AP Physics 1 Practice Multiple Choice - Problems and Solutions

The following are problems and solutions created by Michael Freeman, physics teacher at Somerville High School.

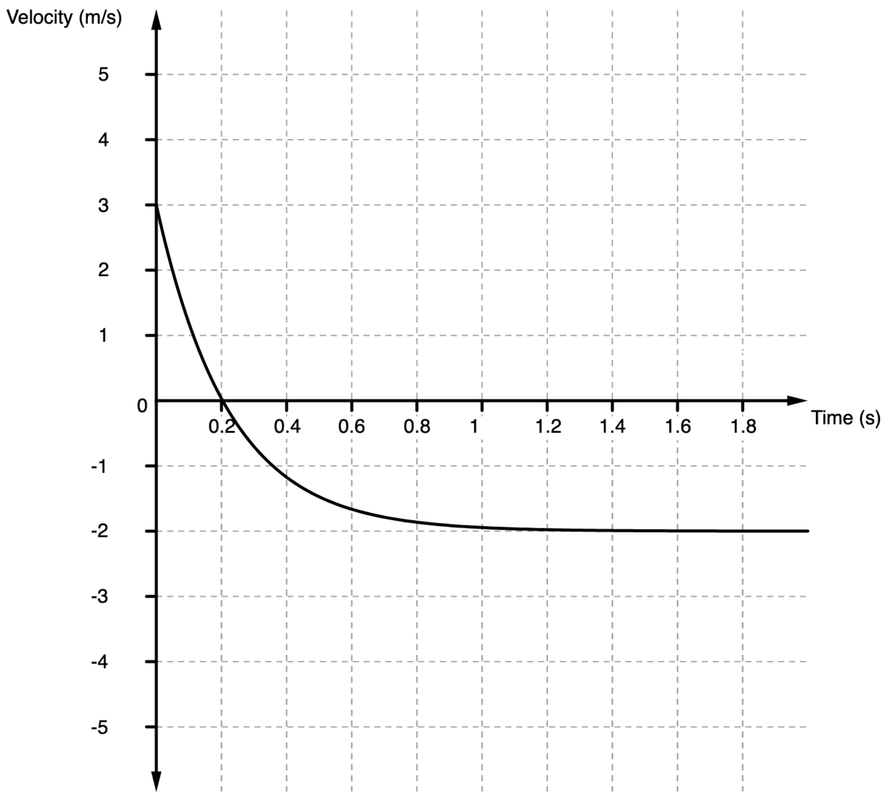
The diagrams and graphs are (almost) all created on *oPhysics.com* a website with interactives based in Geogebra by Tom Walsh.

See more at www.afreeparticle.com .

The AP Physics 1 Multiple Choice section is NOT organized in this way, it is just this way for my own review purposes.

Section 1: Motion and Forces	Section 2: Energy and Momentum	Section 3: SHM, Rotational, Combo
Problem 1: D	Problem 18: A	Problem 35: C
Problem 2: B	Problem 19: B	Problem 36: B
Problem 3: C	Problem 20: B	Problem 37: C
Problem 4: A & C	Problem 21: B	Problem 38: B & C
Problem 5: A	Problem 22: A & C	Problem 39: C
Problem 6: D	Problem 23: A	Problem 40: A
Problem 7: A & D	Problem 24: D	Problem 41: C
Problem 8: A	Problem 25: C	Problem 42: A
Problem 9: D	Problem 26: B	Problem 43: B
Problem 10: C	Problem 27: B	Problem 44: B
Problem 11: C	Problem 28: B	Problem 45: B
Problem 12: D	Problem 29: A	Problem 46: C
Problem 13: A	Problem 30: C	Problem 47: A
Problem 14: C	Problem 31: C	Problem 48: D
Problem 15: D	Problem 32: C	Problem 49: D
Problem 16: C	Problem 33: B	Problem 50: D
Problem 17: D	Problem 34: D	

Problem 1



A light sphere is thrown upwards on a cliff at t = 0s, and experiences a significant drag force. The velocity time graph is shown above. Which of the following describes the direction of the sphere's acceleration just after the throw and the time that the acceleration first reaches zero?

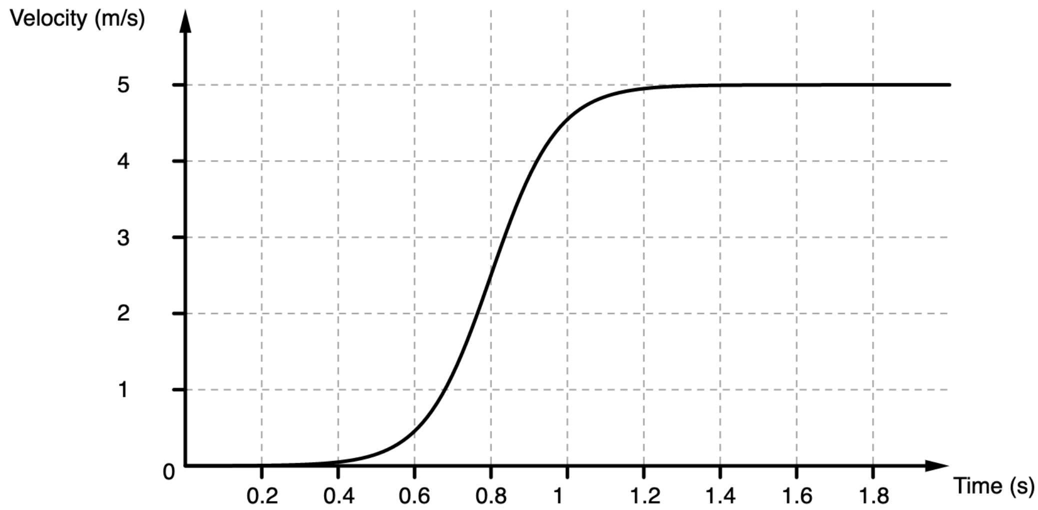
	Direction of the acceleration just after throw	Time the acceleration first reaches zero
A	Up	0.2 s
B	Up	1.2 s
C	Down	0.2 s
D	Down	1.2 s

Answer: D

Explanation: The acceleration is the slope of the velocity-time graph. Initially, negative slope, then zero slope after around 1.2 seconds.

Another way to look at it: Both drag and gravitational forces are directed downward initially, then it reaches its highest point at 0.2 seconds, and finally has balanced forces when it reaches terminal velocity on the way down.

Problem 2



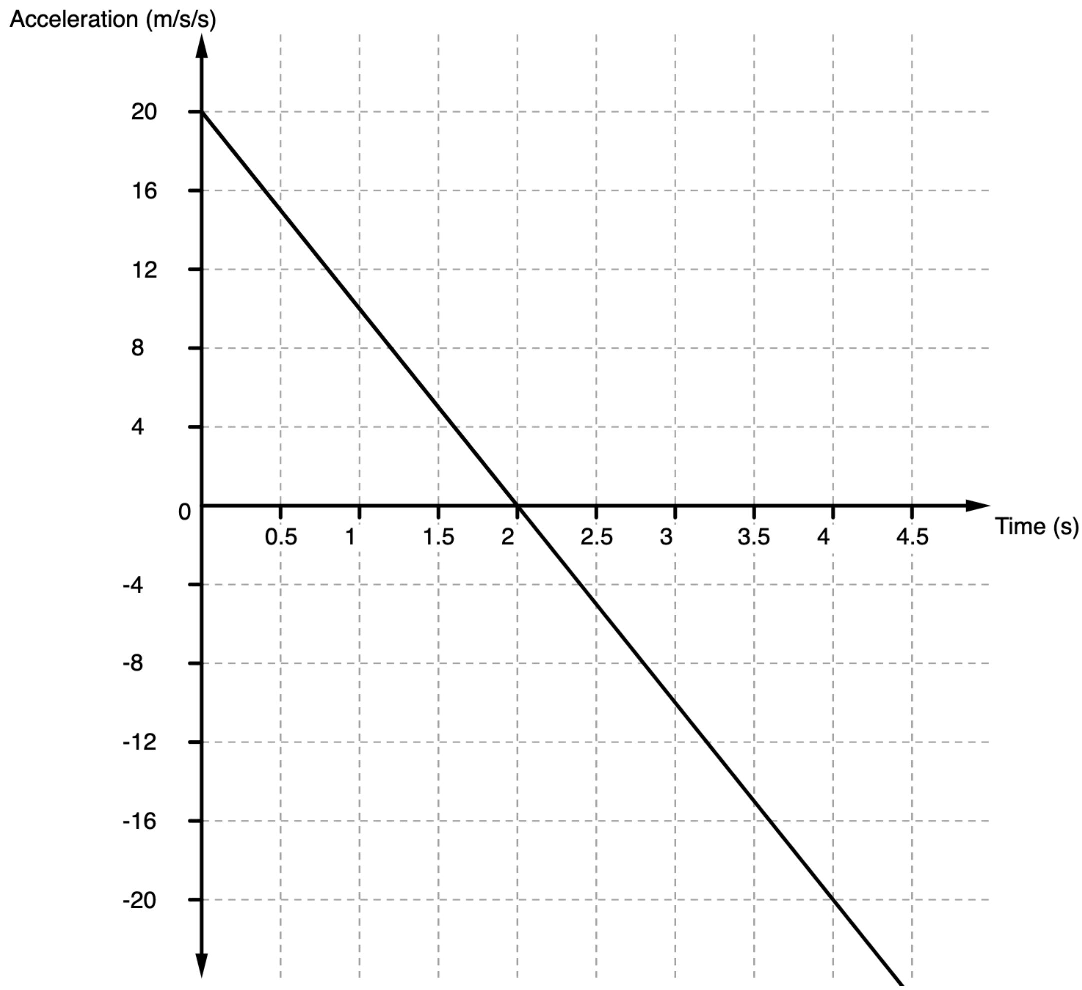
A student pushes a cart horizontally in the positive direction on a frictionless horizontal table and the graph of the motion is shown above. At which of the following times does the student apply the greatest force to the cart?

A. 0.6 s
B. 0.8 s
C. 1.0 s
D. 1.4 s

Answer: B

Explanation: The ranking of net force is determined by the acceleration because the mass stays the same (Newton's Second Law). The acceleration is the slope of the velocity time graph, which is greatest at t = 0.8s.

