A particle of mass *m* is launched from a height *h* at a velocity of 15 m/s at an angle of 35° above the horizontal over flat level ground. Where in the trajectory of the particle is the potential energy of the particle greatest?

a) At the first instant after launch.
b) While it is on the way up.
c) At the highest point in its trajectory.
d) While it is on the way down.
e) At ground level, the lowest point achieved prior to actual contact with the ground.
f) Nowhere.

A particle of mass m is launched from a height $h > 0$ at a velocity of 15 m/s at an angle of 35° above the horizontal over flat level ground. Where in the trajectory of the particle is the potential energy of the particle a minimum?

a) At the first instant after launch.

b) While it is on the way up.

c) At the highest point in its trajectory.

d) While it is on the way down.

e) At ground level, the lowest point achieved prior to actual contact with the ground.

f) Nowhere.

A particle of mass *m* is launched from a height *h* at a velocity of 15 m/s at an angle of 35° above the horizontal over flat level ground. Where in the trajectory of the particle is the kinetic energy of the particle zero?

a) At the first instant after launch.
b) While it is on the way up.
c) At the highest point in its trajectory.
d) While it is on the way down.
e) At ground level, the lowest point achieved prior to actual contact with the ground.
f) Nowhere.

A particle of mass *m* is launched from a height *h* at a velocity of 15 m/s at an angle of 35° above the horizontal over flat level ground. Where in the trajectory of the particle is the kinetic energy of the particle greatest?

a) At the first instant after launch.
b) While it is on the way up.
c) At the highest point in its trajectory.
d) While it is on the way down.
e) At ground level, the lowest point achieved prior to actual contact with the ground.
f) Nowhere.

A particle of mass *m* is launched from a height *h* at a velocity of 15 m/s at an angle of 35° above the horizontal over flat level ground. Where in the trajectory of the particle is the kinetic energy of the particle a minimum?

a) At the first instant after launch.
b) While it is on the way up.
c) At the highest point in its trajectory.
d) While it is on the way down.
e) At ground level, the lowest point achieved prior to actual contact with the ground.
f) Nowhere.

A particle of mass m is launched from a height h at a velocity of 15 m/s at an angle of 35° above the horizontal over flat level ground. Where in the trajectory of the particle is the speed of the particle greatest?

a) At the first instant after launch.
b) While it is on the way up.
c) At the highest point in its trajectory.
d) While it is on the way down.
e) At ground level, the lowest point achieved prior to actual contact with the ground.
f) Nowhere.

A particle of mass *m* is launched from a height *h* at a velocity of 15 m/s at an angle of 35° above the horizontal over flat level ground. Where in the trajectory of the particle is the speed of the particle smallest?

a) At the first instant after launch.

b) While it is on the way up.

c) At the highest point in its trajectory.

d) While it is on the way down.

e) At ground level, the lowest point achieved prior to actual contact with the ground.

f) Nowhere.

Object 2 has twice the mass and half the speed that object 1 has. Which object, if either, has the greater kinetic energy?

a) 1

b) 2

c) Neither.

Object 2 has twice the mass and half the height that object 1 has. Which object, if either, has the greater potential energy?

a) 1

b) 2

c) Neither.

Object 2 has the same mass but twice the speed of object 1. What is the ratio of the kinetic energy of object 2 to that of object 1?

a) ¼

b) ½

c) 1

d) 2

e) 4

A cannon with a lit fuse is sliding forward on a flat horizontal frictionless surface. The powder explodes, the ball exits the cannon at a high speed and the cannon itself comes to a complete rest. Is mechanical energy conserved in this process?

a) Yes

b) No

(Demo) In which case is the oak wheel moving forward along the ramp faster?

a) When it is rolling on the axle.

b) When it is rolling on the wheel.

c) Neither.

(Demo) In which case is the <u>kinetic</u> energy of the oak wheel at the bottom of the ramp greater?

a) **When it is rolling on the axle.**

b) **When it is rolling on the wheel.**

c) **Neither.**

(Demo) In which case is the total energy of the oak wheel at the bottom of the ramp greater?

a) When it is rolling on the axle.

b) When it is rolling on the wheel.

c) Neither.

(Demo) Which object has the greater moment of inertia with respect to its own axis of symmetry?

a) The ring.

b) The disk.

c) Neither.

(Demo) Which object has the greater total energy at the bottom of the ramp?

a) The ring.

b) The disk.

c) Neither.

(Demo) Which object has the greater kinetic energy at the bottom of the ramp?

a) The ring.

b) The disk.

c) Neither.

(DEMO) When I release the wooden wheel it will roll down the wooden rack. It will

a) Take more time to complete the 2nd half of its trip than it does to complete the 1st half.

b) Take less time to complete the 2nd half of its trip than it does to complete the 1st half.

c) Take approximately the same amount of time to complete the 2nd half of its trip as it does to complete the 1st half.

