CHAPTER4PARTA

1.

Cart Mass (kg)	Applied Force (N)	Time Force is Exerted (s)	Final Momentum $\left(\text{kg} \cdot \frac{\text{m}}{\text{s}}\right)$	Final Kinetic Energy (J)
1	5	2	10	50
2	5	2	10	

Two frictionless lab carts start from rest and are pushed along a level surface by a constant force. Students measure the magnitude and duration of the force on each cart, as shown in the partially completed data table above, and calculate final kinetic energy and momentum. Which cart has a greater kinetic energy at the end of the push?

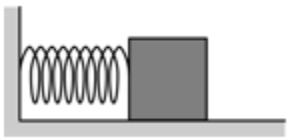
(A) The $1\ \text{kg}$ cart

(B) The $2\ \text{kg}$ cart

(C) Both carts have the same amount of kinetic energy.

(D) The relationship cannot be determined without knowing the distance each cart moved as the force was being applied.

2.



A block on a horizontal surface of negligible friction is placed in contact with an ideal spring, as shown above. The block is moved to the left so that the spring is compressed a distance x from equilibrium and then released from rest. The block has kinetic energy K_1 when it separates from the spring. When the spring is compressed a distance $2x$ and the block is released from rest, the kinetic energy of the block when it separates from the spring is

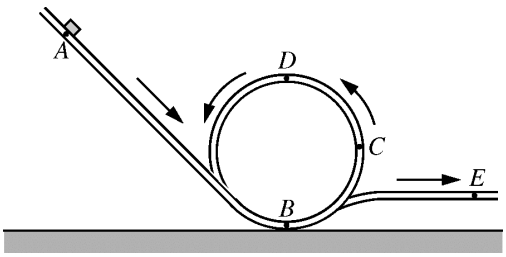
(A) $K_1/2$

(B) K_1

(C) $\sqrt{2K_1}$

(D) $2K_1$

(E) $4K_1$



A block released from rest at position A slides with negligible friction down an inclined track, around a vertical loop, and then along a horizontal portion of the track, as shown above. The block never leaves the track.

CHAPTER4PARTA

3. After the block is released, in which of the following sequences of positions is the speed of the block ordered from fastest to slowest?

(A) *B C D E*

(B) *B E C D*

(C) *D C E B*

(D) *E B C D*

(E) *E D C B*

4. The gravitational potential energy and the kinetic energy of the block are most nearly equal at which position? (Consider the potential energy to be zero at position *B*.)

(A) *A*

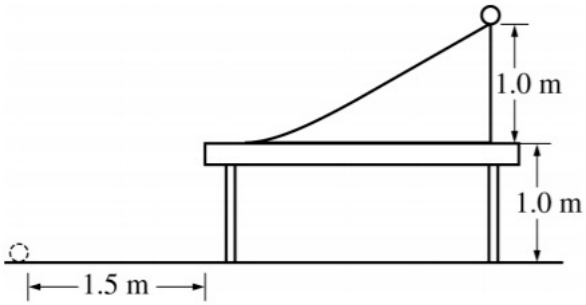
(B) *B*

(C) *C*

(D) *D*

(E) *E*

Questions 12-14 refer to the following material.



A cylinder at rest is released from the top of a ramp, as shown above. The ramp is 1.0 m high, and the cylinder rolls down the ramp without slipping. At the bottom of the ramp, the cylinder makes a smooth transition to a small section of a horizontal table and then travels over the edge at a height of 1.0 m above the floor, eventually landing on the floor at a horizontal distance of 1.5 m from the table.

5. After the cylinder leaves the table, but before it lands, how do the rotational kinetic energy and translational kinetic energy of the cylinder change, if at all?

CHAPTER4PARTA

(A)

Rotational Kinetic Energy	Translational Kinetic Energy
Increases	Increases

(B)

Rotational Kinetic Energy	Translational Kinetic Energy
Increases	Stays the same

(C)

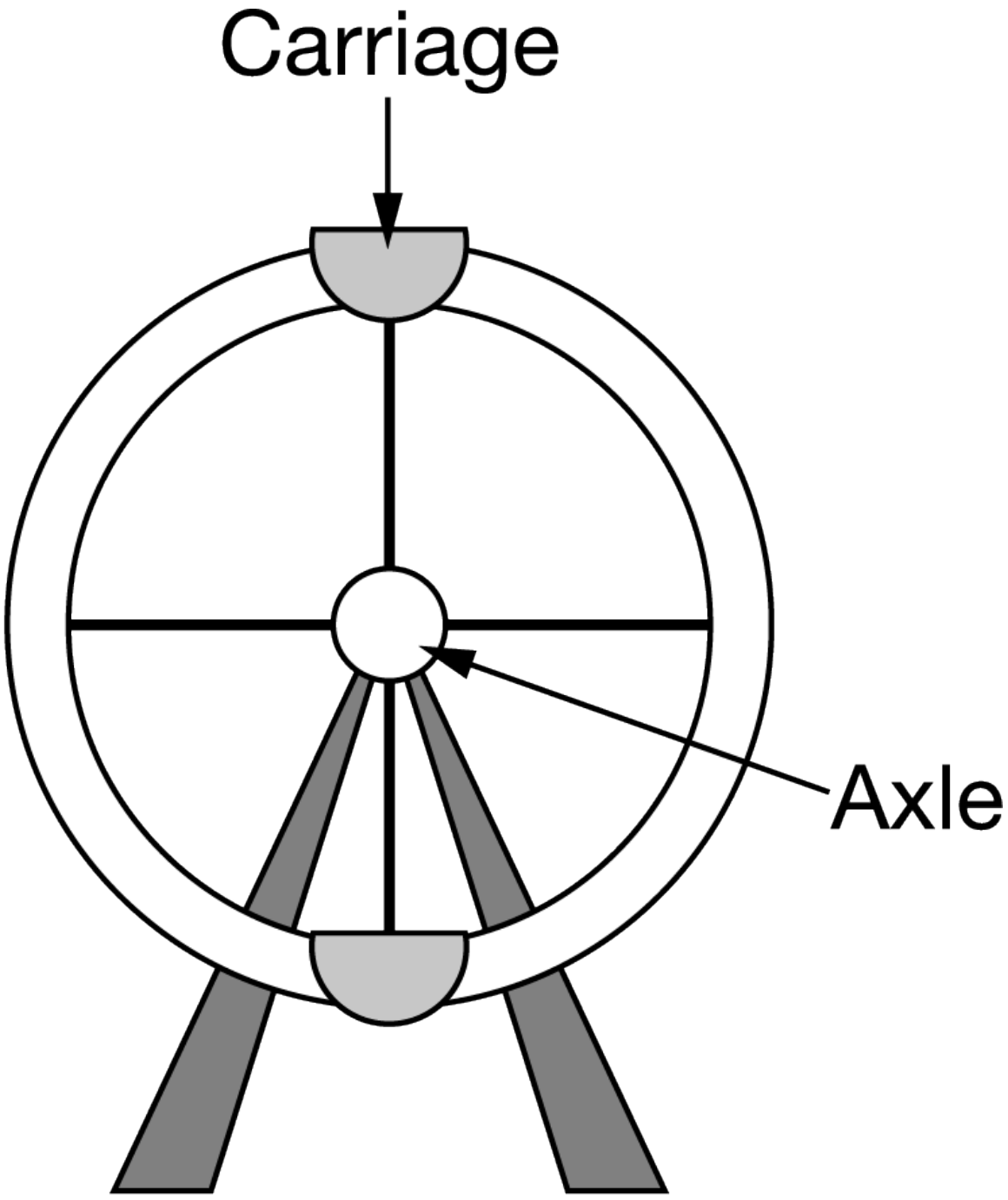
Rotational Kinetic Energy	Translational Kinetic Energy
Stays the same	Increases

(D)

Rotational Kinetic Energy	Translational Kinetic Energy
Stays the same	Stays the same

CHAPTER4PARTA

6.

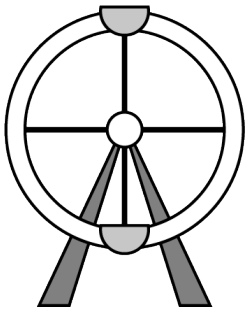


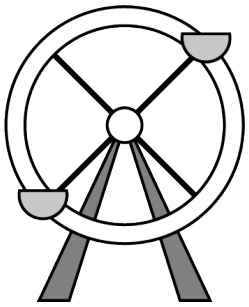
Amusement Park Ride

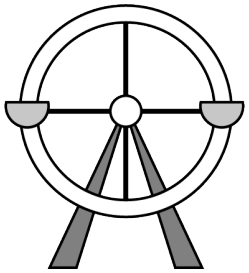
An amusement park ride has two identical carriages that revolve around the center of the ride's axle, as shown in the figure. Both carts travel at a constant tangential speed at all points along the circular path. At what position is the

CHAPTER4PARTA

total mechanical energy of the cart-cart-Earth system at its maximum value?

(A) 

(B) 

(C) 

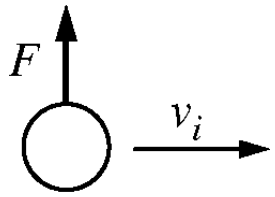
(D) The total energy of the Earth-Ferris wheel ride is constant.

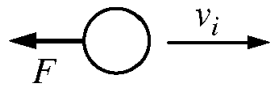
7. An apple is released from rest 500 m above the ground. Due to the combined forces of air resistance and gravity, it has a speed of 40 m s when it reaches the ground. What percentage of the initial mechanical energy of the apple-Earth system was dissipated due to air resistance? Take the potential energy of the apple-Earth system to be zero when the apple reaches the ground.