Problem 3



The acceleration vs. time graph of an object moving in a straight line is shown above. The object starts at the origin with an initial velocity, v_0. Which of the following can be concluded from this graph?

A. The object is in free fall.
B. The object is furthest from the origin at t = 2 s.
C. The object has a velocity of v_0 at t = 4 s.
D. The object experiences a constant net force.

Answer: C

Explanation: The signed area under this graph is the change in velocity which is zero because the positive area cancels out with the negative area.

Problem 4

A block slides without friction at speed *v* off a horizontal table and lands on the floor. Which of the following pairs of measurements would allow one to estimate *v*? Choose two correct answers.

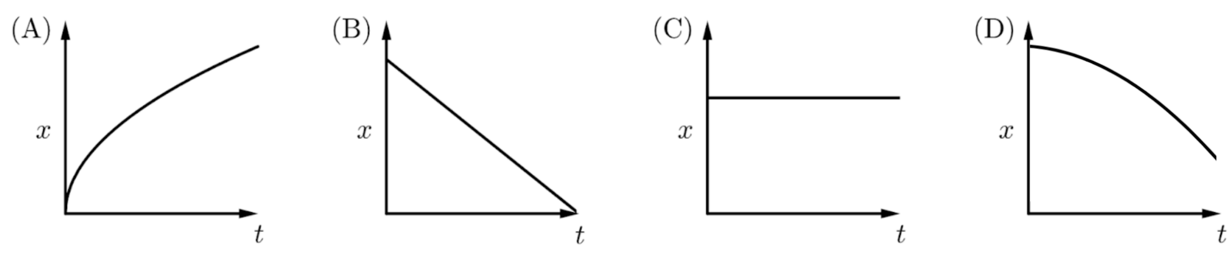
A. The horizontal distance from the table the block landed and the time in the air.
B. The time in the air and the height of the table.
C. The horizontal distance from the table the block landed and the height of the table.
D. The vertical velocity just before reaching the ground and the time in the air.

Answers: A C

Explanation: Ultimately, because the horizontal velocity is constant during this time before hitting the ground, you need just a horizontal distance and a time. The time can be measured, or calculated from the height of the table. B and D give no information about the horizontal distance traveled.

Problem 5

Which of the following position time graphs is consistent with a cart moving in a straight line with a net force in the opposite direction as its direction of motion?

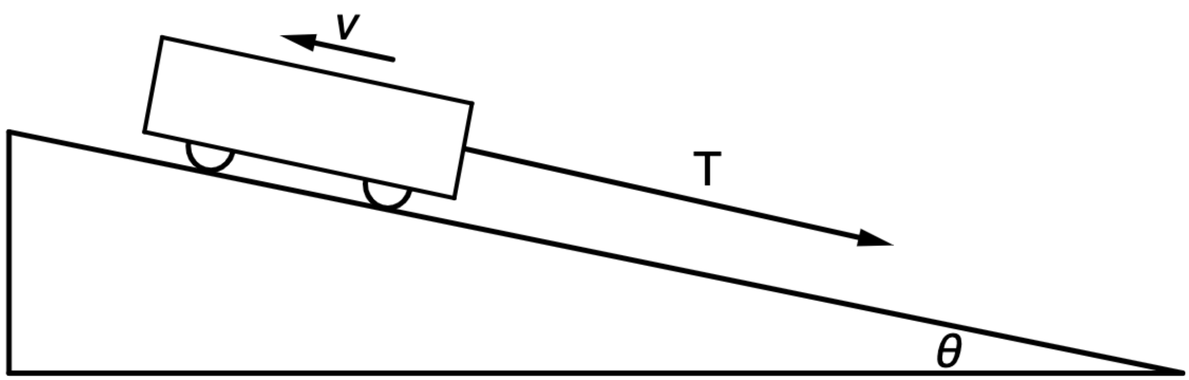


Answer: A

Explanation: The slope of the position time graph is decreasing in magnitude, so the speed should be decreasing. Thus, the acceleration is in the opposition direction as the velocity, and the acceleration is in the same direction as the net force.

Problem 6

While a cart of mass *m* is moving uphill at speed *v*, a rope pulls on it parallel to the incline with a force of magnitude *T*. What is the magnitude of the net force on the cart?



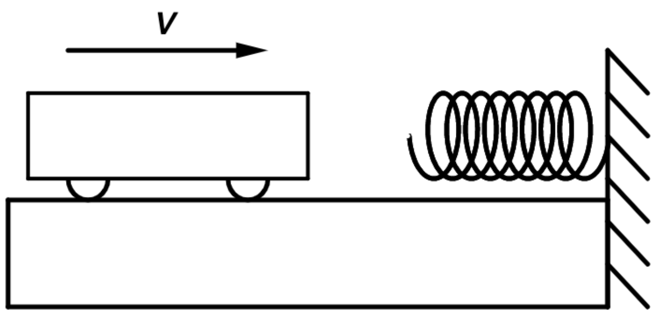
A. $(T-mg)\sin\theta$
B. $(T+mg)\sin\theta$
C. $T-mg\sin\theta$
D. $T+mg\sin\theta$

Answer: D

Explanation: There are two forces pulling both pulling in the same direction (downhill), so their magnitudes, $mg\sin\theta$ and T, will add together.

Problem 7

A cart moving at a constant speed *v* moves towards an ideal linear spring attached to a wall. The cart bounces off the spring and returns to the left again moving at speed *v*. Which of the following describes the acceleration of the cart? **Choose two correct answers**.



Choose two correct answers:

A. The cart's acceleration is zero while not in contact with the spring.
B. The cart's acceleration is constant while in contact with the spring.
C. The cart's acceleration changes direction when the cart changes direction.
D. The magnitude of the cart's acceleration is greatest when the cart is momentarily at rest.

Answers: A and D

Explanation:

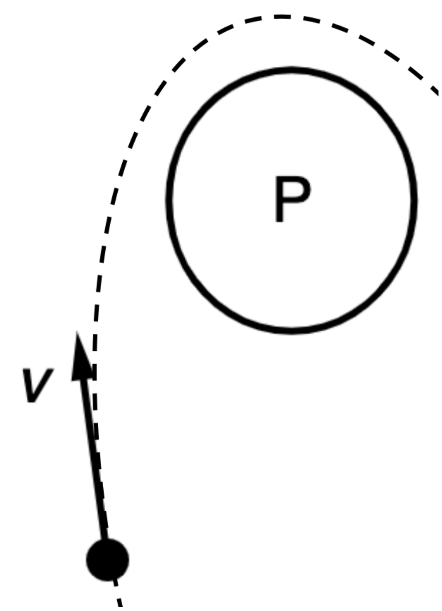
A is correct because constant speed in a straight line implies constant acceleration.

B is incorrect because the force of a linear spring changes linearly with compression, so the acceleration is also changing.

C is incorrect because the net force on the cart is due to the spring, which always points left, so the acceleration is also to the left.

D is correct because the force of a linear spring changes linearly with compression, so the greatest compression results in the greatest force.

Problem 8



An asteroid moves toward planet P on the trajectory shown, only under the influence of planet P's gravitational field. Which of the following describes the speed and the acceleration of the asteroid at this moment?

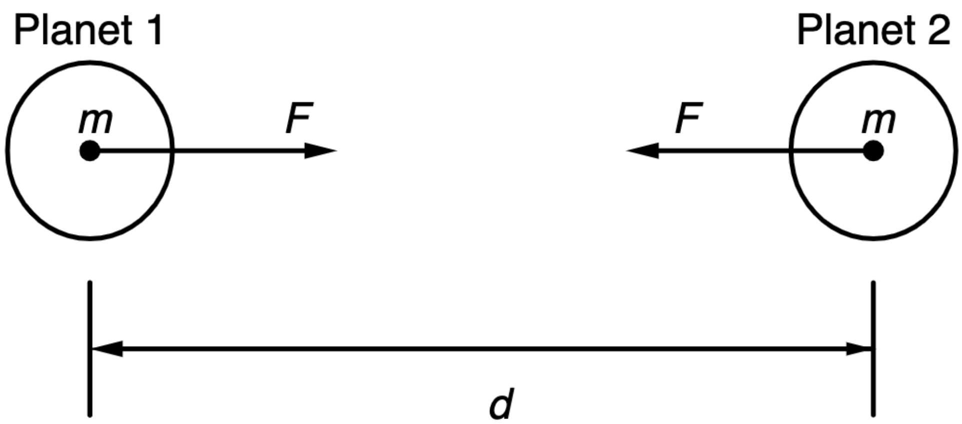
	Speed	**Magnitude of the Acceleration**
A	Increasing	Increasing
B	Increasing	Constant
C	Decreasing	Constant
D	Decreasing	Decreasing

Answer: A

Explanation:

The net force on the asteroid is the gravitational force due to the planet. Since a component of it is in the same direction as the velocity, the speed is increasing. (Or the gravitational potential energy is decreasing). Because the asteroid is getting closer, the net force is increasing due to the inverse square part of Newton's Law of Universal Gravitation, so the acceleration is increasing too.

Problem 9



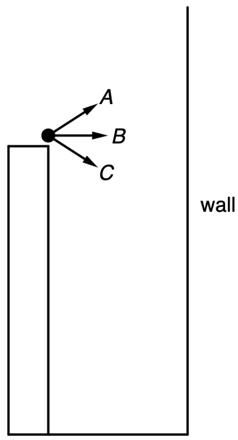
Two planets, both of mass *m,* are a distance *d* apart from each other and exert a force *F* on each other. If Planet 2 is replaced by a planet of mass 2*m*, but the same size and located at the same distance away, what will the new force on each planet be?

	Force on Planet 1 from Planet 2	**Force on Planet 2 from Planet 1**
A	F	F
B	$2F$	F
C	F	$2F$
D	$2F$	$2F$

Answer: D

Explanation: Doubling either mass doubles both forces (these are also Newton's Third Law pairs) from Newton's Law of Universal Gravitation.