(DEMO) I release a hoop and disk, of equal mass and equal diameter, from the top of a ramp, in such a manner that, starting side by side, they both roll down the ramp. Which one gets to the bottom first?

a) The hoop.

b) The disk.

c) They both arrive at the same time.

d) Neither will make it to the bottom of the ramp.

What is the difference between inertia and mass?

a) **There is no difference. Inertia is mass.**

b) **Inertia is an object’s natural tendency not to change how fast it is spinning whereas mass is an object’s natural tendency not to change how fast it is translating (going/traveling through space).**

What is the difference between rotational inertia and moment of inertia?

a) There is no difference. They are two different names for the same physical quantity.

b) Rotational inertia is an object’s natural tendency not to change how fast it is spinning whereas moment of inertia is an object’s natural tendency not to change how fast it is translating (going/traveling through space).

What is the difference between inertia and moment of inertia?

a) There is no difference. They are two different names for the same physical quantity.
b) Moment of inertia is an object's natural tendency not to change how fast it is spinning whereas inertia is mass.
c) Moment of inertia is an object's natural tendency not to change how fast it is spinning whereas inertia is an object's natural tendency not to change how fast it is translating (going/traveling through space).
d) Both b and c above.
e) None of the above.

A spring having a spring constant (a.k.a. force constant) *k* has a relaxed length L_o. How much potential energy will be stored in the spring if it is stretched to the extent that its length is doubled?

a) $\frac{1}{2}kL_o^2$

b) kL_o^2

c) $2kL_o^2$

d) $4kL_o^2$

e) None of the above.

A ball and a block are released side by side from a position near the top of a ramp. The block has the same mass as the ball. The ball rolls down the ramp without slipping. The block slides down the ramp. There is no friction between the block and the ramp. Which object reaches the bottom of the ramp first?

a) The ball.

b) The block.

c) Neither.

A truck rear ends a car that is sitting at a traffic light. The two stick together and slide into the intersection as one. From the skid marks, a police officer determines the speed of the pair at the instant after the collision. Then, she applies conservation of momentum to the pair of vehicles to determine the speed of the truck just prior to the collision. The presence of the frictional force of the road on the vehicles does not invalidate the latter step because…

a) The frictional force doesn’t start acting until after the collision.
b) The ongoing push of each vehicle on the other, during the collision, is so huge compared to the frictional force that the frictional force is negligible.
c) The frictional force is part of the system so it does not affect the momentum of the system.
d) Actually, it is not okay.

Regarding the truck/car collision: A lawyer for the defense argues that since the pair skidded to a halt, conservation of momentum implies that the total momentum of the truck/car pair, prior to the collision, must have been zero. What is wrong with that argument?

a) Nothing. The lawyer is right.
b) The frictional force is an outside push acting on the system. Such a push acting over the time interval from the start of the crash to the end of the skid will have an appreciable effect on the total momentum of the pair.
c) The lawyer is not taking into account the relative weights of the vehicles.
d) None of the above.

Regarding the truck/car collision: Assuming the truck to have a greater mass than the car; during the collision, which vehicle, if either, experiences the bigger change in momentum?

a) Neither.

b) The car.

c) The truck.

Regarding the truck/car collision: During the collision, the earth is pulling downward on both vehicles. Is it okay to neglect this force when calculating the velocity of the pair just after the collision based on the velocity of the truck just before the collision (and the fact that the car is at rest just before the collision)?

a) Yes.

b) No

Regarding the truck/car collision: How does the magnitude of the change of momentum of the car compare to the magnitude of the change of momentum of the truck?

a) They are the same.
b) The change of the momentum of the car is greater.
c) The change of the momentum of the truck is greater.

A person is holding block B of mass m_B at rest on a frictionless ramp. At time 0, block A of mass m_A is sliding down the ramp with speed v. Starting at that instant, Block A slides 1 meter down the ramp before hitting B. At the last instant prior to the collision, the person releases B. The blocks stick together and slide down the ramp as one. Let v' be the speed of the blocks just after collision. Is it true that

$$m_{\mathrm{A}} v = (m_{\mathrm{A}} + m_{\mathrm{B}}) v' \quad ?$$

a) Yes.

b) No.

In an elastic collision of two objects on which no external forces act:
Is momentum conserved?

a) Yes.

b) No.

In an elastic collision of two objects on which no external forces act:
Is mechanical energy conserved?

a) Yes.

b) No.

A hand grenade is flying through outer space. It explodes. Is momentum conserved?

a) **Yes.**

b) **No.**

(Demo) Suppose that both objects are spinning at the same rate. In which case, if either is the angular momentum greater?

a) The case in which the cylinders are close to the axis of rotation.

b) The case in which the cylinders are far from the axis of rotation.

c) Neither.

