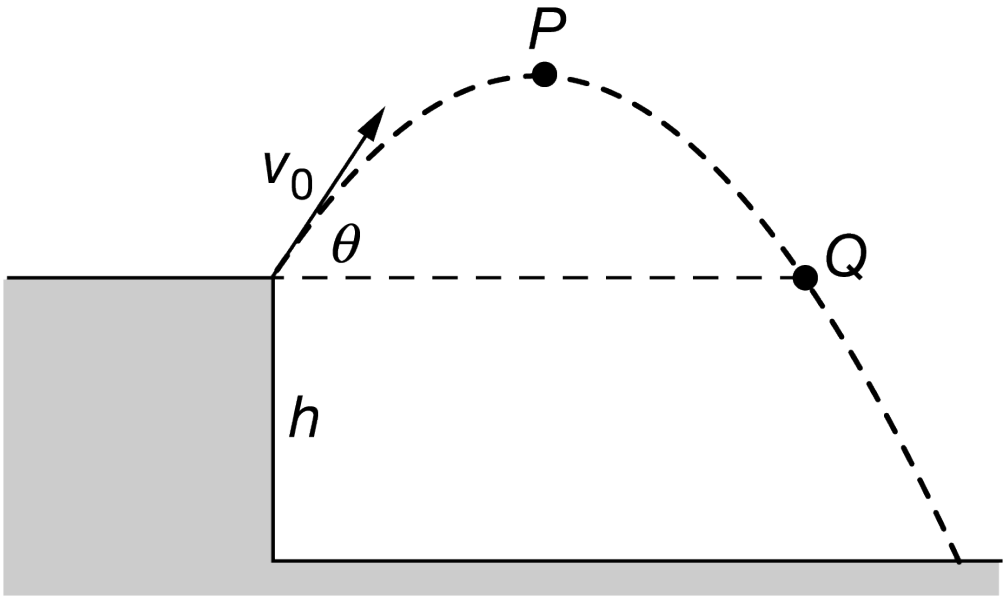
12.



A rock of mass M is thrown from the edge of a cliff of height h with an initial velocity v_0 at an angle θ with the horizontal, as shown in the figure. Point P is the highest point in the rock's trajectory, and point Q is level with the initial position of the rock. All frictional forces are considered to be negligible. Which of the following could correctly describe the total energy of the rock-Earth system at points P and Q?

(A)

Point P	Point Q
0	$\frac{1}{2}Mv_0^2$

(B)

Point P	Point Q
Mgh	$Mgh+\frac{1}{2}Mv_0^2$

(C)

Point P	Point Q
$Mgh+\frac{1}{2}Mv_0^2$	$Mgh+\frac{1}{2}Mv_0^2$

(D)

Point P	Point Q
0	$Mgh+\frac{1}{2}Mv_0^2$

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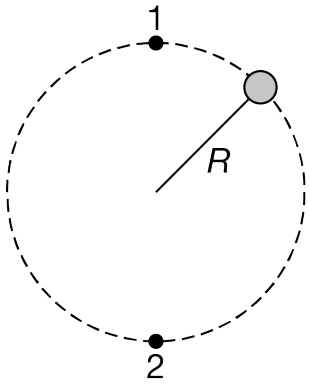
13.



A ball of mass M is attached to a string of negligible mass that has a length R. The ball moves clockwise in a vertical circle, as shown above. Which of the following is true about the ball-string-Earth system as the ball moves from point 1 to point 2?

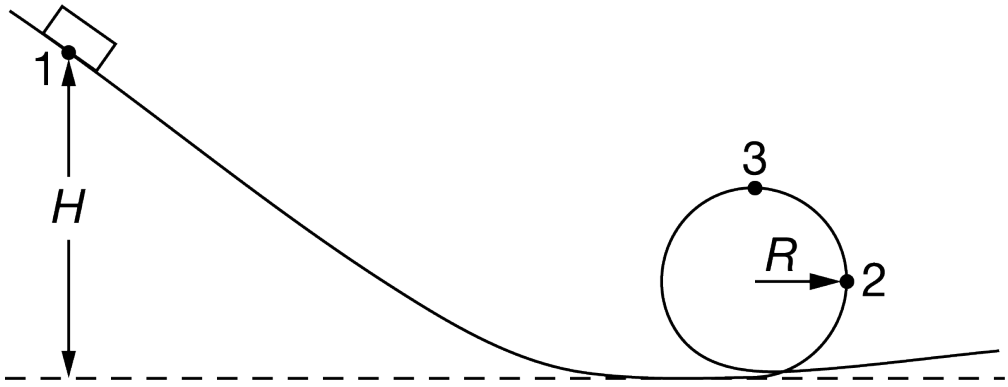
(A) The potential energy decreases by MgR and the tension in the string increases by $2Mg$.

(B) The potential energy decreases by MgR and the tension in the string increases by more than $2Mg$.

(C) The potential energy decreases by $2MgR$ and the tension in the string increases by $2Mg$.