Problem 10



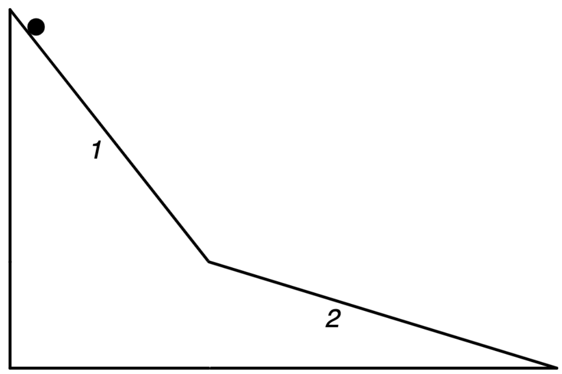
3 clay balls, labeled A, B, and C are launched from the same height at the same speed. A is launched at 30° above horizontal, B is launched horizontally, and C is launched 30° below the horizontal. They all hit the wall (before reaching the ground) in times t_A, t_B, and t_C respectively. Rank these times from least to greatest.

A. $t_A = t_B = t_C$
B. $t_B < t_C < t_A$
C. $t_B < t_A = t_C$
D. $t_B < t_A < t_C$

Answer: C

They all travel the same horizontal distance with constant horizontal velocity. B has the greatest horizontal velocity, whereas A and C have smaller horizontal velocities, equal to each other.

Problem 11



A small ball slides down a frictionless surface after being released from rest at the top. Compare the speed and acceleration of the ball at points 1 and 2.

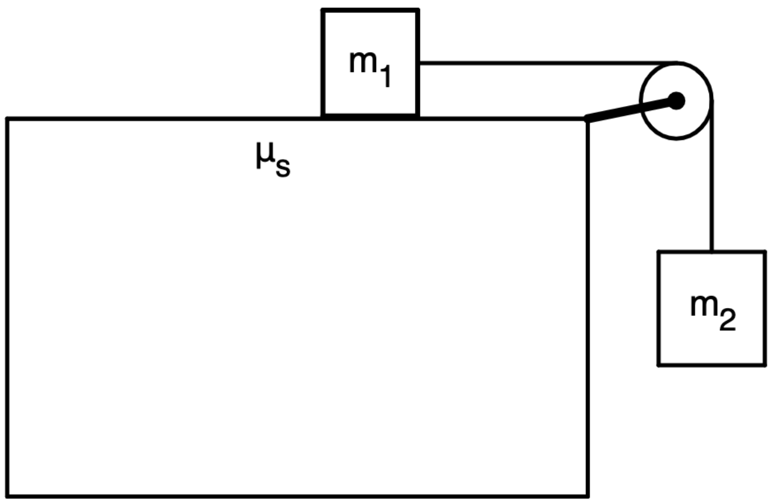
	Speed	Acceleration
A	*Greater at Point 1*	*Greater at Point 1*
B	*Greater at Point 1*	*Greater at Point 2*
C	*Greater at Point 2*	*Greater at Point 1*
D	*Greater at Point 2*	*Greater at Point 2*

Answer: C

The net force on this incline is mgsin(theta) so the acceleration is gsin(theta), so Point 1 has a greater acceleration with the steeper incline. At Point 2 it has accelerated for more time, so has reached a greater speed. You can also look at this from an energy perspective.

Problem 12

Two blocks of mass m_1 and m_2 are connected with a light string around a frictionless pulley as shown. The force of static friction between the block on the table and the table is great enough such that the blocks do not move. What is the magnitude of the force of friction?

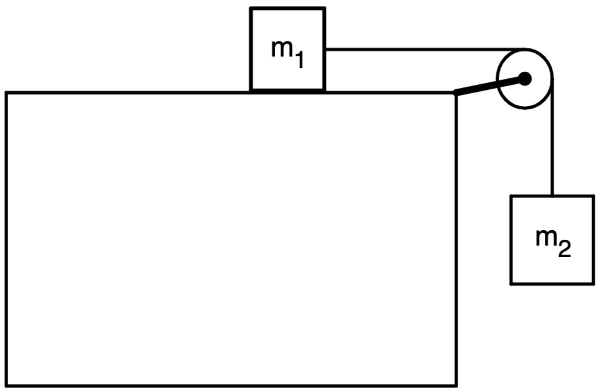


A. $\mu_s m_1 g$
B. $\mu_s (m_1+m_2) g$
C. $(m_1+m_2) g$
D. $m_2 g$

Answer: D

Explanation: Consider the system of just the two masses. The normal and gravitational force on the block on the table must balance because the table block is not accelerating vertically. The other 2 forces (gravitational force on the hanging block and friction on the table block) also must balance then. The coefficient of static friction only determines *maximum* force of static friction.

Problem 13



Two blocks of mass m_1 and m_2 are connected with a light string around a massless, frictionless pulley as shown. The surface between the table and the block is frictionless, and the block on the table is given a tap to the left. After the tap, while the block on the table is still moving left, how does the tension in the string, *T*, compare to the weight of the hanging block, m_2g?

A. $T < m_2g$
B. $T = m_2g$
C. $T > m_2g$
D. This relationship cannot be determined without knowing the ratio of the masses of the blocks.

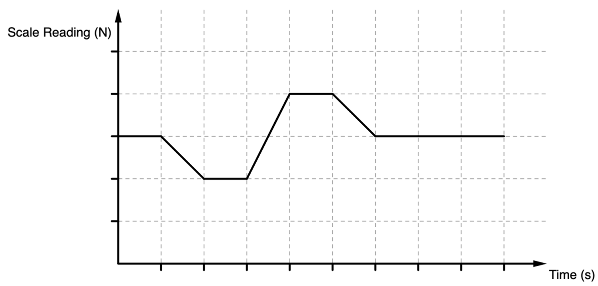
Answer: A

Explanation: The hanging mass is moving upwards, but still has a downward acceleration at this moment, because the only unbalanced external force on the system of two masses is the weight of the hanging mass. For the system of just the hanging mass, there must be net downwards force. Thus the tension pulling up must be less than the weight.

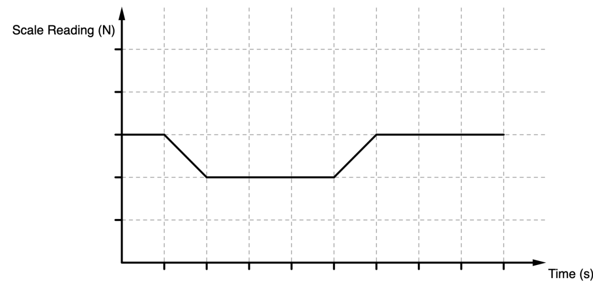
Problem 14

A student stands on a scale holding a box. At a certain moment, they suddenly lift the box over their head, then holds it there. Which of the following graphs best represents the reading of the scale over time?

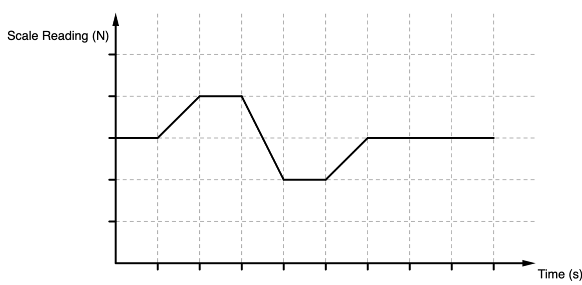
A



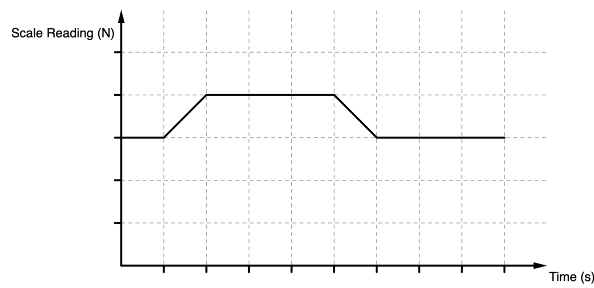
B



C



D



Answer: C

Explanation: Many ways to think about this. One way: while the center of mass of the person-box system is accelerating upwards, the normal force must be greater than their total weight. When the center of mass slows down moving upwards (downward acceleration), the normal force must be less than the total weight. At the beginning and end, the normal force is equal to the total weight.

Problem 15

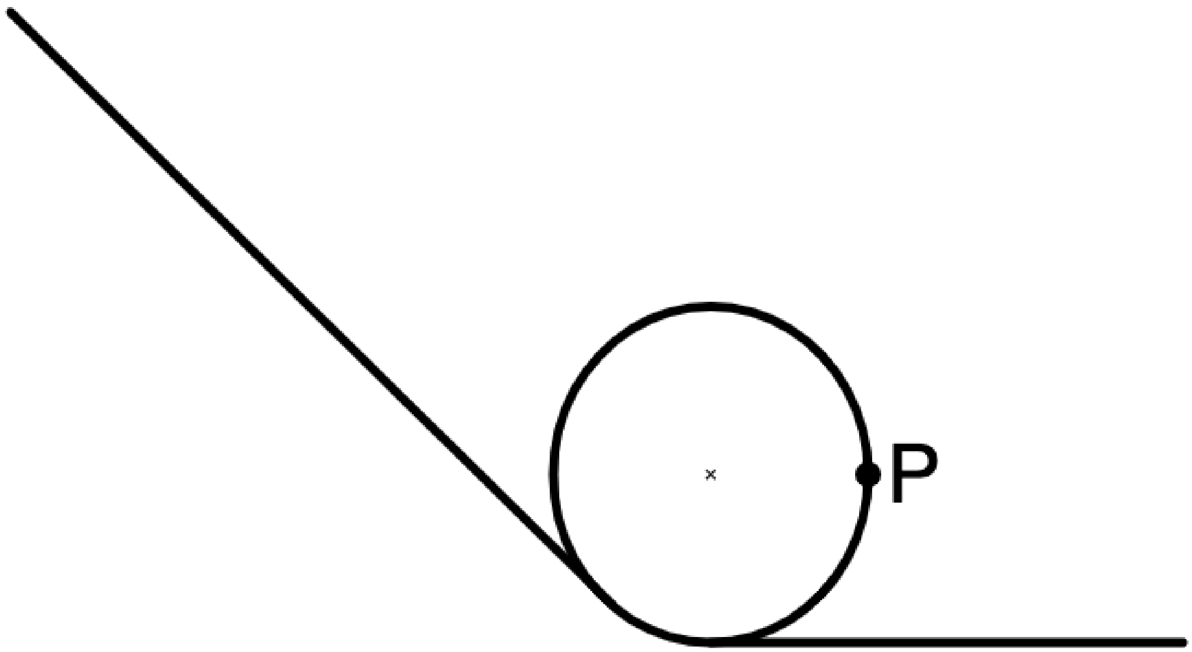
An astronaut is stuck at rest relative to a spacecraft, 15 meters away. Which of the following would be the most effective method to allow the astronaut's center of mass to move closer to the spacecraft?