You gave each of 2 objects a torque to cause it to spin and a torque to cause it to stop spinning. Each object rested on a rotating support. <u>Object a</u> was a bar with 2 metal cylinders attached <u>near the center</u>. Object **b** was a bar with a metal cylinder attached **near each end**.

a) <u>Object a</u> was easier to start and stop.

b) <u>Object a</u> was easier to start but harder to stop.

c) <u>Object a</u> was harder to start and stop.

d) It was just as hard to start or stop **object b** as it was to start or stop <u>object a</u>.

(Demo) What will happen to the magnitude of the student’s angular velocity when the student pulls his arm’s and legs in close to the axis of rotation?

a) It will decrease.

b) It will increase.

c) It will stay the same.

(Demo) Which way, if either, will the student spin when the student flips the wheel?

a) Clockwise as viewed from above.

b) Counterclockwise as viewed from above.

c) The student will not spin.

Recall when the student was spinning on the stool. When he pulled his arms and legs in, what happened to the angular momentum of the student plus that part of the stool that was spinning?

a) The angular momentum increased.

b) The angular momentum decreased.

c) The angular momentum stayed the same.

A man is spinning on a bar stool with arms and legs extended. A friend got him going but at this point, no one and nothing is applying a torque to the spinning seat-plus-man. The man pulls his arms and legs in close to his body. What happens to his moment of inertia?

a) It increases.
b) It decreases.
c) It stays the same.
d) Based on the given information, no other answer provided can be identified as the one best answer.

A man is spinning on a bar stool with arms and legs extended. A friend got him going but at this point, no one and nothing is applying a torque to the spinning seat-plus-man. Consider the direction of his angular velocity at this point to be the positive direction for all rotational quanities. The man pulls his arms and legs in close to his body. What happens to his angular velocity?

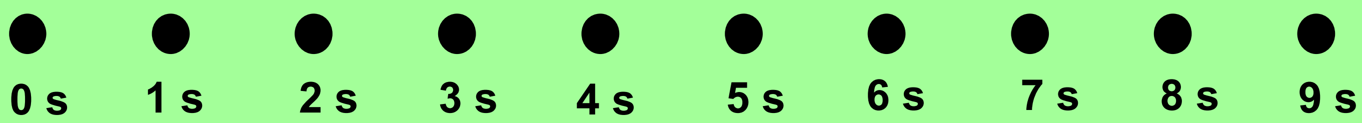
a) It increases.

b) It decreases.

c) It stays the same.

d) Based on the given information, no other answer provided can be identified as the one best answer.

Depicted below is a disk moving on a frictionless horizontal surface. The diagram represents a single multiple-exposure photograph of the disk. The light source is a strobe light which flashes once every second (1.00 s). The photograph has been annotated with the time of the flash as measured by a stopwatch started at the same time as the first flash. Rightward is defined to be the forward direction.



Which of the following statements best describes the motion of the puck?

a) Moving forward and slowing down.

b) Moving forward and speeding up.

c) Moving forward at constant velocity.

d) None of the above.

Depicted below is a disk moving on a frictionless horizontal surface. The diagram represents a single multiple-exposure photograph of the disk. The light source is a strobe light which flashes once every second (1.00 s). The photograph has been annotated with the time of the flash as measured by a stopwatch started at the same time as the first flash. Rightward is defined to be the forward direction.

Which of the following statements best describes the motion of the puck?

a) Moving forward and slowing down.

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c) Moving forward at constant velocity.

d) None of the above.

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Which of the following statements best describes the motion of the puck?

a) Moving forward and slowing down.

b) Moving forward and speeding up.

c) Moving forward at constant velocity.

d) None of the above.

Depicted below is a disk moving on a frictionless horizontal surface. The diagram represents a single multiple-exposure photograph of the disk. The light source is a strobe light which flashes once every second (1.00 s). The photograph has been annotated with the time of the flash as measured by a stopwatch started at the same time as the first flash. Rightward is defined to be the forward direction.

Which of the following statements best describes the motion of the puck?

a) Moving backward and slowing down.

b) Moving backward and speeding up.

c) Moving backward at constant velocity.

d) None of the above.

Depicted below is a disk moving on a frictionless horizontal surface. The diagram represents a single multiple-exposure photograph of the disk. The light source is a strobe light which flashes once every second (1.00 s). The photograph has been annotated with the time of the flash as measured by a stopwatch started at the same time as the first flash. Rightward is defined to be the forward direction.

Which of the following statements best describes the motion of the puck?

a) Moving forward and slowing down.

b) Moving forward and speeding up.

c) Moving forward at constant velocity.

d) None of the above.

The acceleration of an object is:

a) **How fast and in what direction the object is going.**

b) **How fast and in what direction the position of the object is changing.**

c) **How fast and in what direction the velocity of the object is changing.**

When I am backing up and slowing down, my acceleration is:

a) forward.

b) zero.

c) backward.