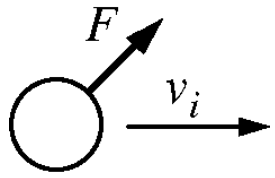
(A) 16%
(B) 40%
(C) 60%
(D) 84%

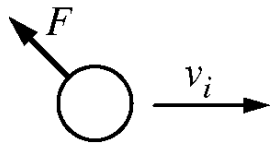
8. An object is moving to the right with speed v_i when a force of magnitude F is exerted on it. In which of the following situations is the object's direction of motion changing and kinetic energy decreasing at the instant shown?

CHAPTER4PARTA

(A) 

(B) 

(C) 

(D) 

9. A person holds a book at rest a few feet above a table. The person then lowers the book at a slow constant speed and places it on the table. Which of the following accurately describes the change in the total mechanical energy of the Earth-book system?

(A) The total mechanical energy is unchanged, because there is no change in the book's kinetic energy as it is lowered to the table.

(B) The total mechanical energy is unchanged, because no work is done on the Earth-book system while the book is lowered.

(C) The total mechanical energy decreases, because the person does positive work on the book by exerting a force that opposes the gravitational force.

(D) The total mechanical energy decreases, because the person does negative work on the book by exerting a force on the book in the direction opposite to its displacement.

10. A rubber ball with mass 0.20 kg is dropped vertically from a height of 1.5 m above a floor. The ball bounces off of the floor, and during the bounce 0.60 J of energy is dissipated. What is the maximum height of the ball after the bounce?

(A) 0.30 m

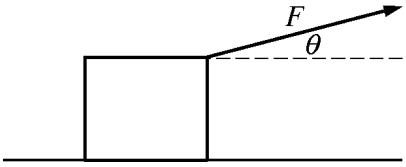
(B) 0.90 m

(C) 1.2 m

(D) 1.5 m

CHAPTER4PARTA

Refer to the following material for answering group of questions.



A crate is on a horizontal frictionless surface. A force of magnitude F is exerted on the crate at an angle θ to the horizontal, as shown in the figure above, causing the crate to slide to the right. The surface exerts a normal force of magnitude F_N on the crate. As the crate slides a distance d, it gains an amount of kinetic energy ΔK. While F is kept constant, the angle θ is now doubled but is still less than 90^o. Assume the crate remains in contact with the surface.

11. As the crate slides a distance d, how does the new gain in kinetic energy compare to ΔK?

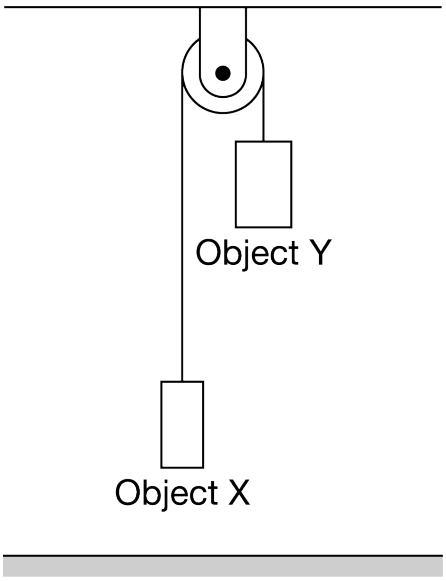
(A) The new gain is greater than ΔK.

(B) The new gain is less than ΔK

(C) The new gain is equal to ΔK.

(D) The new gain is greater or less than ΔK depending on the value of θ

12.



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 gravitational potential energy of the Object X-Object Y-Earth system change? All frictional forces are considered to be negligible.

CHAPTER4PARTA

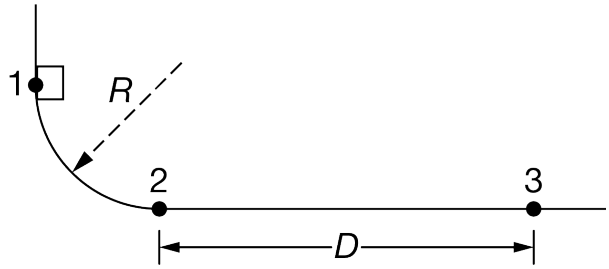
(A) The gravitational potential energy increases because the center of mass of Object X and Object Y moves upward.

(B) The gravitational potential energy increases because the center of mass of Object X and Object Y moves downward.

(C) The gravitational potential energy decreases because the center of mass of Object X and Object Y moves upward.

(D) The gravitational potential energy decreases because the center of mass of Object X and Object Y moves downward.

13.



A block of mass M is released from rest at point 1, as shown in the figure. The block slides without frictional forces along the circular arc but encounters frictional forces as soon as it reaches the horizontal portion of the track at point 2. The block travels a distance D along the horizontal track before coming to rest at point 3. Consider the block-Earth system. In terms of the mechanical energy of the system, which of the following claims is correct, and why?

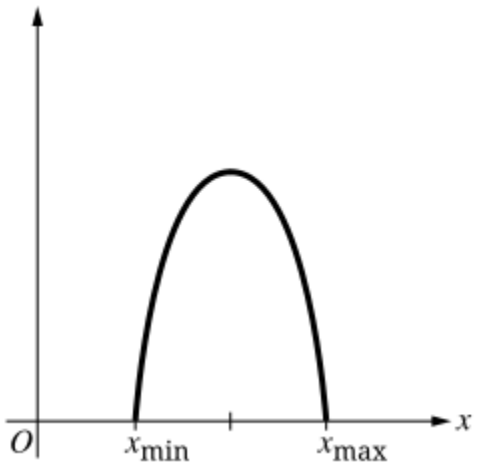
(A) The system is open, because there is a net force exerted on the block.

(B) The system is open, because the block's velocity is zero at points 1 and 3.

(C) The system is closed, because there is a net force exerted on the block.

(D) The system is closed, because the block's velocity is zero at points 1 and 3.

14.



A block attached to a spring oscillates between two positions, $x_{\min}$ and $x_{\max}$, on a horizontal surface. The graph shown plots a quantity as a function of the position of the block. Which of the following quantities when plotted on the vertical axis would result in the graph shown?

CHAPTER4PARTA

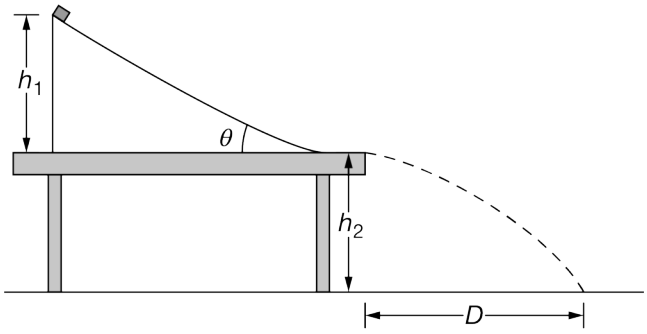
(A) The kinetic energy of the spring-block system

(B) The magnitude of the force exerted by the spring on the block

(C) The potential energy of the spring-block system

(D) The total mechanical energy of the spring-block system

15.



An inclined track is secured to a table. The height of the highest point of the track above the tabletop is h_1. The height from the tabletop to the floor is h_2. A block of mass M is released from rest and slides down the track such that all frictional forces are considered to be negligible. The block leaves the track horizontally and strikes the ground at a distance D from the edge of the track as shown. Which of the following statements is correct about the scenario? Select two answers.

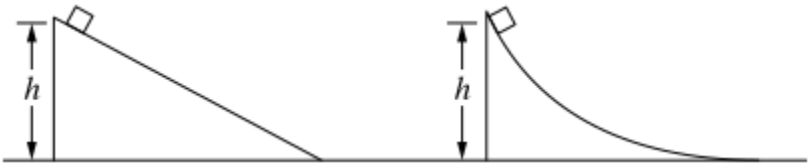
A If the block is released from a height $2h_1$, the block will land at a distance $2D$ away from the end of the track.

B If the block's mass is increased to $2M$, the block will land at a distance $2D$ away from the edge of the track.

C The total mechanical energy of the system containing only the block increases from the moment of release to the moment it strikes the ground.

D The total mechanical energy of the block-Earth system remains constant.

16.



The figure shows two identical blocks held at height h near the top of two different ramps. The blocks are simultaneously released from rest and slide down the ramps with negligible friction. Which of the following quantities must be equal for both blocks? Select two answers.

A The speed of each block at the bottom of the ramp

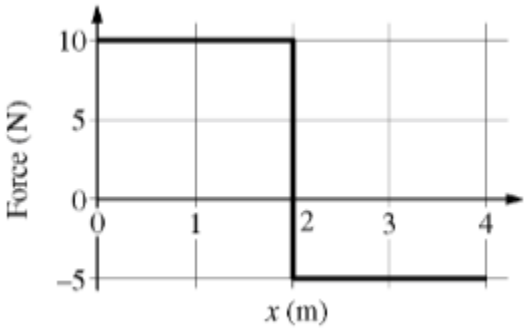
B The time needed for each block to reach the bottom of the ramp

C The work done by the gravitational force on each block as the blocks slide down the ramp

D The magnitude of the average acceleration of each block as the blocks slide down the ramp

CHAPTER4PARTA

17.



A cart is moving on a level track in the positive x-direction. A force acting parallel to the x-axis is exerted on the cart. The graph above shows the net force exerted on the cart as a function of displacement. As the cart travels from $x = 0$ m to $x = 4$ m , what is the net change in the kinetic energy of the cart?

(A) An increase of 20 J

(B) An increase of 10 J

(C) A decrease of 20 J

(D) A decrease of 10 J

18. A string is used to pull a block up a ramp such that the block travels with a constant speed while remaining in contact with the ramp. Frictional forces are nonnegligible. Which of the following statements correctly predicts how the absolute value of the work done by gravity W_g on the block compares to the absolute value of the work done by the string W_s on the block as the block travels up the ramp?