A. The astronaut swings their arms quickly towards the spacecraft, then slowly away many times in a row.
B. The astronaut swings their arms quickly away from the spacecraft, then slowly towards it, many times in a row.
C. The astronaut throws a rock towards the spacecraft.
D. The astronaut throws a rock away from the spacecraft.

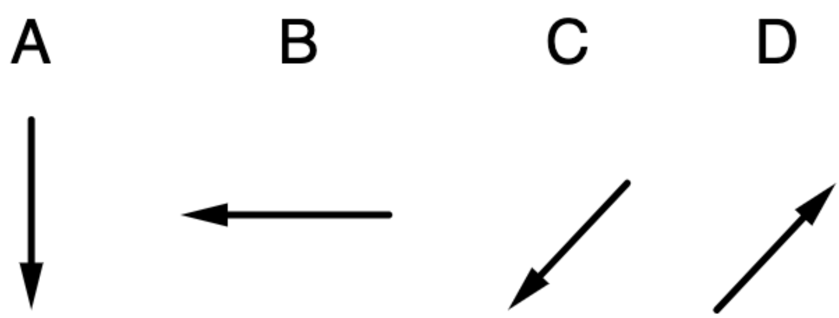
Answer: D

Newton's Third Law, there will be an equal and opposite force on the astronaut towards the spacecraft if they throw it away from the spacecraft.

Problem 16



A block is released from rest on the frictionless ramp and loop-de-loop. When the block reaches point P it is moving upward and the magnitude of the normal force from the surface is equal to the block's weight. In which direction is the block's acceleration at this time?



Answer: C

Explanation: Only two forces act on the block, normal and gravitational force. Normal force points left (away from the surface) and the gravitational force points down. The prompt says they are equal, so the net force, and thus the acceleration must point down and to the left.

Problem 17

Two rocks are thrown vertically upwards. Rock A (mass = 3 kg) is thrown upwards at 5 m/s. Rock B (m = 6 kg) is thrown upwards at 10 m/s. Which of the following describes the time taken to reach their respective maximum heights and the magnitude of the net force acting on them at their maximum height?

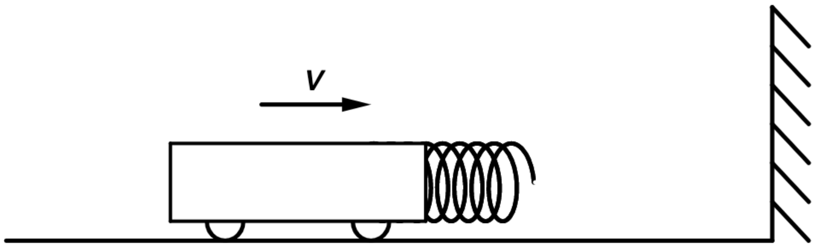
	Time taken to reach its own maximum height	**Magnitude of the Net Force at its own maximum height**
A	*Greater for Rock A*	*Same for both rocks*
B	*Greater for Rock A*	*Greater on Rock B*
C	*Greater for Rock B*	*Same for both rocks*
D	*Greater for Rock B*	*Greater on Rock B*

Answer: D

Explanation: Both objects are uniformly accelerated downward with the same acceleration (not dependent on their mass), so Rock B will take a longer time to stop moving upwards. The net force is *mg* downwards the whole time, which does depend on the mass, and is greater on Rock B.

Problem 18

A cart with ideal linear spring attached collides with a wall. The cart has mass *m* and speed *v*, and the spring compresses a maximum distance of Δx. A second cart with mass 4*m*, speed 2*v*, but with the same linear spring attached, also collides with the wall. What will the maximum spring compression be for the second cart?



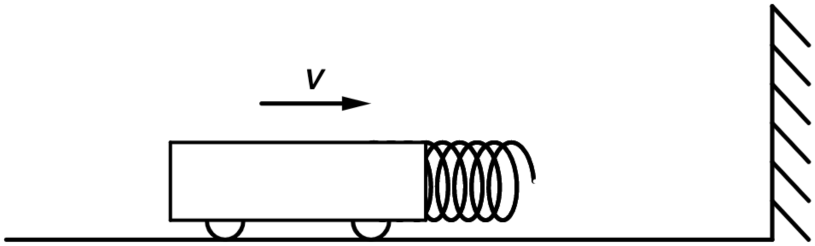
A. $4\Delta x$
B. $6\Delta x$
C. $8\Delta x$
D. $16\Delta x$

Answer: A

Explanation:
Using conservation of energy $\frac{1}{2}mv^2 = \frac{1}{2}k\Delta x^2$
-> $\Delta x = \text{sqrt}(m/k)v$

Quadrupling the mass results in a factor of 2 times the compression, and so does doubling the speed, so in total there is 2*2 more times the compression.

Problem 19



A cart with attached spring moving at speed *v* collides elastically with a wall, bouncing backwards with an equal speed *v*. Which of the following describe the total work done on and net impulse applied to the cart-spring system by the wall during this collision?

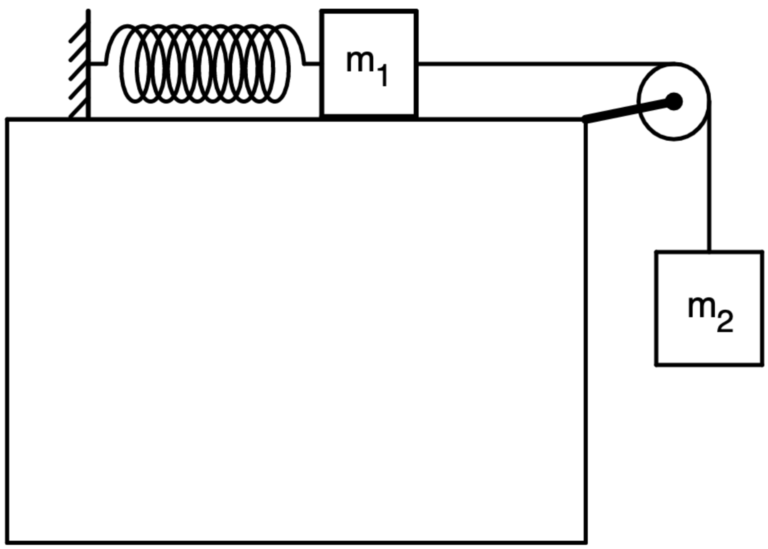
	Total work done on the cart-spring system by the wall	Net impulse applied to the cart-spring system by the wall
A	Zero	Zero
B	Zero	Non-zero
C	Non-zero	Zero
D	Non-zero	Non-zero

Answer: B

There is no net change in kinetic energy and also the contact point that the force was applied to didn't move, so no work was done on the cart-spring system. There was an impulse (F*Δt) and the direction of the cart's momentum vector changed (even though its magnitude did not).

Problem 20

Two masses are connected by a light string as shown below. The mass on the table can slide without friction. The spring has force constant *k*, and the system is released from rest with the spring initially at its natural relaxed length of L_0. Which of the following is an expression for the maximum length of the spring?



A. $L_0 + \frac{m_2 g}{k}$

B. $L_0 + \frac{2m_2 g}{k}$

C. $L_0 + \frac{(m_1+m_2)g}{k}$

D. $L_0 + \frac{2(m_1+m_2)g}{k}$

Answer: B

Explanation: At the maximum stretch, the kinetic energy will be zero, so the change in spring potential energy will be equal to the change in gravitational potential energy.

Let x be the stretch of the spring.

$1/2kx^2 = m_2gx$

$1/2kx = m_2g$

$x = 2m_2g/k$

Problem 21

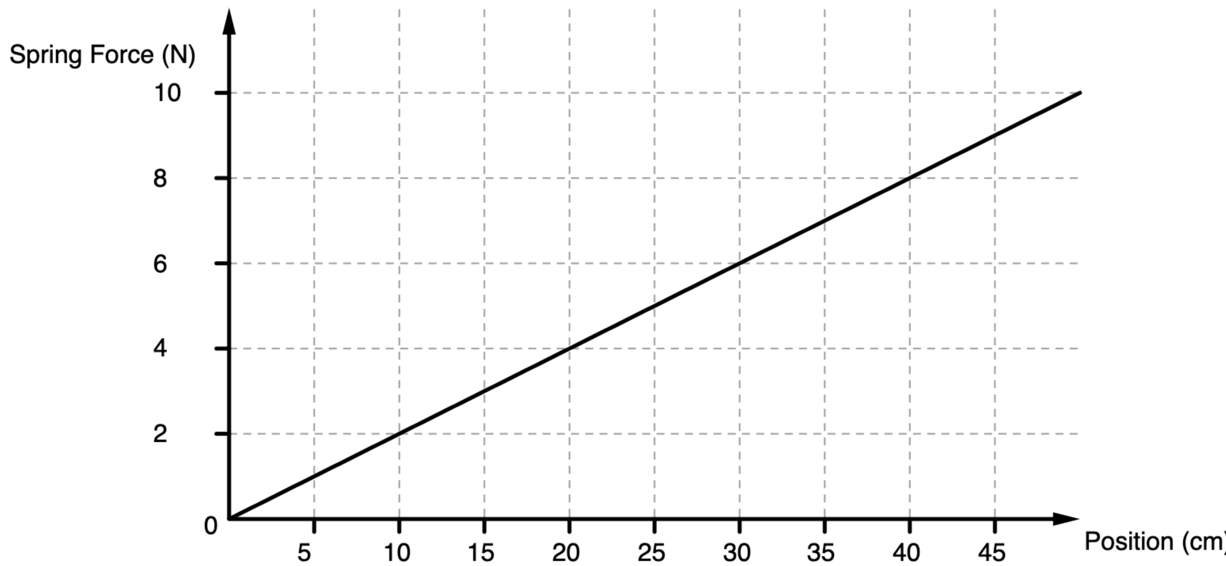
A block slides down a hill at a constant speed. Which of the following describes the mechanical energy of just the block (E_{block}) and the mechanical energy of the block-Earth system ($E_{block\text{-}Earth}$)?