For motion along a line with forward positive: Suppose the acceleration of an object is a constant 2.00 m/s^2. Further assume that the object is released from rest at time 0. How much does the velocity of the object increase during the first second of the motion of the object?

a) 0.50 m/s
b) 1.00 m/s
c) 2.00 m/s
d) 4.00 m/s
e) None of the above.

For motion along a line with forward positive: Suppose the acceleration of an object is a constant 2.00 m/s^2. Also suppose that the object is released from rest at time 0. How much does the velocity of the object increase during the 3rd second (from t = 2.00 s to t = 3.00 s) of the motion of the object?

a) 0.50 m/s

b) 1.00 m/s

c) 2.00 m/s

d) 4.00 m/s

e) None of the above.

At time 0, an object is released from rest at the top of a flat frictionless ramp tilted at an angle of about 20 degrees. The speed at 2 seconds will be ___________ the speed at 1 second.

a) half

b) the same as

c) twice

d) four times

e) None of the above.

At time 0, an object is released from rest at the top of a flat frictionless ramp tilted at an angle of about 20 degrees. The total distance traveled at 2 seconds will be ______________ the total distance traveled at 1 second.

a) the same as

b) twice

c) three times

d) four times

e) None of the above.

At time 0, an object is released from rest at the top of a flat frictionless ramp tilted at an angle of about 20 degrees. The distance traveled during the 2nd second will be ______________ distance traveled during the 1st second.

a) the same as
b) twice
c) three times
d) four times
e) None of the above.

At time 0, an object is released from rest at the top of a flat frictionless ramp tilted at an angle of about 20 degrees. The speed at 60 cm will be __________ the speed at 30 cm.

a) the same as
b) twice
c) three times
d) four times
e) None of the above.

What is wrong with the part of the procedure, shown below, used to solve this problem?

Two cars are headed toward each other. At time zero they are 885 m apart. Car 1 is moving at a steady 33.0 m/s (and continues to do so throughout the period of observations) whereas, at time zero, cart 2 has a velocity of 4.50 m/s but is speeding up at a steady 1.50 m/s². When and where do they collide?

CAR #1

$$x_1 = x_{10} + v_{10}t + \tfrac{1}{2}a_1t^2$$

$$x_1 = v_{10}t$$

CAR #2

$$x_2 = x_{20} + v_{20}t + \tfrac{1}{2}a_2t^2$$

$$x_2 = v_{20}t + \tfrac{1}{2}a_2t^2$$

$$x_1 = x_2$$

$$v_{10}t_* = v_{20}t_* + \tfrac{1}{2}a_2t_*^2$$

$$v_{10} = v_{20} + \tfrac{1}{2}a_2t_*$$

$$t_* = 2\frac{v_{10} - v_{20}}{a_2}$$

$$t_* = 2\,\frac{33.0\,\text{m/s} - 4.50\,\text{m/s}}{1.50\,\text{m/s}^2}$$

Car 1 is at rest at point A. Car 2 is approaching car 1 from behind with a constant forward velocity of <u>7.00 m/s</u>.

<u>2 seconds</u> before car 2 reaches point A,

car 1 takes off and goes forward, directly away from car 2, with a constant acceleration of <u>5.00 m/s^2</u>.

At the instant car 2 reaches point A, car 2 begins a steady forward acceleration of <u>5.00 m/s^2</u>. Does car 2 ever catch up with car 1?

a) Yes

b) No

Car 1 is at rest at point A. Car 2 is approaching car 1 from behind with a constant forward velocity of <u>15.00 m/s</u>.

<u>2 seconds</u> before car 2 reaches point A,

car 1 takes off and goes forward, directly away from car 2, with a constant acceleration of <u>5.00 m/s^2</u>.

At the instant car 2 reaches point A, car 2 begins a steady forward acceleration of <u>5.00 m/s^2</u>. Does car 2 ever catch up with car 1?

a) Yes

b) No

Two cars are headed in one and the same direction on a straight level road. At time zero they are side by side. At time zero car 1 has a speed of 77.0 m/s and car 2 is at rest. Car 1 continues to travel at 77.0 m/s while car 2 experiences an acceleration of 1.20 m/s^2 (in the direction in which both cars are headed). Does car 2 ever catch up with car 1?