(A) $W_g > W_s$, because the block remains entirely in contact with the ramp due to the gravitational force.

(B) $W_g > W_s$, because the block travels in a direction that has horizontal and vertical components.

(C) $W_g < W_s$, because the work done on the block by Earth is zero.

(D) $W_g < W_s$, because mechanical energy is dissipated by friction.

CHAPTER4PARTA

19.

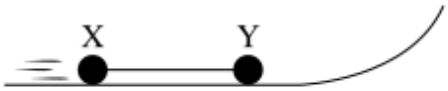


Figure 1

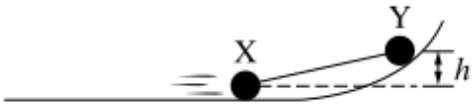


Figure 2

Sphere X and Sphere Y, each of mass m_0, are connected by a rigid rod of negligible mass. The two-sphere system slides with speed v_0 across a horizontal surface toward a curved ramp, as shown in Figure 1. When Sphere Y reaches a height of h, Sphere X is still on the horizontal surface, as shown in Figure 2. Frictional forces are negligible. What is the total kinetic energy of the two-sphere system at the instant shown in Figure 2 ?

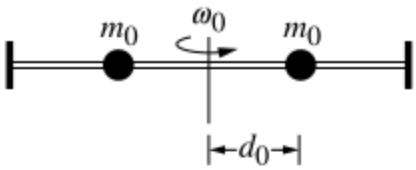
(A) $\frac{1}{2}m_0{v_0}^2 - \frac{1}{2}m_0gh$

(B) $\frac{1}{2}m_0{v_0}^2 - m_0gh$

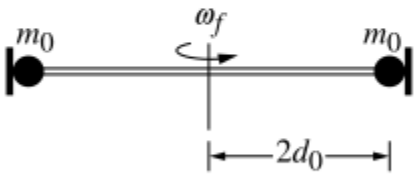
(C) $m_0{v_0}^2 - m_0gh$

(D) $m_0{v_0}^2 - 2m_0gh$

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Initial State



Final State

Note: Figures not drawn to scale.

Consider a system that consists of two beads and a thin rod of negligible mass. In the initial state, the beads, each of mass m_0, are attached with their centers a distance d_0 from the center of the rod. The rod is freely rotating with angular speed ω_0 about a fixed vertical axis through the center of the rod, as shown. Then, an internal mechanism releases the beads and they slide with negligible friction outward until the beads hit the end stops. In the final state, the centers of the beads are a distance $2d_0$ from the center of the rod, which is rotating with an angular speed ω_f, as shown. The curved arrows in the figures indicate the directions only, not the magnitudes, of the angular speeds.

20. Which of the following quantities of the beads-rod system at the initial and final state is the same?

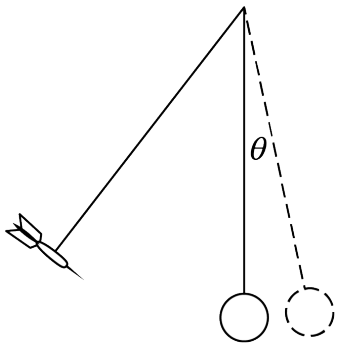
(A) Angular momentum
(B) Period of rotation
(C) Rotational inertia
(D) Rotational kinetic energy

21. Which of the following is constant for an object in uniform circular motion?

(A) Kinetic energy
(B) Velocity
(C) Acceleration
(D) Displacement
(E) Linear momentum

CHAPTER4PARTA

22.



A dart and a rubber sphere are suspended from the same point by light strings. When the dart is released from the position shown above, it swings downward until its tip strikes the sphere. The dart can have different tips attached. Tip A will stick into the rubber sphere upon impact. Tip B will bounce inelastically off the sphere. Tip C will bounce elastically off the sphere. For which tip, if any, will the sphere swing to the greatest maximum angle θ ?

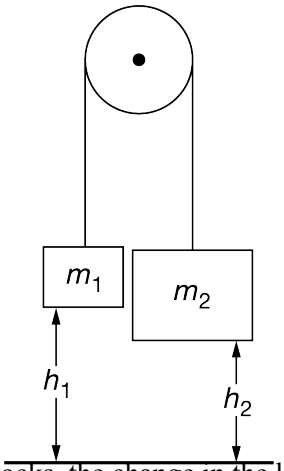
(A) Tip A

(B) Tip B

(C) Tip C

(D) None of the tips; the angle will be the same for each.

23. The Atwood's machine shown consists of two blocks of mass m_1 and m_2 that are connected by a light string that passes over a pulley of negligible friction and negligible mass. The block of mass m_1 is a distance h_1 above the ground, and the block of mass m_2 is a distance h_2 above the ground. m_2 is larger than m_1. The two-block system is released from rest. Which of the following claims correctly describes the outcome after the blocks are released from rest but before the block of m_2 reaches the ground? Select two answers.



A For the system consisting of the two blocks, the change in the kinetic energy of the system is equal to the work done by gravity on the system.

B For the system consisting of the two blocks, the change in kinetic energy of the system is equal to the sum of $m_1gh_1 + m_2gh_2$.

C For the system consisting of the two blocks and the pulley, the increase in kinetic energy of the system is equal to the decrease in the gravitational potential energy of the system.

D For the system consisting of the two blocks, the pulley, and Earth, the change in the total mechanical energy of the system is zero.

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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.

24. Using a number of measurements, the student determines the following.

Spring constant	85 N / m
Mass of object	0.50 kg
Amplitude of oscillation	0.30 m
Maximum speed of object	3.9 m / s

The total energy of the object-spring system is most nearly

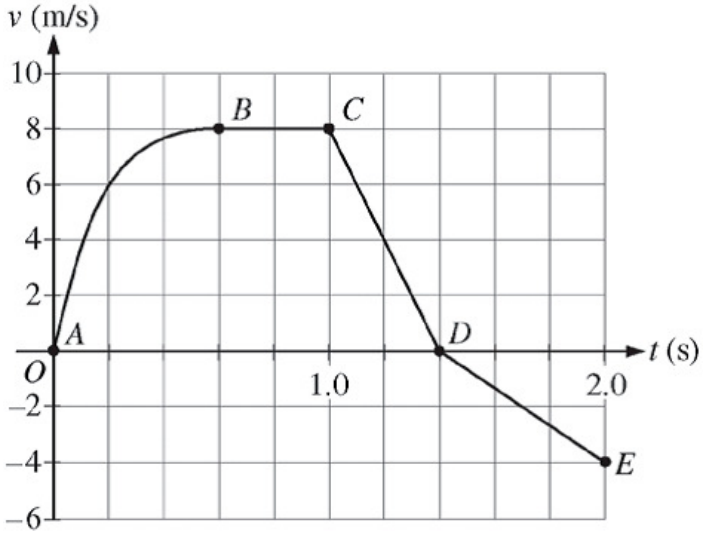
(A) 0.98 J

(B) 3.8 J

(C) 7.6 J

(D) 12.8 J

Refer to the following material for answering the questions.



A cart is constrained to move along a straight line. A varying net force along the direction of motion is exerted on the cart. The cart's velocity v as a function of time t is shown in the graph above. The five labeled points divide the graph into four sections.

25. During some part of the motion, the work done on the cart is negative. What feature of the motion indicates this?

CHAPTER4PARTA

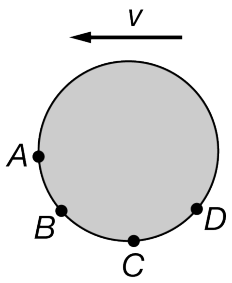
(A) The speed is increasing.

(B) The speed is decreasing.

(C) The acceleration is positive.

(D) The acceleration is negative.

26.



Top View

A disk is sliding to the west with speed v, as shown in the figure above. As the disk slides by, a child will use a rubber mallet to hit the disk at one of the four labeled points. The child will exert a force directly toward the center of the disk. To change the kinetic energy of the disk by the smallest amount, the child should hit the disk at which point?

(A) A

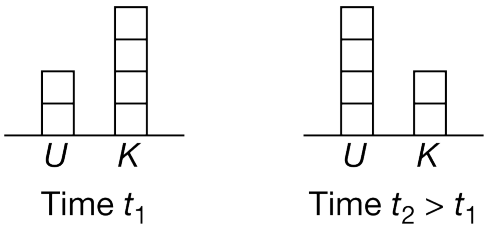
(B) B

(C) C

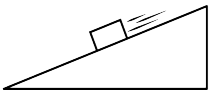
(D) D

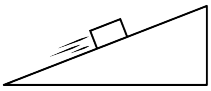
CHAPTER4PARTA

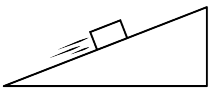
27.

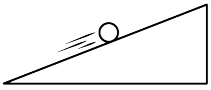


The energy bar charts shown in the figure indicate the gravitational potential energy U and total kinetic energy K for a system at two different times, t_1 and a later time t_2. The tables describe four different situations.

Situation A	System: A block and Earth	Description: The block is sliding down a ramp. Friction is negligible.
	Time t_1: The block is near the top of the ramp.	Time t_2: The block is near the bottom of the ramp.

Situation B	System: A block and Earth	Description: The block is sliding up a ramp. Friction is negligible.
	Time t_1: The block is near the bottom of the ramp.	Time t_2: The block is near the top of the ramp.

Situation C	System: A block and Earth	Description: The block is sliding up a ramp. Friction is NOT negligible.
	Time t_1: The block is near the bottom of the ramp.	Time t_2: The block is near the top of the ramp.