	E_{block}	$E_{block\text{-}Earth}$
A	Stays constant	Stays constant
B	Stays constant	Decreases
C	Decreases	Stays constant
D	Decreases	Decreases

Answer: B

Explanation: The mechanical energy of just the block is just its kinetic energy, which is constant because its mass and speed are constant. The mechanical energy of the block-Earth system decreases because it includes the decrease in gravitational potential energy (but not the increase in thermal energy which is not mechanical energy).

Problem 22



A force meter is used to pull a block of unknown mass (on a frictionless table) attached to a spring fixed to a wall and the reading is plotted against the position of the force meter. Which of the following could be determined from this graph? **Choose two correct answers.**

A. The spring force constant of the spring.
B. The acceleration of the block at a given position if released from rest on a frictionless table.
C. The work done on the spring-block system to stretch it by 50 cm.
D. The distance the spring will stretch if hung vertically.

Answer: A & C

Explanation:
A: Can be determined from the slope of this graph
B: Need to know mass to know this.
C: Can be determined from the area under the curve
D: Need to know the mass to know this.

Problem 23

Two carts, one mass *m*, the other mass 2*m,* are compressed the same distance *d* against identical springs and released from rest. They separate from the springs and collide and stick together. In which direction will the two carts move after the collision?

A. Left
B. Right
C. The two carts will stop in the center.
D. The direction depends on the relationship between *mg* and *kd*.

Answer: A

Explanation: The two cart system starts with zero momentum. The same energy is stored in both springs, but the right spring applies a greater impulse to the larger cart (same average force but for a longer time), so it will have more momentum and continue moving in the same direction after the collision.

Problem 24

Two carts, one mass *m*, the other mass 2*m,* are compressed the same distance *d* against identical springs with spring constant *k* and released from rest. They separate from the springs and collide and stick together. Which spring does more work on the cart that it pushes?

A. The spring on the left pushing the cart of mass *m*.
B. The spring on the right pushing the cart of mass 2*m*.
C. The springs do the same amount of work, zero.
D. The springs do the same amount of work, a positive amount.

Answer: D

Explanation: Each spring increases one cart's energy by $\frac{1}{2}kd^2$.

Problem 25

A clay ball is shot and sticks to a side wall inside of a cart that is free to roll on a floor. In which direction is the cart moving just after the clay is shot and just after the collision with the wall?

	Cart's direction of motion just after shot	Cart's direction of motion just after stick
A	Leftward	Rightward
B	Leftward	Leftward
C	Leftward	No motion
D	No motion	Rightward

Answer: C

Using conservation of momentum or Newton's Third Law, there must be a force pushing the cart to the left during the shooting of the clay. Momentum is conserved for the cart clay system because there are no external net forces though. In addition, the total momentum at the beginning was zero. So when the clay sticks to the cart, they both come to rest.

Problem 26

Cart 1 (m_1 = 3 kg) and Cart 2 (m_1 = 2 kg) move towards each other at speeds of v_1 = 3 m/s and v_2 = 4 m/s respectively, as shown above. They stick together during the collision. Which of the following is true about the collision?

A. The cart with more kinetic energy will continue moving forward after the collision.
B. The impulse on each cart will have the same magnitude.
C. The kinetic energy will stay the same before and after the collision.
D. The more massive cart will have a greater change in velocity.

Answer: B

Explanation: Cart 1 has more momentum, while Cart 2 has more kinetic energy. They do apply equal and opposite forces to each other for equal times, so the impulses on each will be equal.

Problem 27

A block with momentum *p* is sliding on a frictionless table and a student uses a force probe to bring it to a stop. In combination with a motion detector, the student plots a force-time and force-distance graph. Which of the following would be an estimate of *p*?

A. The slope of the force-time graph
B. The area under the force-time graph
C. The slope of the force-distance graph
D. The area under the force-distance graph

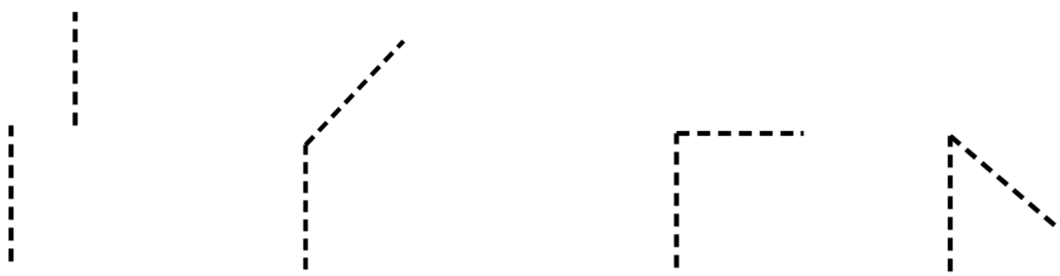
Answer: B

Explanation: Area under the force-time graph is equal to the impulse, which in turn is equal to the change in momentum. Since the block ends with zero momentum, p = the change in momentum = area under force-time graph.

Problem 28

A 2 kg puck travelling north at 5 m/s on frictionless ice is given a short 10 N•s impulse to the east. Which of the following is a possible path taken by the puck?

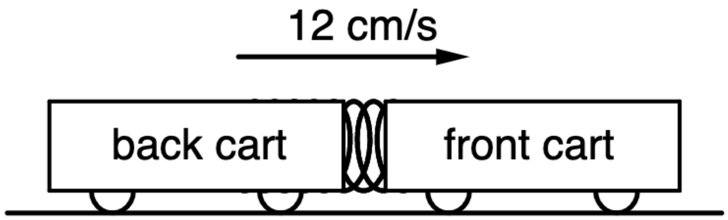
A. B. C. D.



Answer: B

Explanation: The puck will still have all of its northward momentum, but now also an equal amount of eastward momentum, resulting in a northeast momentum.

Problem 29



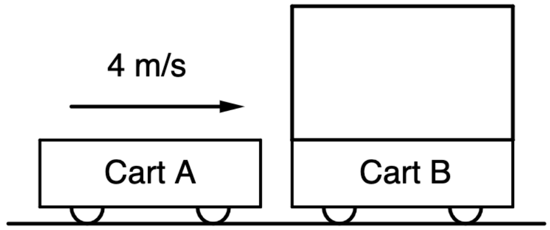
A spring loaded system consisting of two equal mass carts is moving to the right at 12 cm/s on a frictionless surface when at t = 0, the spring is released. The front cart travels 32 cm from t = 0s to t = 2s. How far does the back cart travel between t = 0s to t = 2s and in what direction?

A. 16 cm to the right
B. 8 cm to the right
C. 8 cm to the left
D. 16 cm to the left

Answer: A

Explanation: During the “explosion” the two carts each must change momentum by equal and opposite amounts. Since they are equal mass, this means that they must change velocity by equal and opposite amounts. The front cart is now apparently moving 16 cm/s (24 cm in 2 s), so changed by +4 cm/s, so the back cart must change by -4 cm/s, to +8 cm/s. Thus it will move +16 cm in 2 seconds.

Problem 30



Cart A (mass = *m*) moving at 4 m/s collides elastically with Cart B (mass = 3*m*), initially at rest. After the collision, Cart B is moving forward at 2 m/s. How fast and in what direction is Cart A moving after the collision?

A. 2 m/s to the right
B. 0 m/s
C. 2 m/s to the left
D. 4 m/s to the left

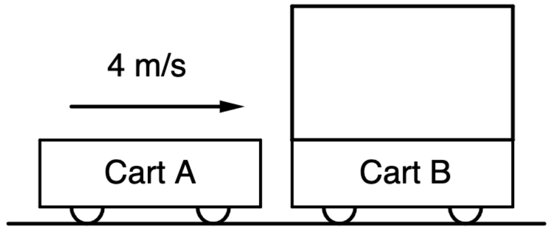
Answer: C

Explanation: One could use conservation of momentum. I remember this:

- During an elastic collision when one object one starts at rest,
    - if the masses are equal the first objects stop.
    - If the moving object has more mass, it keeps moving forward.
    - If the moving object has less mass, it bounces back.

However, it can't bounce back at the same speed, because this wouldn't conserve energy.

Problem 31



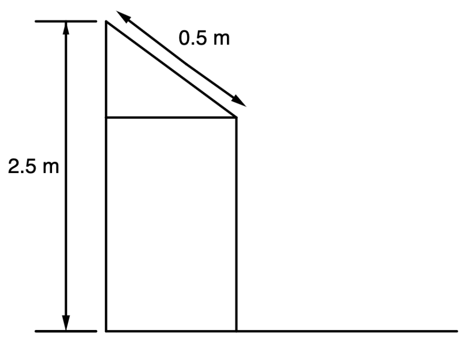
Cart A (mass = *m*) moving at 4 m/s collides elastically with cart B (mass = 3*m*), initially at rest. After the collision Cart B is moving forward at 2 m/s. What percentage of Cart A's original kinetic energy does Cart B have after the collision?

A. 25 %
B. 50 %
C. 75 %
D. 100 %

Answer: C

Without loss of generality, set m = 1kg. Using $K = \frac{1}{2}mv^2$, Cart A starts with 8 J, and Cart B ends with 6 J

Problem 32



(Drawing not to scale)

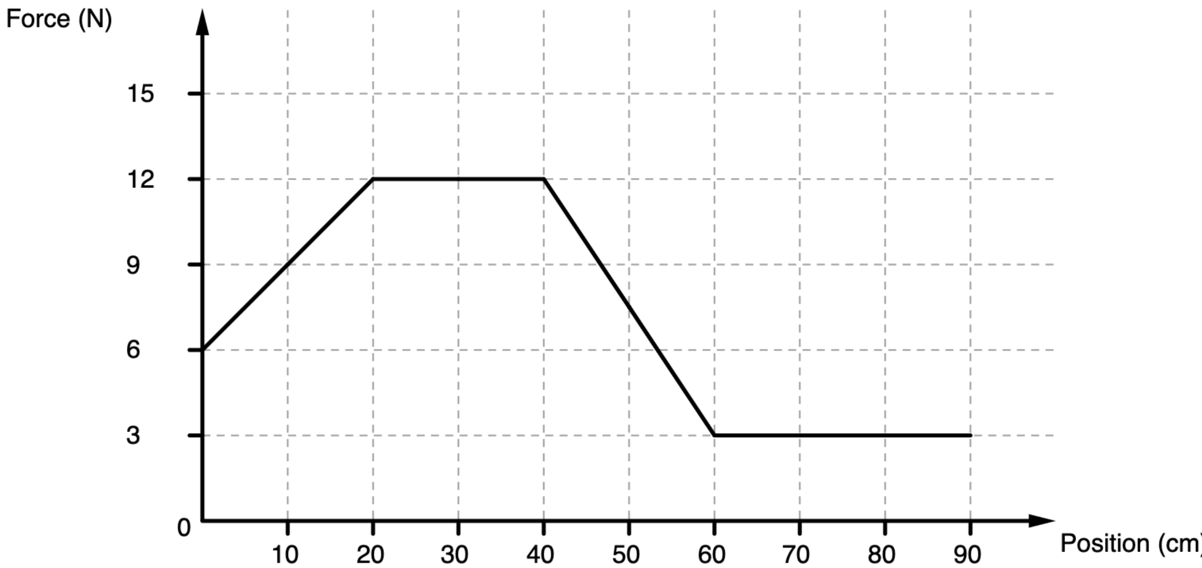
A 2 kg block is released from rest 2.5 meters above the ground on a 0.5 meter long ramp where the block experiences a force of friction equal to 10 Newtons. What is the block's kinetic energy just before reaching the ground?