a) Yes

b) No

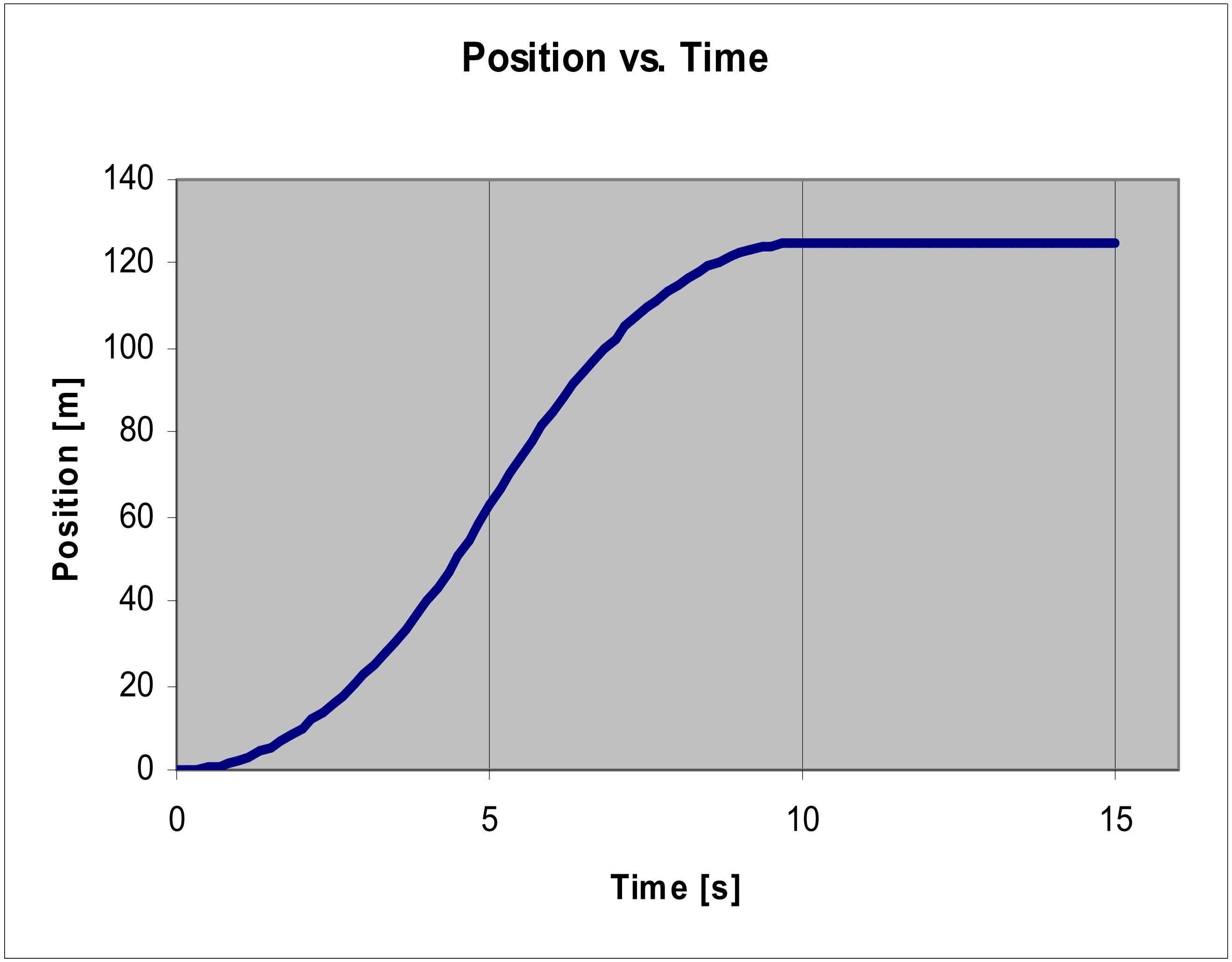
During which time interval is the car always backing up?

a) 0-5s

b) 5-10s

c) 10-15s

d) None of the above.