(D) The potential energy decreases by $2MgR$ and the tension in the string increases by more than $2Mg$.

14.



A small block of mass $M = 0.10\,\text{kg}$ is released from rest at point 1 at a height $H = 1.8\,\text{m}$ above the bottom of a track, as shown in the diagram. It slides down the track and around the inside of a loop of radius $R = 0.6\,\text{m}$. The speed of the block is $2.5\,\text{m/s}$ at point 3. Which of the following claims about the situation is correct?

(A) The gravitational potential energy of the block-Earth system at point 3 is less than the gravitational potential energy at point 2.

(B) The kinetic energy of the block at point 3 is greater than the kinetic energy of the block at point 2.

(C) The mechanical energy of the block-Earth system at point 3 is less than the mechanical energy of the block-Earth system at point 1.

(D) The mechanical energy of the block-Earth system at point 2 is equal to the gravitational potential energy of the block-Earth system at point 1.

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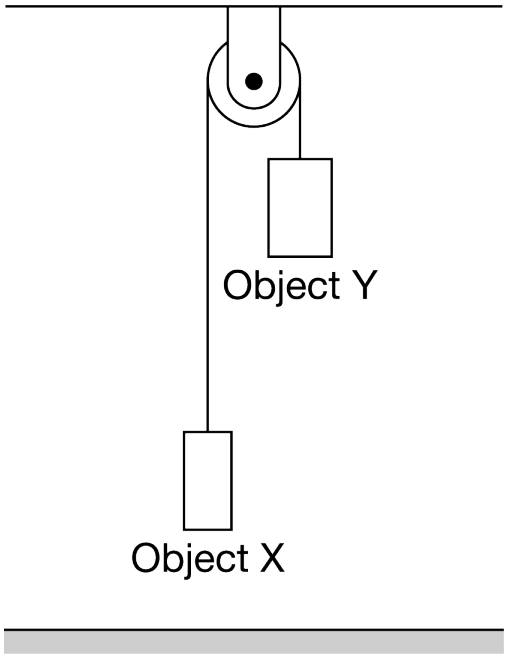
15.



Objects X and Y are connected by a string of negligible mass and suspended vertically over a pulley of negligible mass, creating an Atwood's machine, as shown in the figure. The objects are initially at rest, and the mass of object Y is greater than the mass of object X. As object Y falls, how does the kinetic energy of the center of mass of the two-object system change? Justify your selection. All frictional forces are considered to be negligible.

(A) The kinetic energy increases because the gravitational force due to Earth does positive net work on the system.

(B) The kinetic energy increases because the gravitational force due to Earth does negative net work on the system.

(C) The kinetic energy decreases because the gravitational force due to Earth does positive net work on the system.

(D) The kinetic energy decreases because the gravitational force due to Earth does negative net work on the system.

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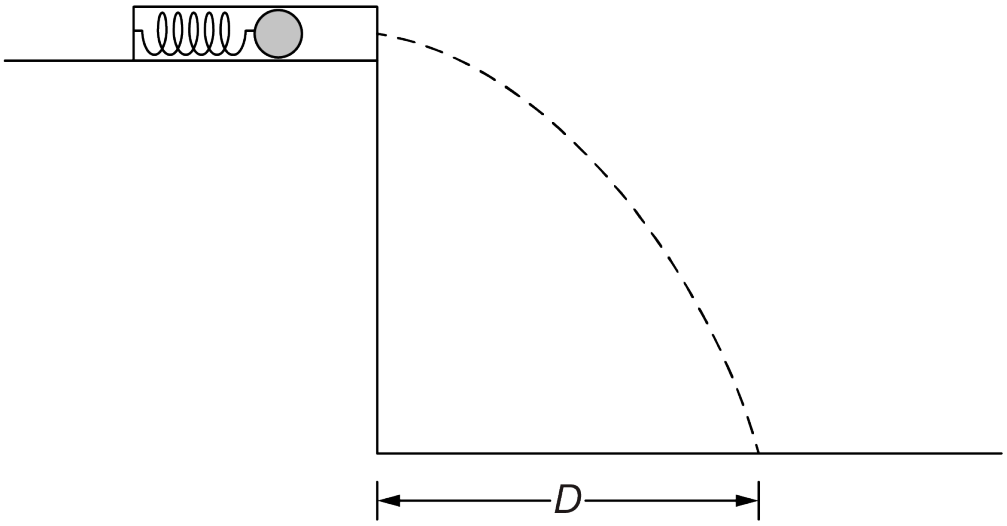
16.



A small object of mass M is shot horizontally from a spring launcher that is attached to a table. All frictional forces are considered to be negligible. The ball strikes the ground a distance D from the base of the table, as shown in the figure. A second object of mass $\frac{M}{2}$ is launched from the same launcher such that the spring is compressed the same distance as in the original scenario. The distance from the base of the table that the object lands is

(A) greater than $\frac{D}{2}$ but less than D

(B) D

(C) greater than D but less than $2D$

(D) greater than or equal to $2D$.