A. 5 J
B. 40 J
C. 45 J
D. 50 J

Answer: C

Setting h=0 on the ground. The block-Earth system starts with energy equal to mgh = 2kg*10N/kg*2.5m = 50 J. It loses F*d = 10N*0.5m = 5J on the ramp.

Problem 33



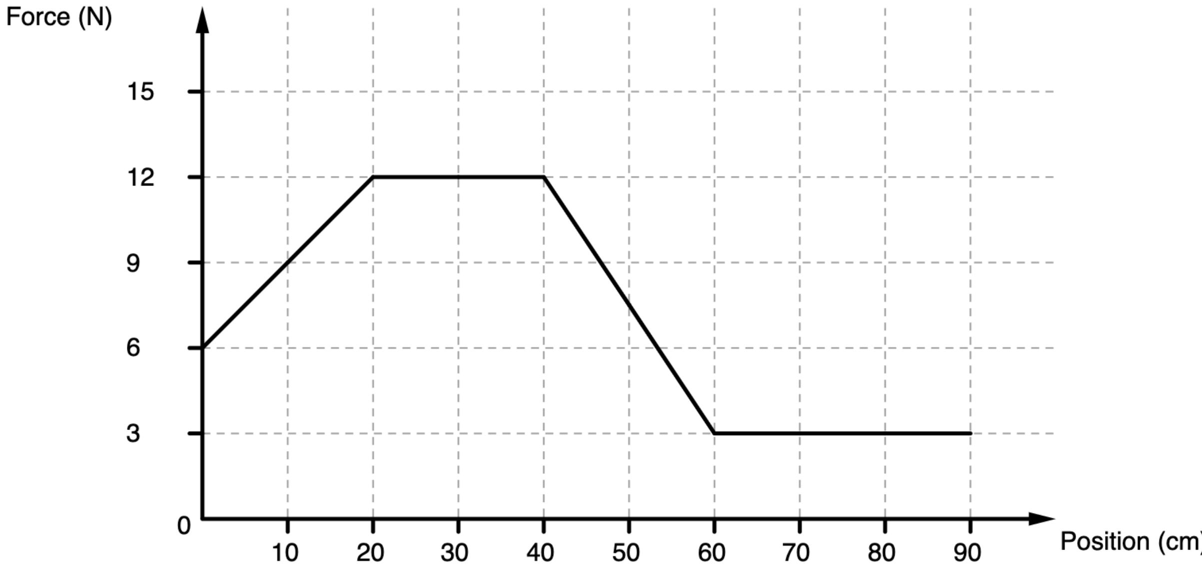
Starting from rest a frictionless cart is pushed horizontally with a force probe, and the graph of force vs. position is shown in the above. During what section was the change in the cart's kinetic energy the greatest?

A. 0 - 20 cm
B. 20 - 40 cm
C. 40 - 60 cm
D. 60 - 90 cm

Answer: B

The work done is equal to the area under the graph, which is equal to the change in kinetic energy. The area is greatest between 20 cm and 40 cm.

Problem 34



Starting from rest a frictionless cart is pushed horizontally with a force probe and the graph of force vs. position is shown in the above. During what 20 cm section was the time to travel that section the shortest?

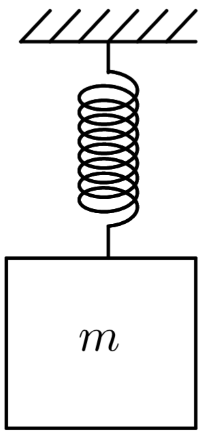
A. 0 - 20 cm
B. 20 - 40 cm
C. 40 - 60 cm
D. 60 - 80 cm

Answer: D

The kinetic energy increases the entire time, so the cart is moving the fastest at the end.

Problem 35

A block with known mass, *m*, is hung vertically from a spring with unknown spring force constant and brought to rest. Which of the following measurements, if recorded on its own, would NOT allow someone to calculate the spring constant with the known mass?

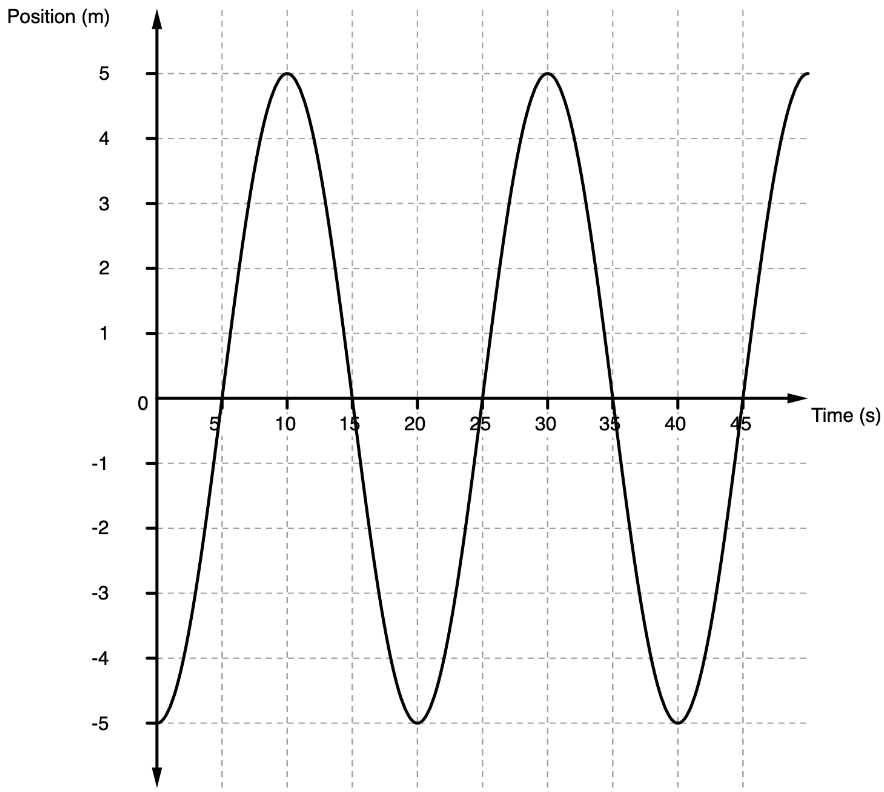


A. Measure the distance that the spring stretches from its natural length when hanging at rest.
B. Pull the mass downward, release, and measure the time it takes to complete one oscillation.
C. Pull the mass downward, release, and measure the distance between the highest and lowest points of the oscillation.
D. Hold the mass such that the spring is relaxed, release, and measure the distance between the highest and lowest points of the oscillation.

Answer: C
A: You can balance forces to determine k
B: You can use period of a mass-spring system
C: This is simply twice the amplitude. The amplitude only depends on how far it was pulled down from equilibrium in the first place, so no information about the spring constant is contained in this distance.
D: You can use conservation of energy, setting the change in gravitational potential equal to the change in spring potential energy.

Problem 36

A mass-spring system is stretched, released from rest, and undergoes simple harmonic motion with its position-time graph shown below. What is the first time after the release the kinetic energy of the block reaches a minimum?



A. 5 s
B. 10 s
C. 15 s
D. 20 s

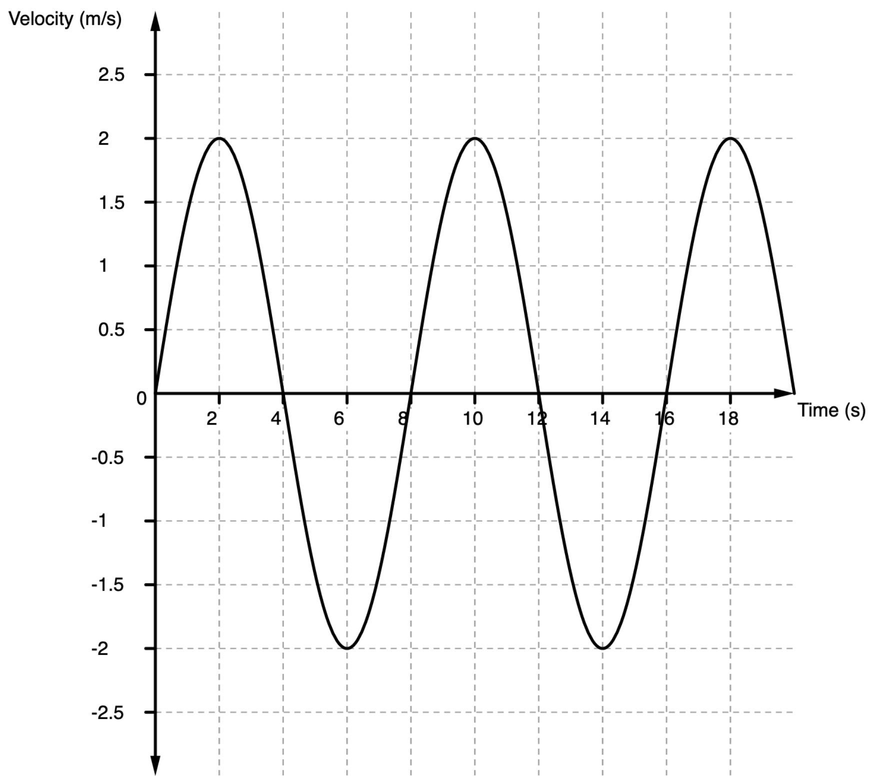
Answer: B

Explanation:

The kinetic energy is minimum and zero when the speed is zero, which is at the extreme positions and when the slope is zero.