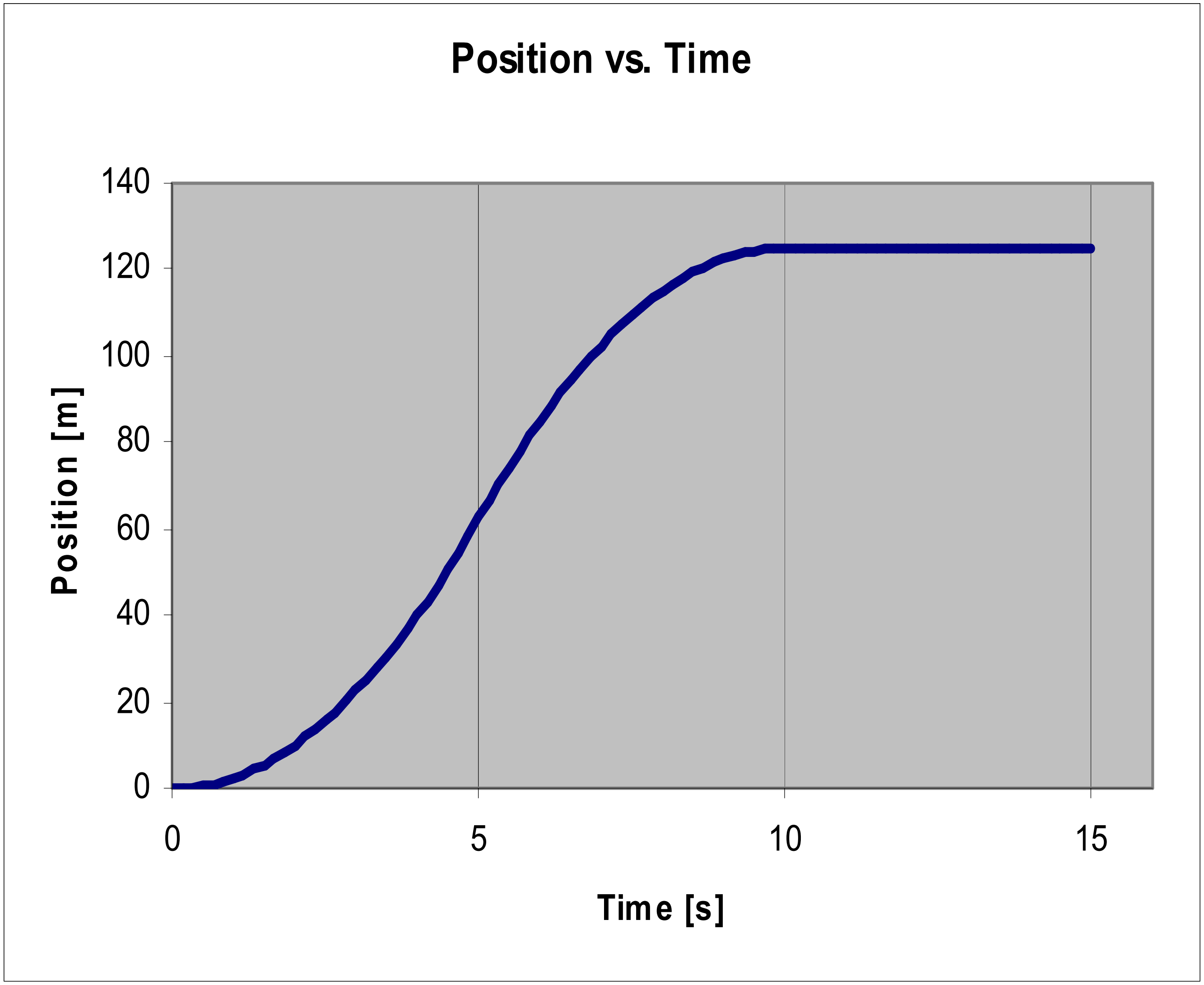
During which time interval is the car always speeding up?

a) 0-5s

b) 5-10s

c) 10-15s

d) None of the above.



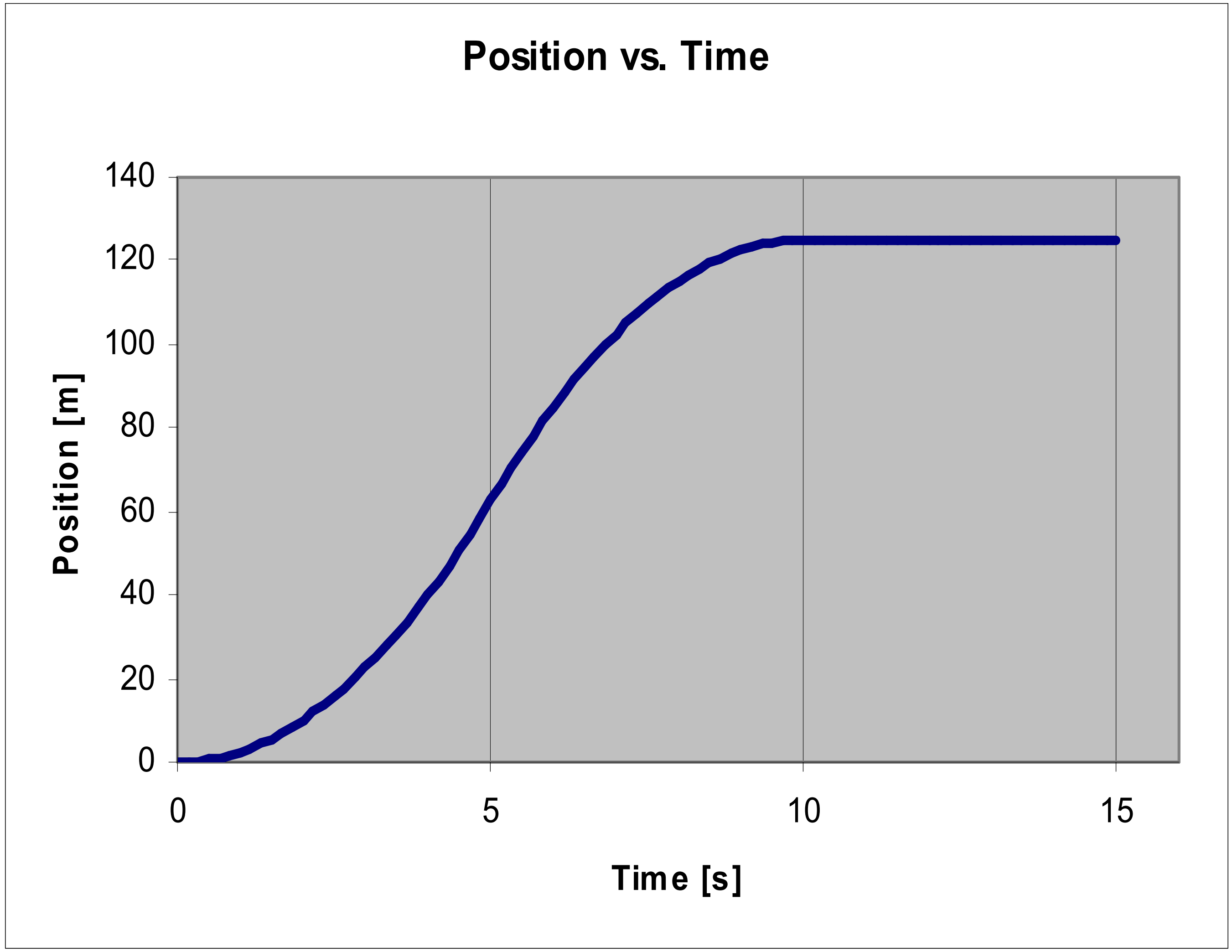
During which time interval is the car always at rest?