Situation D	System: A cylinder and Earth	Description: The cylinder is rolling up a ramp without slipping.
	Time t_1: The cylinder is near the bottom of the ramp.	Time t_2: The cylinder is near the top of the ramp.

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For which of the situations could the energy bar charts accurately depict U and K at the two times? Select two answers.

A Situation A

B Situation B

C Situation C

D Situation D

28. A test car and its driver, with a combined mass of $600\ \text{kg}$, are moving along a straight, horizontal track when a malfunction causes the tires to stop rotating. The car skids to a halt with constant acceleration, leaving skid marks on the road during the whole time it skids. Which two of the following measurements, taken together, would allow engineers to find the total mechanical energy dissipated during the skid? Select two answers.

A The length of the skid marks

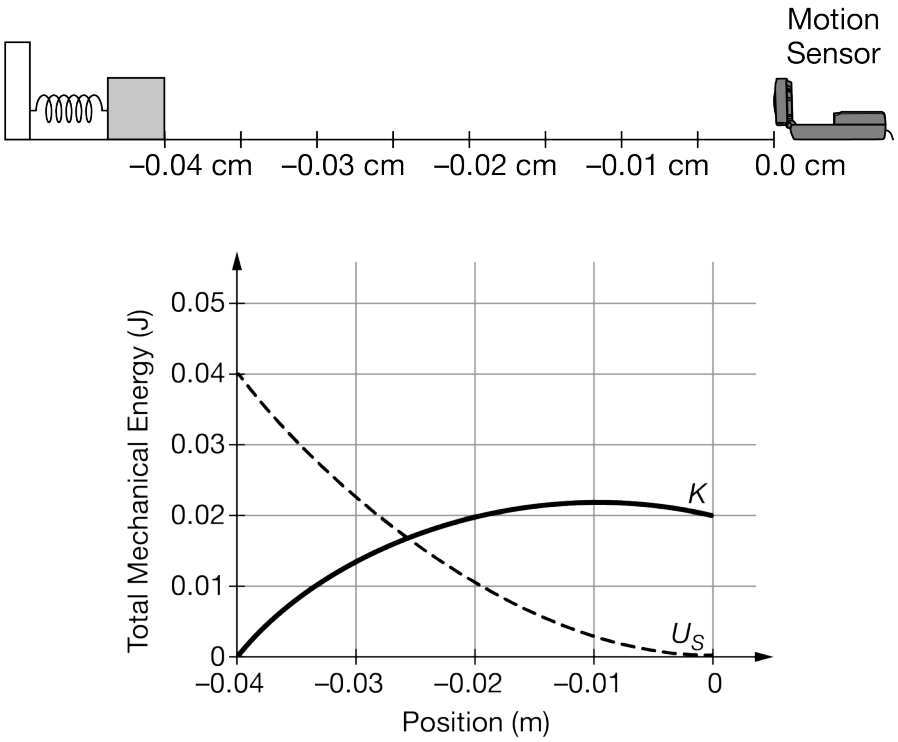
B The contact area of each tire with the track

C The coefficient of static friction between the tires and the track

D The coefficient of kinetic friction between the tires and the track

CHAPTER4PARTA

29.



A block of mass $0.10\ \text{kg}$ is attached and secured to one end of a spring with spring constant $50\ \frac{\text{N}}{\text{m}}$. The other end of the spring is secured to a wall. The block is pushed against the spring, which compresses the spring to a position of $x = -0.04\ \text{m}$. When uncompressed, the end of the spring that is attached to the block is at a position of $x = 0.00\ \text{m}$. The block-spring system is then released from rest, and the block travels along a horizontal, rough track. A motion sensor is placed so that it measures the velocity of the object as it slides along the track. A graph of total mechanical energy of the block-spring system as a function of position is shown. Which of the following statements about the block-spring system are true? Select two answers.

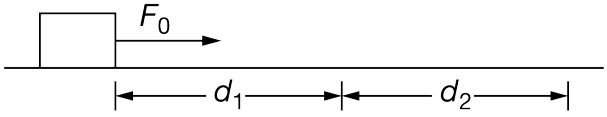
A The force exerted on the block by the spring at $x = -0.02\ \text{m}$ is $1\ \text{N}$.

B The block has maximum speed at $x = 0.00\ \text{m}$.

C The block has half the initial spring potential energy at $x = -0.025\ \text{m}$.

D The work done by friction as the block travels from $x = -0.04\ \text{m}$ to $x = -0.02\ \text{m}$ is $0.01\ \text{J}$.

30.



A force F_0 is applied continuously to a box initially at rest on a horizontal surface. The box slides with negligible friction for equal distances d_1 and d_2, as shown. How does the kinetic energy gained by the block over distance interval d_2, ΔK_2, compare to the kinetic energy gained over distance interval d_1, ΔK_1, and why?

CHAPTER4PARTA

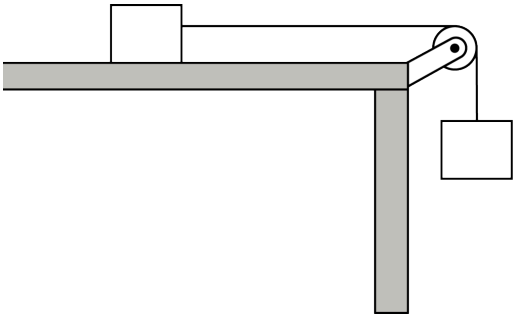
(A) $\Delta K_2 = \Delta K_1$, because the velocity increases by the same amount over intervals d_1 and d_2.

(B) $\Delta K_2 = \Delta K_1$, because the applied force does the same work on the block over intervals d_1 and d_2.

(C) $\Delta K_2 > \Delta K_1$, because the block is moving faster on average over interval d_2.

(D) $\Delta K_2 > \Delta K_1$, because the rate of change of kinetic energy is greater over interval d_2.

31.



A block is set on a table, where there is negligible friction between the block and the table. The block is connected to an identical hanging block by a lightweight string that passes over an ideal pulley as shown. When the blocks are released from rest, the two-block system gains kinetic energy because work is done on the system. Which type of force or forces make a nonzero contribution to the net work done on the two-block system?

(A) Gravitational force only

(B) Gravitational force and tension only

(C) Gravitational force and normal force only

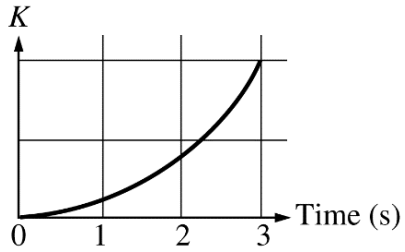
(D) Gravitational force, tension, and normal force

An object of mass *m* is initially at rest and free to move without friction in any direction in the *xy*-plane. A constant net force of magnitude *F* directed in the +*x* direction acts on the object for 1 s. Immediately thereafter a constant net force of the same magnitude *F* directed in the +*y* direction acts on the object for 1 s. After this, no forces act on the object.

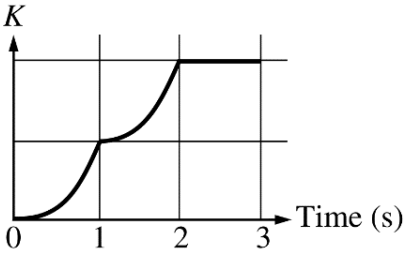
32. Which of the following graphs best represents the kinetic energy *K* of the object as a function of time?

CHAPTER4PARTA

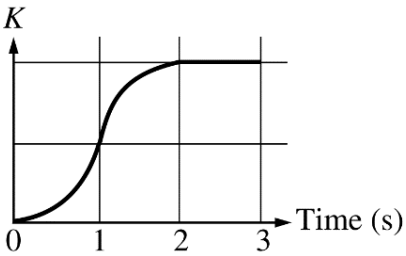
(A)



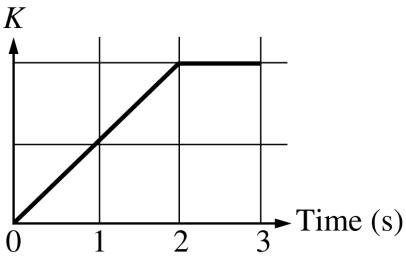
(B)



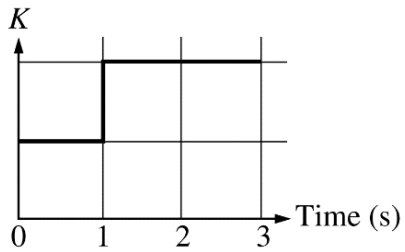
(C)



(D)



(E)



CHAPTER4PARTA

33.

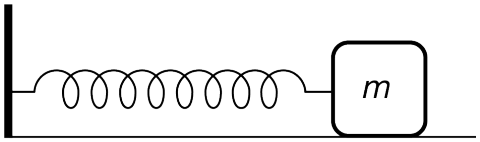


Figure 1

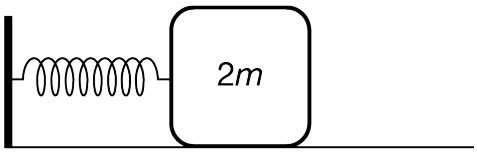


Figure 2

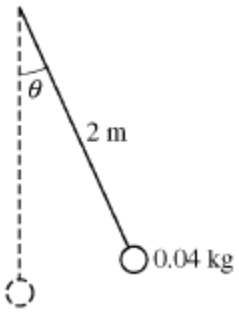
A block on a horizontal surface is placed in contact with a light spring with spring constant k, as shown in Figure 1. When the block is moved to the left so that the spring is compressed a distance d from its equilibrium length, the potential energy stored in the spring-block system is E_m . When a second block of mass $2m$ is placed on the same surface and the spring is compressed a distance $2d$, as shown in Figure 2, how much potential energy is stored in the spring compared to the original potential energy E_m ? All frictional forces are considered to be negligible.