Problem 37

A mass-spring system is stretched, released from rest, and undergoes simple harmonic motion with its velocity-time graph shown below. Which of the following is equal to the distance from the equilibrium position that the mass was initially stretched?



A. The peak of the curve at Time = 2 s
B. The slope of a line connected the origin to the peak of the curve at Time = 2 s
C. The area under the curve between Time = 0 s and Time = 2 s
D. The average value of the curve between Time = 0 s and Time = 2 s

Answer: C

Explanation:

The area under the curve is the change in position. The position changes by a distance equal to the amplitude when the velocity goes from zero to its maximum value.

Problem 38

Which of the following would allow for an experimental estimate of the free fall acceleration on a given planet? Choose two correct answers.

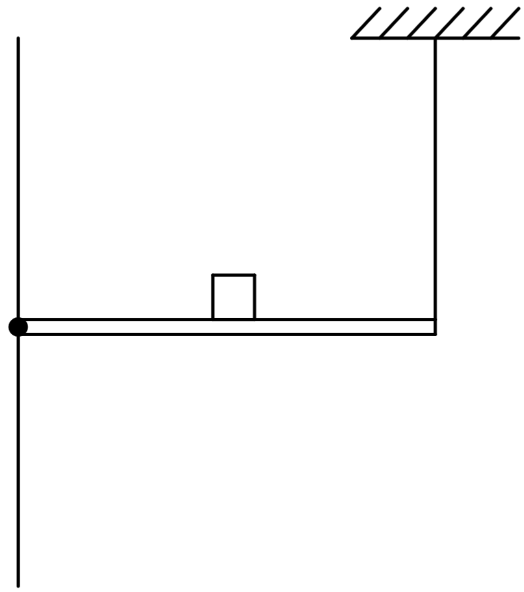
A. Drop a ball from 2.0 meters high and measure the maximum height it rebounds to.
B. Time a solid sphere released from rest and rolling without slipping down a 1.0 meter long ramp angled at 30° above horizontal.
C. Measure the period of 1.5 m long pendulum pulled to an amplitude of 5°.
D. Measure the period of a 250g mass oscillating vertically on a 4 N/m spring.

Answers: B and C

A is incorrect because it depends on the material and height dropped from, not *g.*
B is correct, the acceleration is gsin(theta), and you have time, initial velocity, and displacement.
C is correct because you can use the period of a pendulum equation.
D is incorrect because the period depends on the mass and spring constant, not *g.*

Problem 39

Pictured below is a box at rest on a beam, held up by a frictionless pivot on the left and a rope on the right. The box is currently at the center of the beam. If the box were to be moved to the right side of the beam, what would happen to the tension in the rope and the force on the pivot?



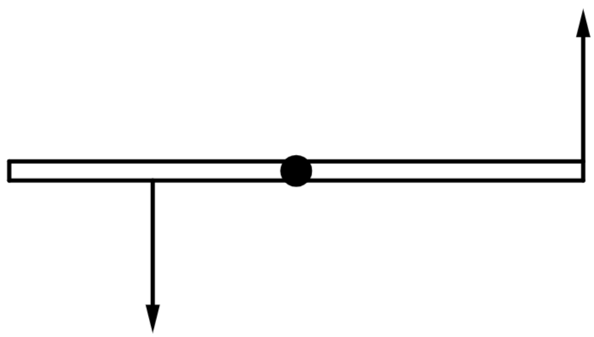
A. The tension in the rope and the force on the pivot would both increase.
B. The tension in the rope would increase, while the force on the pivot would stay the same.
C. The tension in the rope would increase, while the force on the pivot would decrease.
D. Both forces would remain the same.

Answer: C

Explanation: Balancing torques with the axis of rotation at the pivot, the box now applies a greater clockwise torque, so the rope needs to apply a bigger counterclockwise torque to balance. The pivot cannot apply a torque about itself. However, now there is a greater upwards force of tension, and the downwards forces have not changed, so the upward force from the pivot (and thus the downwards force on the pivot) decreases.

Problem 40

A uniform rod is spinning clockwise around a frictionless pivot located at the rod's center, when at a certain moment two forces of equal magnitude are exerted on the rod, as shown below (top view). Which of the following describes what is happening to the angular speed of the rod about the pivot, and the force of the pivot on the rod?



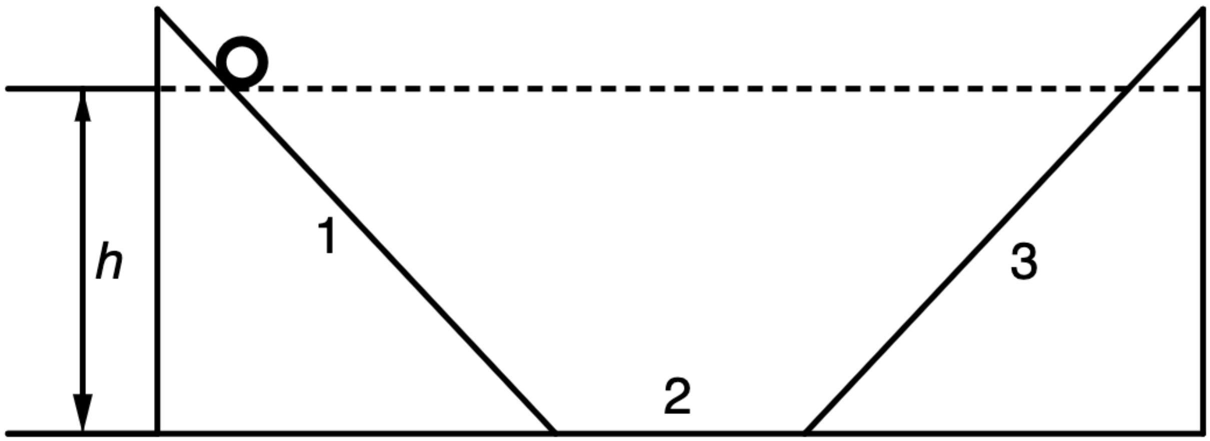
	Angular Speed	Force of the pivot on the rod
A	Decreasing	Zero
B	Constant	Zero
C	Decreasing	Upward
D	Constant	Upward

Answer: A

Explanation: The two forces cause a net torque about the pivot, but not a net force.

Problem 41

Two ramps are set-up as shown. The ball rolls without slipping on surfaces 1 and 2, while surface 3 is frictionless. Which of the following describes the maximum height that the ball will reach on surface 3 if released from rest on surface 1 at height *h*?



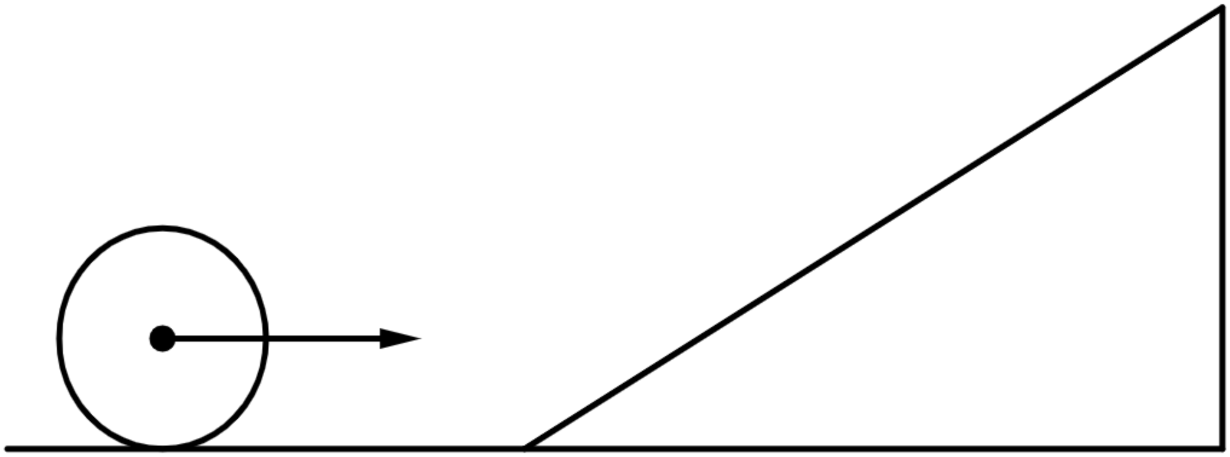
A. Greater than *h*
B. Equal to *h*
C. Less than *h* but greater than zero
D. Zero

Answer: C

Explanation:

The rotational kinetic energy stays constant on the way up the second ramp, with no torque from friction to change the angular velocity. Thus, the gravitational potential cannot reach the same level as before.

Problem 42



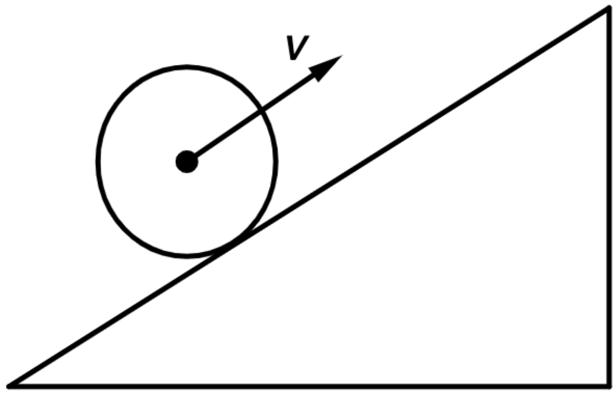
A solid cylinder rolls without slipping, encounters a ramp and rolls to a maximum height h. If a hollow cylinder with the same mass and initial translational velocity encounters the same ramp while rolling without slipping, what vertical height will it reach?

A. Greater than h
B. Equal to h
C. Less than h but greater than zero
D. Zero

Answer: A

The hollow cylinder has the same translational kinetic energy, but more rotational energy to begin with than the solid cylinder. This all converts to gravitational potential energy.