a) 0-5s

b) 5-10s

c) 10-15s

d) None of the above.



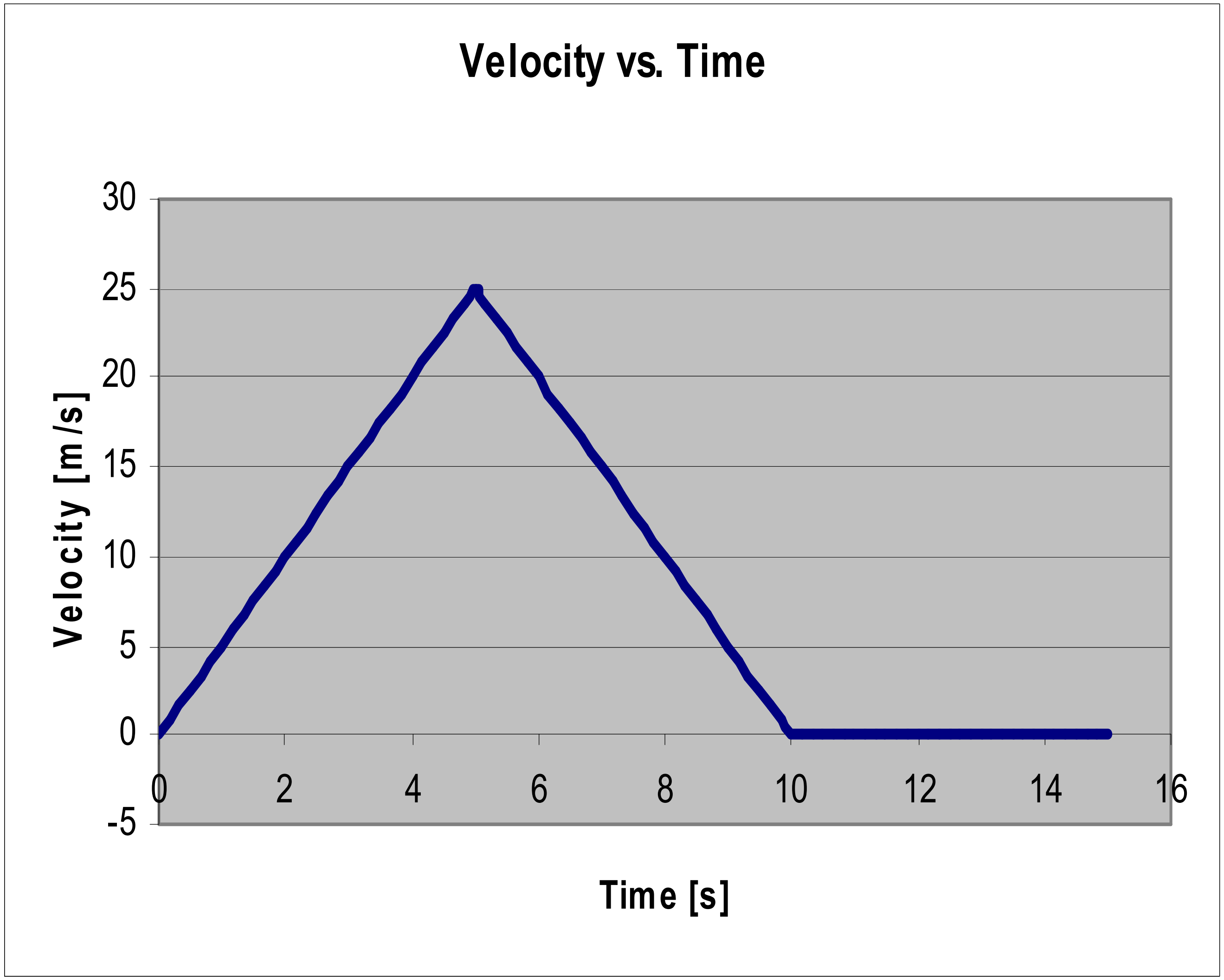
During which time interval is the car backing up?