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

(B) E_m

(C) $2E_m$

(D) $4E_m$



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 $\cos\Theta = 0.9$.

34. If the pendulum is released from rest, the maximum speed the bob attains is most nearly

(A) 1 m/s

(B) $\sqrt{2}$ m/s

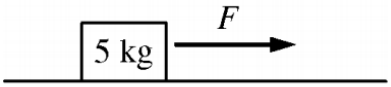
(C) 2 m/s

(D) 4 m/s

(E) 6 m/s

CHAPTER4PARTA

35.



A force *F* is exerted on a 5 kg block to move it across a rough surface, as shown above. The magnitude of the force is initially 5 N, and the block moves at a constant velocity. While the block is moving, the force is instantaneously increased to 12 N. How much kinetic energy does the block now gain as it moves a distance of 2 m?

(A) 10 J

(B) 14 J

(C) 24 J

(D) 34 J

36. In which of the following situations is the kinetic energy of the object decreasing?

(A) A sphere is dropped from a building.

(B) A satellite is moving in a circular orbit around Earth.

(C) A baseball is heading upward after being thrown at an angle.

(D) An elevator is moving upward at a constant velocity.

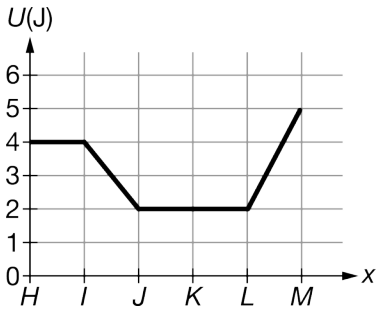
37. A block of mass M is sliding with an initial speed v_i along a horizontal surface with negligible friction. A constant force of magnitude F_A is exerted on the object at an upward angle of 60° from the horizontal, causing the object to speed up. If the block remains in contact with the floor, what is the change in the block's kinetic energy as it moves a horizontal distance Δx ?

(A) $\frac{1}{2}F_A\Delta x$

(B) $F_A\Delta x$

(C) $\frac{1}{2}Mv_i^2 + \frac{1}{2}F_A\Delta x$

(D) $\frac{1}{2}Mv_i^2 + F_A\Delta x$



The graph above shows the potential energy U of a system as one object in the system moves along the x-axis and the rest of the system does not move. Six evenly-spaced points along the x-axis are labeled. At point H, the object is moving in the positive x-direction and the mechanical energy of the system is $5.0\ \text{J}$. As the object moves, no energy enters or leaves the system.

CHAPTER4PARTA

38. What is the kinetic energy of the object at point K ?

(A) $5\ \mathrm{J}$

(B) $4\ \mathrm{J}$

(C) $3\ \mathrm{J}$

(D) $2\ \mathrm{J}$

39. In which segment does the net force exerted on the object have the greatest magnitude?

(A) HI

(B) IJ

(C) JL

(D) LM

---

40. Consider a system of two objects and Earth. Object X and object Y are held together by a light string as shown in the figure. M_{Y} is larger than M_{X}. The two-object system is released from rest in the orientation shown in the figure at a height H above Earth's surface. The change in the kinetic energy of the system from when it is released to the instant it hits the ground is most nearly



(A) $M_{\mathrm{Y}}gH$

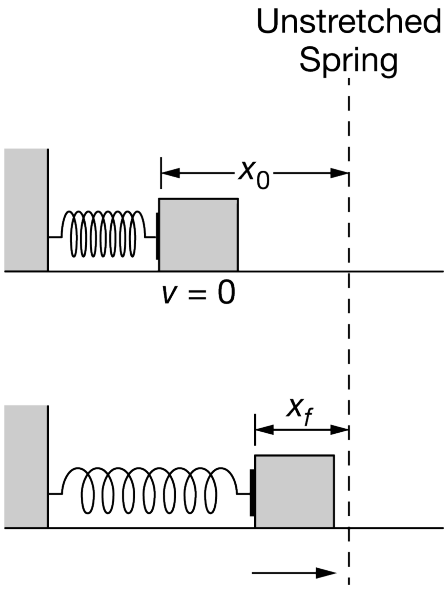
(B) $M_{\mathrm{X}}gH$

(C) $(M_{\mathrm{Y}} - M_{\mathrm{X}})gH$

(D) $(M_{\mathrm{Y}} + M_{\mathrm{X}})gH$

CHAPTER4PARTA

41.



A block of mass m is launched by a spring of negligible mass along a horizontal surface of negligible friction. The spring constant of the spring is k. The spring is initially compressed a distance x_0. The block is released from rest. Some time after the block is released and travels in the direction shown in the figure, the spring compression is x_f. Which of the following mathematical calculations can a student use to determine the speed v_f of the block at this new position?

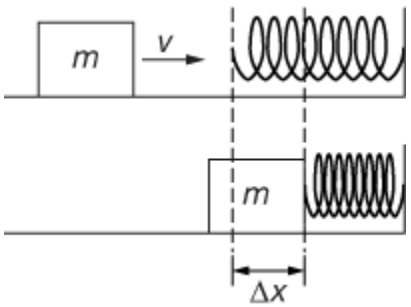
(A) $\frac{1}{2}kx_0^2 = \frac{1}{2}mv_f^2$. Solve for v_f.

(B) $\frac{1}{2}kx_0^2 = \frac{1}{2}kx_f^2 + \frac{1}{2}mv_f^2$. Solve for v_f.

(C) $F_{\|}d = \frac{1}{2}m\Delta v^2$ and $F_{\|} = kx_0$. Solve for Δv.

(D) $Fd\cos\theta = \frac{1}{2}m\Delta v^2$ and $F = kx_0$. Solve for Δv.

42.



A block of mass m slides with speed v along a frictionless, horizontal surface toward an unstretched spring attached to a wall, as shown above. The block compresses the spring a maximum distance Δx. Which of the following values of block mass and initial speed would result in the same maximum compression distance Δx for the spring?

CHAPTER4PARTA

(A)

Block Mass	Initial Speed
$2m$	$v/4$

(B)

Block Mass	Initial Speed
$2m$	$2v$

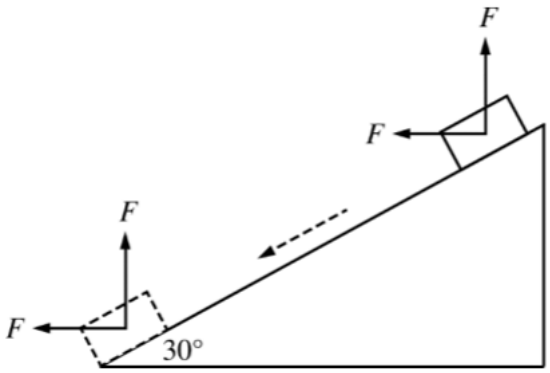
(C)

Block Mass	Initial Speed
$4m$	$v/4$

(D)

Block Mass	Initial Speed
$4m$	$v/2$

43.



A block is released from rest and slides down a frictionless ramp inclined at 30° from the horizontal. When the block reaches the bottom, the block-Earth system has mechanical energy E_0. The experiment is repeated, but now horizontal and vertical forces of magnitude F are exerted on the block while it slides, as shown above. When the block reaches the bottom, the mechanical energy of the block-Earth system

(A) is greater than E_0

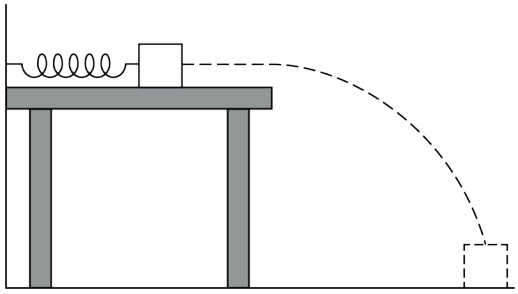
(B) is equal to E_0

(C) is less than E_0

(D) cannot be determined without knowing F

CHAPTER4PARTA

44.



A block is set on a rough horizontal table where frictional forces are not negligible. The block is pushed against a horizontal spring, and it is released at time $t = 0$. The spring pushes the block across the table. At time $t = t_1$, the block leaves the table. The block strikes the ground at time $t = t_2$. Which of the following describes the change in mechanical energy of the **block-spring** system for times $0 < t < t_1$ and $t_1 < t < t_2$?

(A)

$0 < t < t_1$	$t_1 < t < t_2$
Stays the same	Stays the same

(B)

$0 < t < t_1$	$t_1 < t < t_2$
Increases	Decreases

(C)

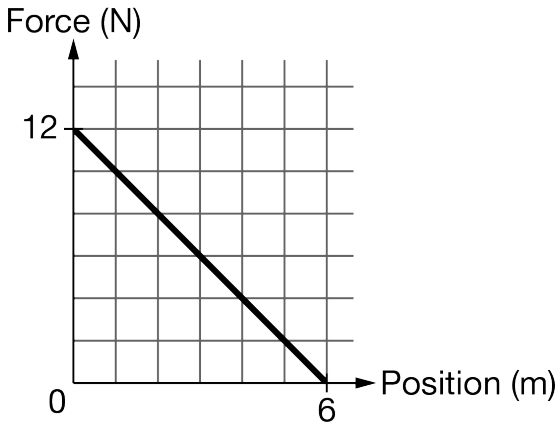
$0 < t < t_1$	$t_1 < t < t_2$
Stays the same	Increases

(D)

$0 < t < t_1$	$t_1 < t < t_2$
Decreases	Increases

CHAPTER4PARTA

45.