Problem 43



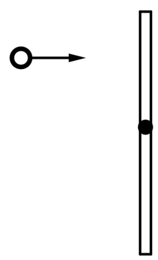
A solid cylinder rolls without slipping up a ramp. While rolling up the ramp, in what direction is the net force on the cylinder and net torque about its center of mass?

	Net Force	**Net Torque about the center of mass**
A	Down the hill	Clockwise
B	Down the hill	Counterclockwise
C	Up the hill	Clockwise
D	Up the hill	Counterclockwise

Answer: B

The net force is the mgsin(theta) - static friction force, which we know points downhill to decrease the translational speed of the cylinder. Since the translational speed is decreasing and it is rolling clockwise without slipping, there must be a counterclockwise torque (this time due just to friction) about the center of mass.

Problem 44



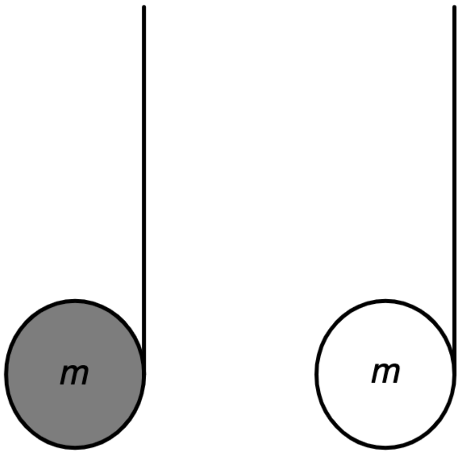
On a frictionless surface, a puck slides towards, and elastically bounces off of a rod which is fixed to a frictionless pivot (above is a top view). Which of the following are conserved in the puck-rod system during this collision?

I. Energy
II. Translational Momentum
III. Angular Momentum about the pivot

A. I & II only
B. I & III only
C. II & III only
D. I, II, & III

Answer: B
Energy is conserved because the collision is elastic. Translational momentum is not conserved because the pivot applies a net external force to prevent the center of mass of the rod from translating forward. Angular momentum is conserved because there is zero external torque about the pivot in the puck-rod system.

Problem 45



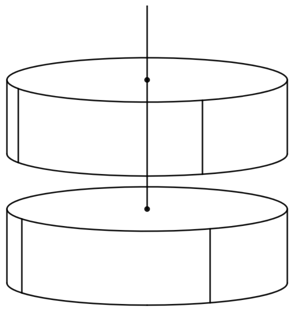
Two equal mass cylinders with strings wrapped around them are released from rest from the same height above the ground so that they rotate without slipping. The cylinder on the left is solid, while the cylinder on the right is hollow. Which cylinder hits the ground first and which cylinder's string has a greater tension?

	Hits the ground first	**Greater tension in its string**
A	Solid cylinder	Solid cylinder
B	Solid cylinder	Hollow cylinder
C	Hollow cylinder	Solid cylinder
D	Hollow cylinder	Hollow cylinder

Answer: B

Explanation: The hollow cylinder has a greater rotational inertia, and because they are in a sense rolling without slipping, this affects how fast they will translate downwards. The solid cylinder has more mass that doesn't need to rotate as much, so will hit the ground first. Using Newton's Second Law, the tension (upward force) must be greater on the hollow cylinder, to cause a smaller acceleration.

Problem 46



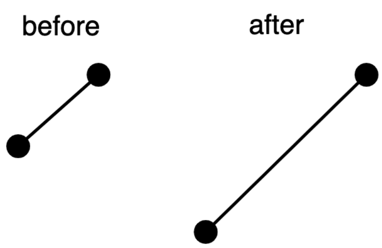
A cylinder spinning counterclockwise is dropped onto a different cylinder spinning clockwise (both as viewed from the top) about a vertical axis. The two cylinders stick together and both spin counterclockwise. Which of the following can be concluded for certain from this observation?

A. The dropped cylinder has a greater mass.
B. The dropped cylinder has a greater rotational inertia about the center vertical axis.
C. The dropped cylinder had a greater angular momentum about the center vertical axis before the collision.
D. The dropped cylinder had a greater rotational kinetic energy about the center vertical axis before the collision.

Answer: C

Angular momentum is conserved in this collision, so the dropped cylinder must have had a greater angular momentum to keep spinning in the same direction. If the dropped cylinder had a smaller enough angular velocity (made up for by a greater rotational inertia) it is possible that it had a smaller rotational kinetic energy, but a greater angular momentum.

Problem 47



A toy consisting of two identical spheres attached by a light string is thrown upwards with a clockwise rotation about its center of mass. As it moves upward, the string stretches out. Which of the following describes what happens to the angular momentum and the rotational kinetic energy about the center of mass of the two-sphere system?

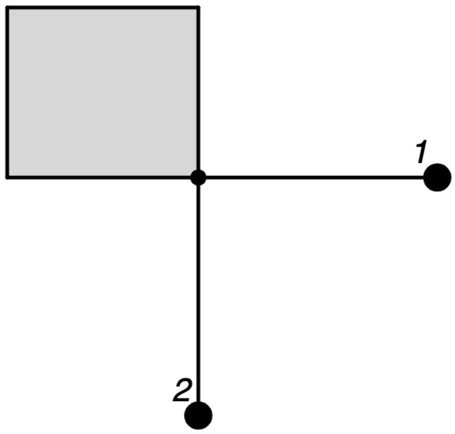
	Angular Momentum	**Rotational Kinetic Energy**
A	Stays constant	Decreases
B	Stays constant	Stays constant
C	Increases	Increases
D	Decreases	Stays constant

Answer: A

The angular momentum is conserved, so the angular speed decreases by the same factor that the rotational inertia increases. However, the rotational kinetic energy is proportional to the rotational inertia and the angular speed *squared* so the decrease in angular speed will overcome the increase in rotational inertia.

Problem 48

A pendulum bob attached to a light string is held horizontally and released from rest at position 1 and swings down through position 2. What is the magnitude and direction of the bob's acceleration at position 2?

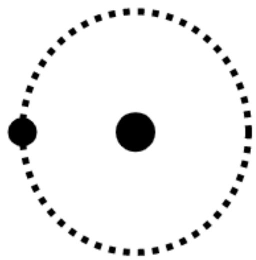


	Magnitude of the Acceleration at Point 2	Direction of the Acceleration at Point 2
A	g	Down
B	2g	Down
C	g	Up
D	2g	Up

Answer: D

Explanation: Using conservation of energy, the speed will be v = sqrt(2gL) where L is the length of the string. Since the pendulum is moving in a circle a = v^2/r at point 2, towards the center of the circle (up). Since L = r for this situation, a = 2gL/L = 2g.

Problem 49



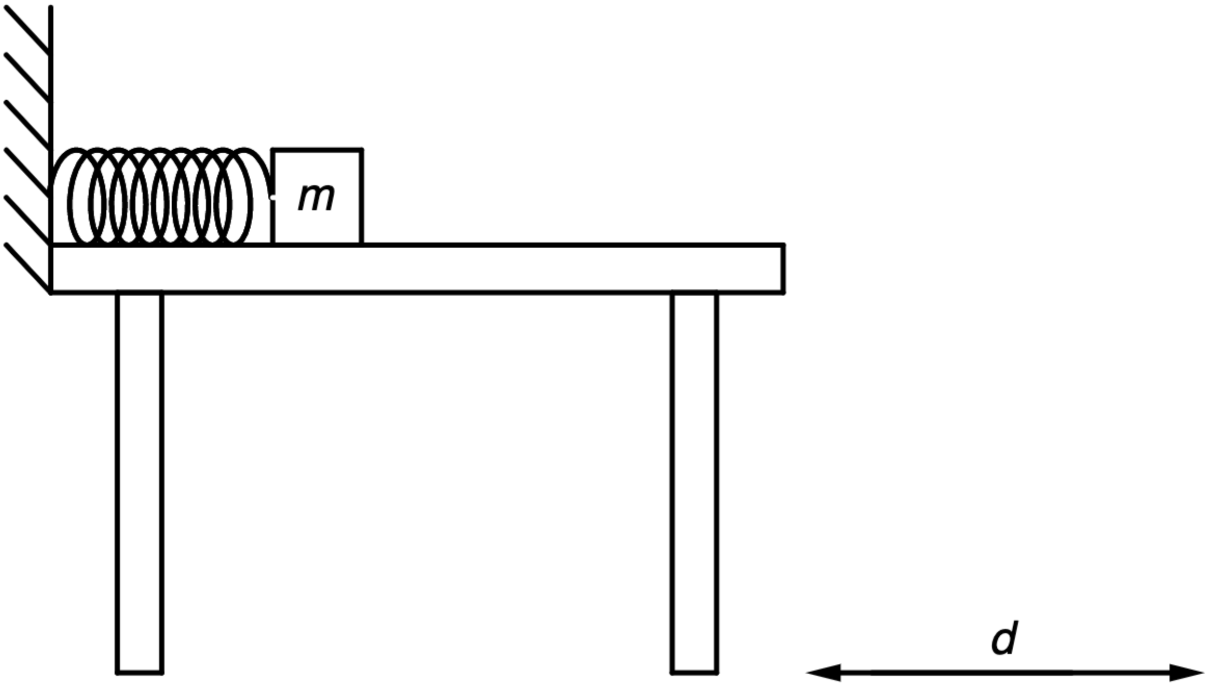
A planet orbits a star in a circular orbit. Which of the following best explains why the kinetic energy of the planet is constant.

A. The net force on the planet is zero.
B. There is only one force on the planet.
C. The net force on the planet is always parallel to its direction of motion.
D. The net force on the planet is always perpendicular to its direction of motion.

Answer: D

There can only be net work done to change the kinetic energy of an object if the net force has a component that is parallel to the direction of motion.

Problem 50



A block with mass m is compressed against a spring a distance Δx on a frictionless table, released, separates from the spring and lands a horizontal distance d away from the table with a kinetic energy K. If the block is replaced with a block of greater mass and the experiment is repeated, what will happen to the horizontal distance travelled and the kinetic energy just before landing?

	New horizontal distance traveled in the air	New kinetic energy just before landing
A	Equal to d	Equal to K
B	Equal to d	Greater than K
C	Less than d	Equal to K
D	Less than d	Greater than K

Answer: D

Explanation: The energy of the spring-block-Earth system is conserved in both cases, but the one with more mass will change gravitational potential energy by more, so the kinetic energy just before landing will be more. The block will be moving slower, so it will land at a distance less than d.