A $2\ \text{kg}$ box is pushed from rest across a horizontal surface where friction between the box and the surface is negligible. Students record the applied force at several equally spaced positions while pushing the box and create the graph shown. The change in momentum of the box is most nearly

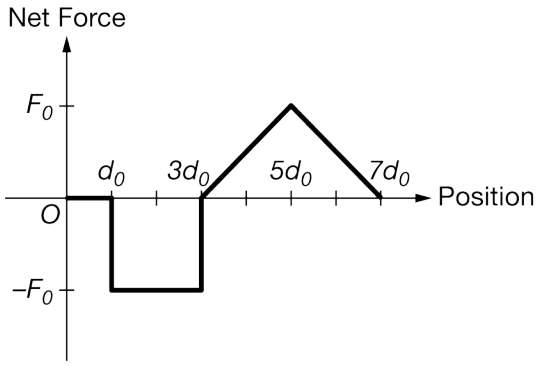
(A) $2\ \text{kg} \cdot \text{m/s}$

(B) $6\ \text{kg} \cdot \text{m/s}$

(C) $12\ \text{kg} \cdot \text{m/s}$

(D) $36\ \text{kg} \cdot \text{m/s}$

46.



An object is moving along a straight, flat section of track. The net force acting on the object as a function of position is shown in the graph, where the positive direction is in the direction of motion of the object. Assuming the object moves from position $x = 0$ to $x = 7d_0$ without stopping or moving backward, which of the following statements about its motion are correct? Select two answers.

A The object has its greatest kinetic energy at position $5d_0$.

B The kinetic energy of the object at position d_0 is greater than $2F_0d_0$.

C The object has the same kinetic energy at position d_0 that it has at position $7d_0$.

D The kinetic energy of the object is not changing when it is between positions d_0 and $3d_0$.

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47. An object is released from rest at a height H near and above the surface of Earth. As the object falls toward the surface, Earth's atmosphere exerts a resistive force on the object such that it reaches a terminal velocity before it reaches the ground. Which of the following claims is true? Select two answers.

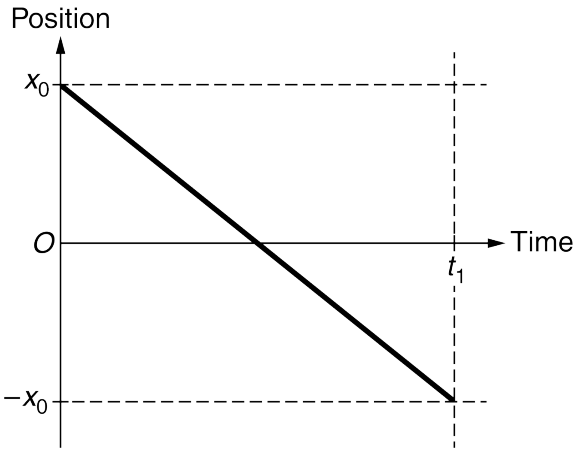
A The system consisting of only the object is an open system.

B Earth's atmosphere does negative work on the object as it falls toward the surface.

C The change in the object's kinetic energy from the instant it is released from rest, to the instant it reaches terminal velocity, is zero.

D The total mechanical energy of the object-Earth system remains constant at all times in which the object is in motion.

48.



An object moves in a straight line along a horizontal surface. The position x of the object as a function of time t is shown by the graph. Which of the following statements are true for the object? Select two answers.

A The kinetic energy of the object decreases from $t = 0$ to $t = t_1$.

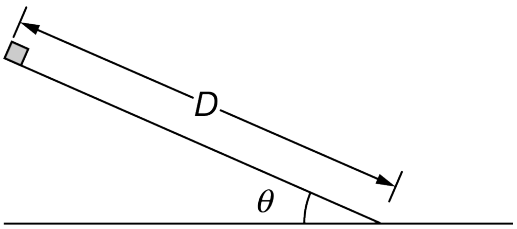
B The change in momentum of the object from $t = 0$ to $t = t_1$ is equal to zero.

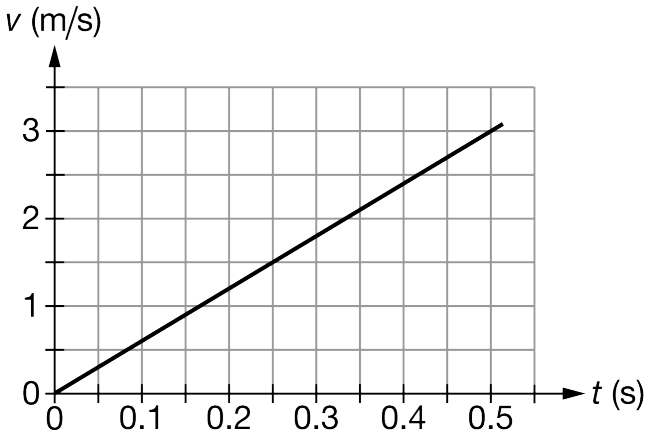
C The work done on the object from $t = 0$ to $t = t_1$ is equal to zero.

D The impulse given to the object from $t = 0$ to $t = t_1$ is nonzero.

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49.





A block of mass M is released from rest and slides down an incline, as shown in the figure. The length D of the incline is 0.8 m and the angle of the incline, θ, is 37°. A graph of the speed v as a function of time t of the block as it descends the incline is shown. How could a student use the graph and the information provided to determine whether the block-Earth system is an open system or a closed system?

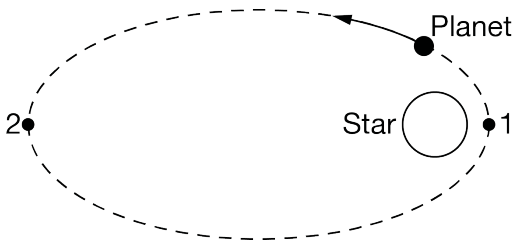
(A) Use the known mass of the block and the final velocity of the block after 0.5 s to determine the final kinetic energy of the block.

(B) Use the known length of the incline and the known angle that the incline makes with the horizontal to determine the height above the ground at which the block is released. Use this height and the object's known mass to determine the initial gravitational potential energy of the block-Earth system.

(C) Use the known mass of the block and the initial velocity of the block at 0.0 s to determine the initial kinetic energy of the block. Compare it with final kinetic energy of the block that can be found as described above.

(D) Determine final kinetic energy as described above and compare it with the initial gravitational potential energy of the block-Earth system as described above.

50.



A planet moves in an elliptical orbit around a star, as shown in the diagram. Which of the following is true as the planet moves from position 1 to position 2?

CHAPTER4PARTA

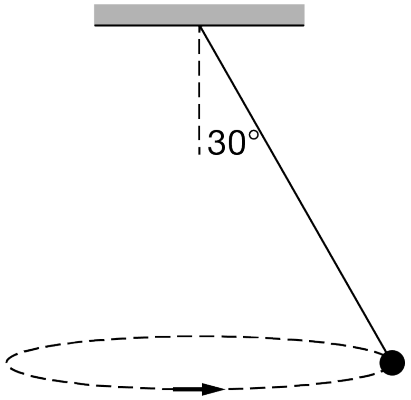
(A) The planet loses kinetic energy due to negative gravitational work; thus, the total energy in the planet-star system decreases.

(B) The planet's kinetic energy increases due to positive gravitational work; thus, the total energy in the planet-star system increases.

(C) Kinetic energy decreases and gravitational potential energy increases, but the total energy in the planet-star system stays constant.

(D) Potential energy decreases and kinetic energy increases, but the total energy in the planet-star system stays constant.

51.



One end of a string is attached to the ceiling and the other end is attached to a small sphere traveling in a circular path, as shown above, with a constant speed of $1\ \mathrm{m/s}$. The string makes an angle of 30° to the vertical. If the tension in the string is $6\ \mathrm{N}$ and the circumference of the circle is $1\ \mathrm{m}$, how much work is done on the sphere by the string as the sphere travels through one revolution?

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

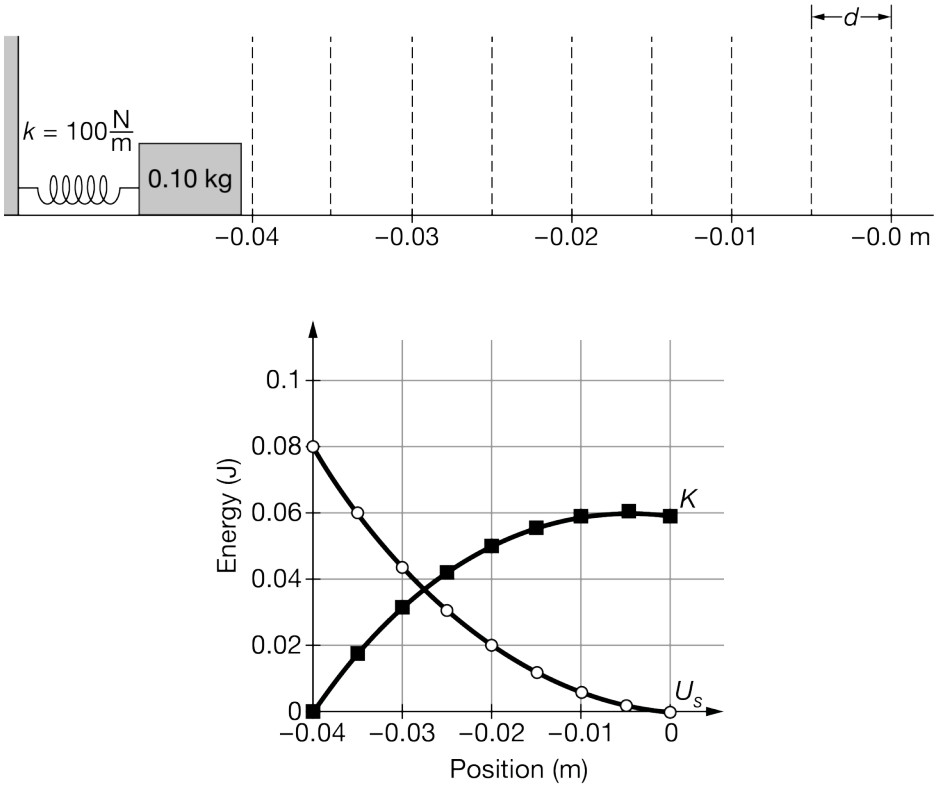
(B) $3\ \mathrm{J}$

(C) $6\ \mathrm{J}$

(D) $12\ \mathrm{J}$

CHAPTER4PARTA

52.



A block of mass $M = 0.10\ \text{kg}$ is attached to one end of a spring with spring constant $k = 100\ \frac{\text{N}}{\text{m}}$. The other end of the spring is attached to a fixed wall. The block is pushed against the spring, compressing it a distance $x = 0.04\ \text{m}$. The block is then released from rest, and the block-spring system travels along a horizontal, rough track. Data collected from a motion detector are used to create a graph of the kinetic energy K and spring potential energy U_s of the system as a function of the block's position as the spring expands. How can the student determine the amount of mechanical energy dissipated by friction as the spring expanded to its natural spring length?

(A) Use Fd with F equal to the distance the spring is compressed. Then multiply the value by the spring constant of the spring. Then multiply this value by d equal to the total displacement of the center of mass of the block.

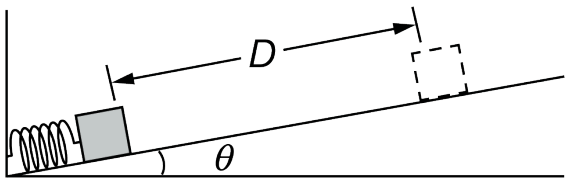
(B) Subtract the final kinetic energy of the block-spring system from the initial spring potential energy stored within the block-spring system.

(C) Use $\frac{1}{2}kx^2$ with k equal to $100\frac{\text{N}}{\text{m}}$ and x equal to the maximum compression of the spring.

(D) Use the value of the kinetic energy of the block-spring system when the block is at a position of $0\ \text{m}$.

CHAPTER4PARTA

53.



A block of mass M is at rest on a ramp that is inclined at an angle θ with respect to the horizontal. Frictional forces are considered to be nonnegligible. The block is pushed against a spring and then held in place. The spring is compressed a distance of x_1, and the spring is not secured to the block. The block is then released from rest, travels up the incline, and comes to rest after traveling a distance D, as shown above. Which of the following claims correctly describes the energy of the system under consideration from when the block compressed the spring and when the block has traveled a distance D along the incline? Select two answers.

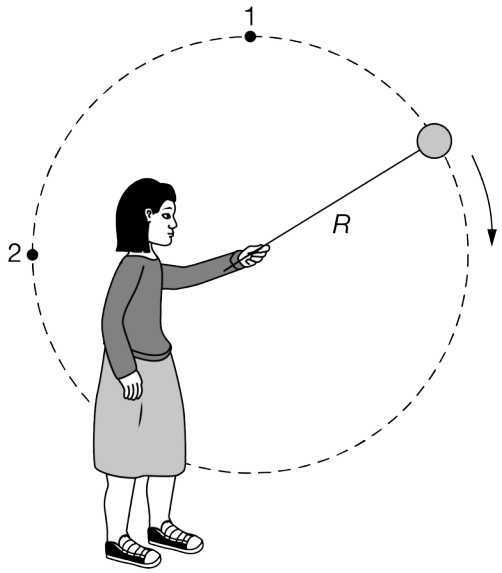
A The mechanical energy of the system consisting of the spring increases by $\frac{1}{2}kx_1^2$.

B The mechanical energy of the system consisting of the block does not change.

C The mechanical energy of the system consisting of the block and Earth increases by more than zero but less than $\frac{1}{2}kx_1^2$.

D The mechanical energy of the system consisting of the spring, block, and Earth increases by $\frac{1}{2}kx_1^2$.

54.



A student swings a ball at the end of a string of length R in a vertical circle as shown. The ball moves with the minimum speed necessary to complete a circular path at point 1. Consider the system of the ball. In terms of the mechanical energy of the system, which of the following claims is correct, and why?

(A) The system is open, because the ball is able to complete a full revolution around the circle.

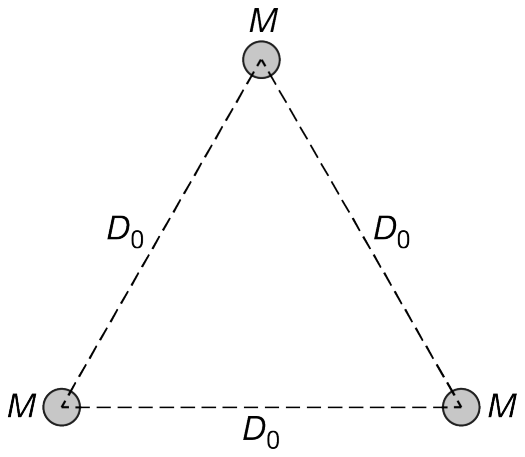
(B) The system is open, because a net force is exerted on the ball as it travels in a circle.

(C) The system is closed, because the ball is able to complete a full revolution around the circle.

(D) The system is closed, because the speed of the ball remains constant as it travels in the vertical circle.

CHAPTER4PARTA

55.



Three identical massive bodies are at the corners of an equilateral triangle, each a distance D_0 from the center of mass of the other two bodies, as shown in the figure. Each body has mass M. What is the gravitational potential energy of the three-body system?

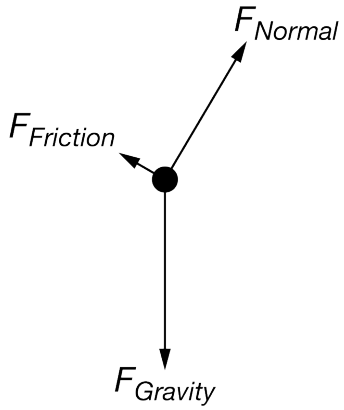
(A) Zero

(B) $-\frac{GM^2}{D_0}$

(C) $-\frac{2GM^2}{D_0}$

(D) $-\frac{3GM^2}{D_0}$

56.



The diagram shows the forces exerted on a block that starts from rest and speeds up as it moves down a rough incline near Earth's surface. Which of the following statements are true? Select two answers.

A The momentum of Earth remains constant as the block slides down the incline.

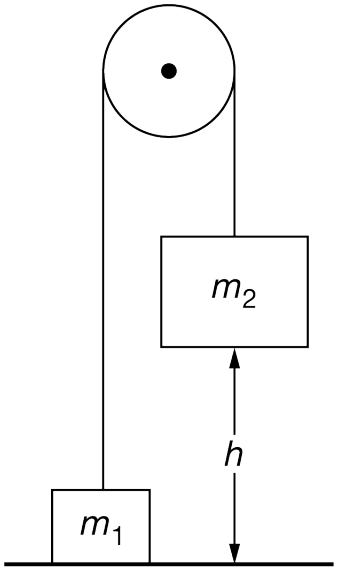
B The total mechanical energy of the block-Earth system decreases as the block slides down the incline.

C The momentum of the block increases as the block slides down the incline.

D The total mechanical energy of the block-Earth system remains constant as the block slides down the incline.

CHAPTER4PARTA

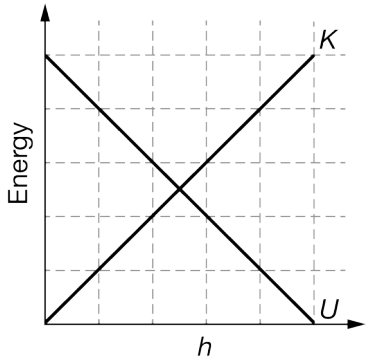
57.



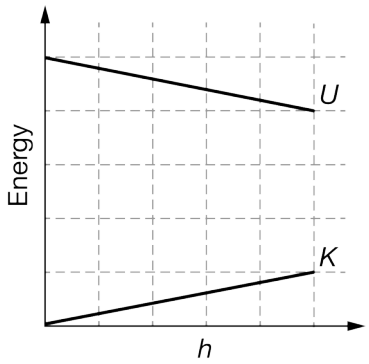
The Atwood's machine shown consists of two blocks connected by a light string that passes over a pulley of negligible mass and negligible friction. The blocks are released from rest, and m_2 is greater than m_1. Assume that the reference line of zero gravitational potential energy is the floor. Which of the following best represents the total gravitational potential energy U and total kinetic energy K of the block-block-Earth system as a function of the height h of block m_1?

CHAPTER4PARTA

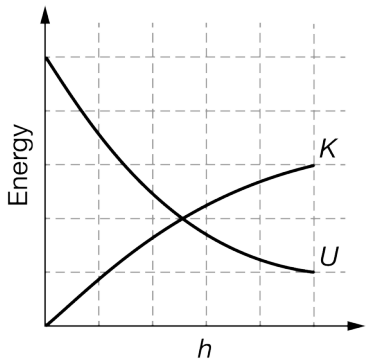
(A)



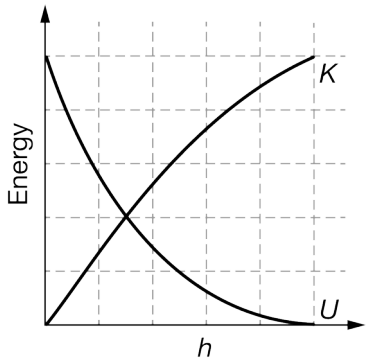
(B)



(C)

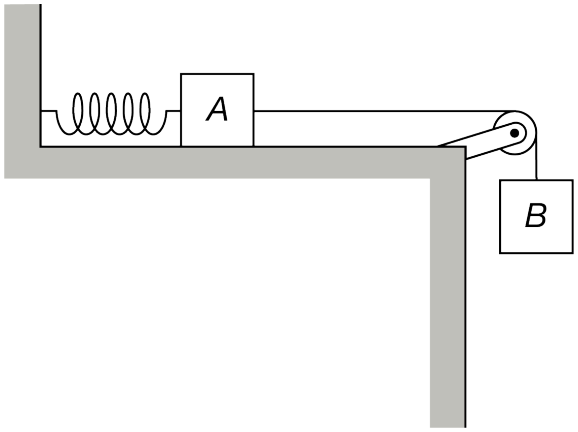


(D)



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58.



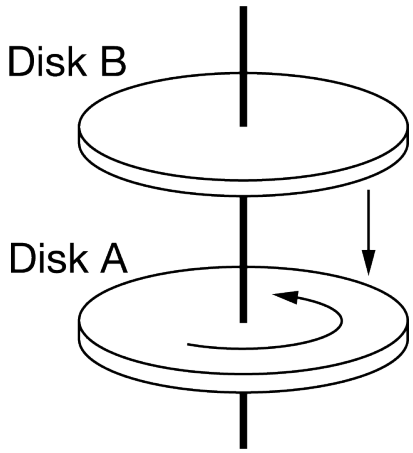
Block A is set on a rough horizontal table and is connected to a horizontal spring that is fixed to a wall, as shown. Block A is then also connected to hanging block B by a lightweight string that passes over an ideal pulley, as shown. The friction force exerted on block A by the table is not negligible. The blocks are initially held at rest so that the spring is not stretched. When the blocks are released, hanging block B moves downward and block A on the table moves to the right until the system comes again to rest. Let E_1 be the mechanical energy of the blocks-spring system, and let E_2 be the mechanical energy of the blocks-spring-Earth system. How do these two energies change from when the blocks are held at rest to when the blocks come to rest again?

	Blocks-Spring System	**Blocks-Springs-Earth System**
A	Increases	Decreases
B	Decreases	Increases
C	Remains constant	Decreases
D	Remains constant	Remains constant

(A) A
(B) B
(C) C
(D) D

CHAPTER4PARTA

59.



Cylindrical disk A is rotating freely about an axis when an identical disk B that is not rotating is dropped directly on top of disk A. If the two disks stick together, how does the total angular momentum and total kinetic energy of the two-disk system after the disks are stuck together compare to that of the system before disk B was dropped?

(A)

Total Angular Momentum	Total Kinetic Energy
Remains the same	Is one-half its original value

(B)

Total Angular Momentum	Total Kinetic Energy
Remains the same	Is one-fourth its original value

(C)

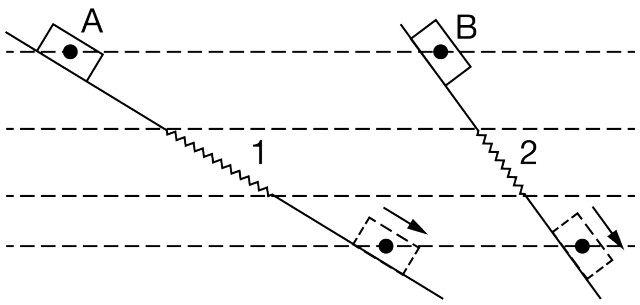
Total Angular Momentum	Total Kinetic Energy
Is one-half its original value	Is one-half its original value

(D)

Total Angular Momentum	Total Kinetic Energy
Is one-half its original value	Is one-fourth its original value

CHAPTER4PARTA

60.



Identical blocks A and B are initially at rest on ramps inclined at different angles and with their centers of mass at the same height, as shown above. The ramps are frictionless except for rough sections 1 and 2 represented by the jagged lines, which have the same coefficient of kinetic friction. The blocks are released. How do the speeds of the blocks compare when they are at the locations represented by the dashed rectangles at the bottom of each ramp?

(A) Block A has a greater speed.

(B) Block B has a greater speed.

(C) The blocks have the same speed.

(D) The speeds cannot be compared without knowing the angles of the ramps or the coefficient of kinetic friction in sections 1 and 2.

61. Two identical spaceships are moving through space both with speed v_0. Both spaceships experience a net force of magnitude F_0 over the same time interval. For spaceship 1, the net force acts in the same direction as the spaceship is moving; for spaceship 2, the net force is directed opposite to the spaceship's motion, causing spaceship 2 to slow down but not stop. For which spaceship, if either, does the kinetic energy change by a greater magnitude, and why?

(A) Spaceship 1 will have a greater change in kinetic energy because the distance traveled is greater than that of spaceship 2.

(B) Spaceship 2 will have a greater change in kinetic energy because the force slows down the spaceship.

(C) Spaceship 1 and 2 have the same change in kinetic energy because the time and the force are the same.

(D) Spaceship 1 and 2 have the same change in kinetic energy because the net work done on each has the same magnitude.

62. A block slides across a flat, horizontal surface to the right. For each choice, the arrows represent velocity vectors of the block at successive intervals of time. Which of the following diagrams represents the situation in which the block loses kinetic energy?

(A)

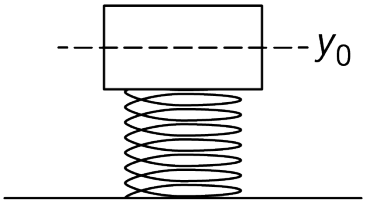
(B)

(C)

(D)

CHAPTER4PARTA

63.



A block of mass m is at rest on top of a spring of spring constant k as shown above. The block is then pushed down a distance y below its initial position y_0 and released from rest. What is the block's kinetic energy when it first returns to position y_0 ?

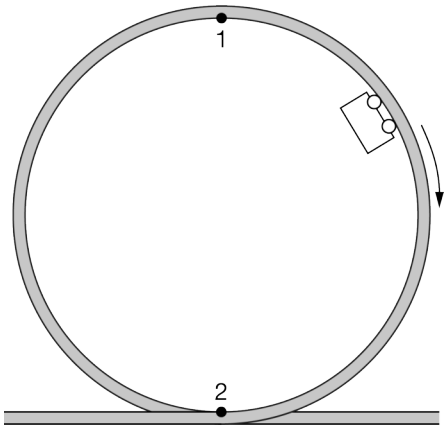
(A) $2mgy$

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

(C) $\frac{1}{2}ky^2 + mgy$

(D) $\frac{1}{2}ky^2 - mgy$

64.



A cart is going around a circular loop, as shown in the figure. The cart moves with the smallest speed necessary to stay in contact with the loop to complete a circular path at point 1. What is the speed of the cart at point 2?

(A) Zero

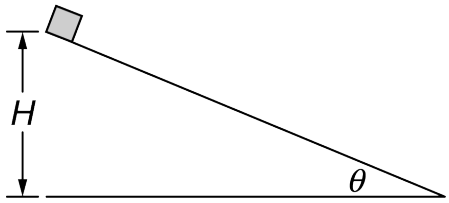
(B) $\sqrt{gR}$

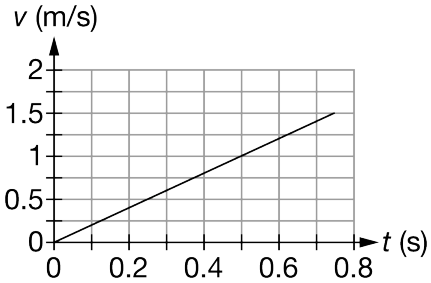
(C) $\sqrt{3gR}$

(D) $\sqrt{5gR}$

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65.





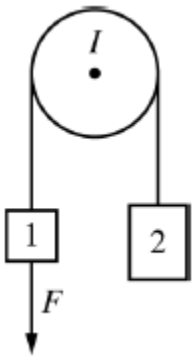
A $2\,\text{kg}$ block is placed at the top of an incline and released from rest near Earth's surface and unknown distance H above the ground. The angle θ between the ground and the incline is also unknown. Frictional forces between the block and the incline are considered to be negligible. The block eventually slides to the bottom of the incline after $0.75\,\text{s}$. The block's velocity v as a function of time t is shown in the graph starting from the instant it is released. How could a student use the graph to determine the total energy of the block-Earth system?

(A) Use mgy_0 with $m = 2\,\text{kg}$ and y_0 equal to the area bound between the horizontal axis and the curve.

(B) Use $\frac{1}{2}mv_f^2$ with $m = 2\,\text{kg}$ and v_f equal to the final velocity of the object that can be found from the graph.

(C) Use Fd with F equal to the normal force exerted on the block and d equal to the area bound between the horizontal axis and the curve.

(D) The answer cannot be determined without knowing the initial height of the object above the ground.



Two blocks are connected by a string with negligible mass that passes over a pulley with nonzero rotational inertia I, as shown above. The axle of the pulley has negligible friction. The string does not slip on the pulley. Block 1 has mass $4\,\text{kg}$ and block 2 has mass $6\,\text{kg}$. An additional force with magnitude F is initially exerted on block 1 so that the blocks do not move and is then removed.

CHAPTER4PARTA

66. After the additional force is removed, what happens to the gravitational potential energy of the pulley-blocks-Earth system?

(A) It remains constant and zero.

(B) It remains constant but is greater than zero.

(C) It increases.

(D) It decreases.