a) 0-5s

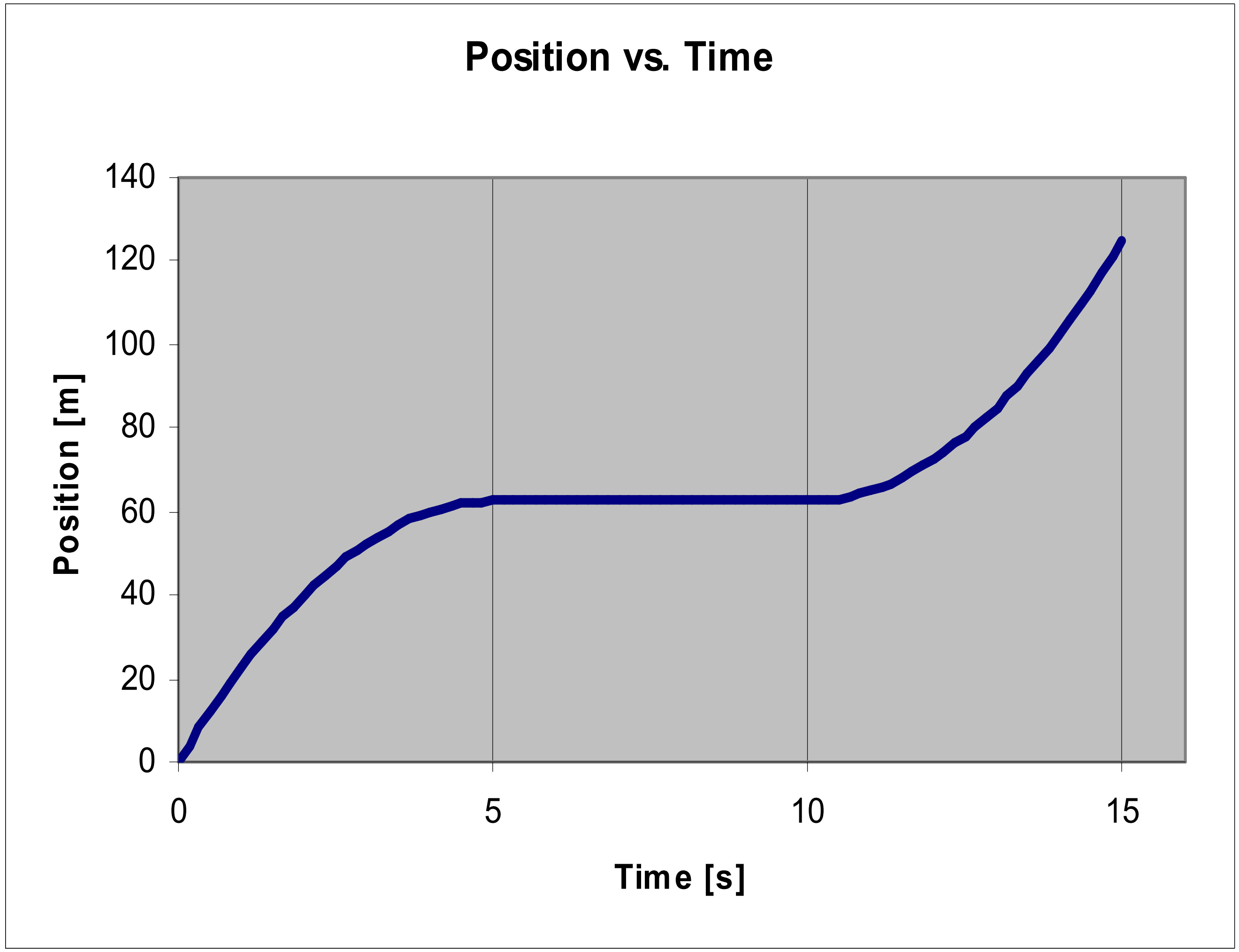
b) 5-10s

c) 10-15s

d) None of the above.



Which of the following is true of the initial velocity?



a) It is zero.
b) It is positive.
c) It is negative.
d) Not enough information is given to distinguish which of the answers above is correct.

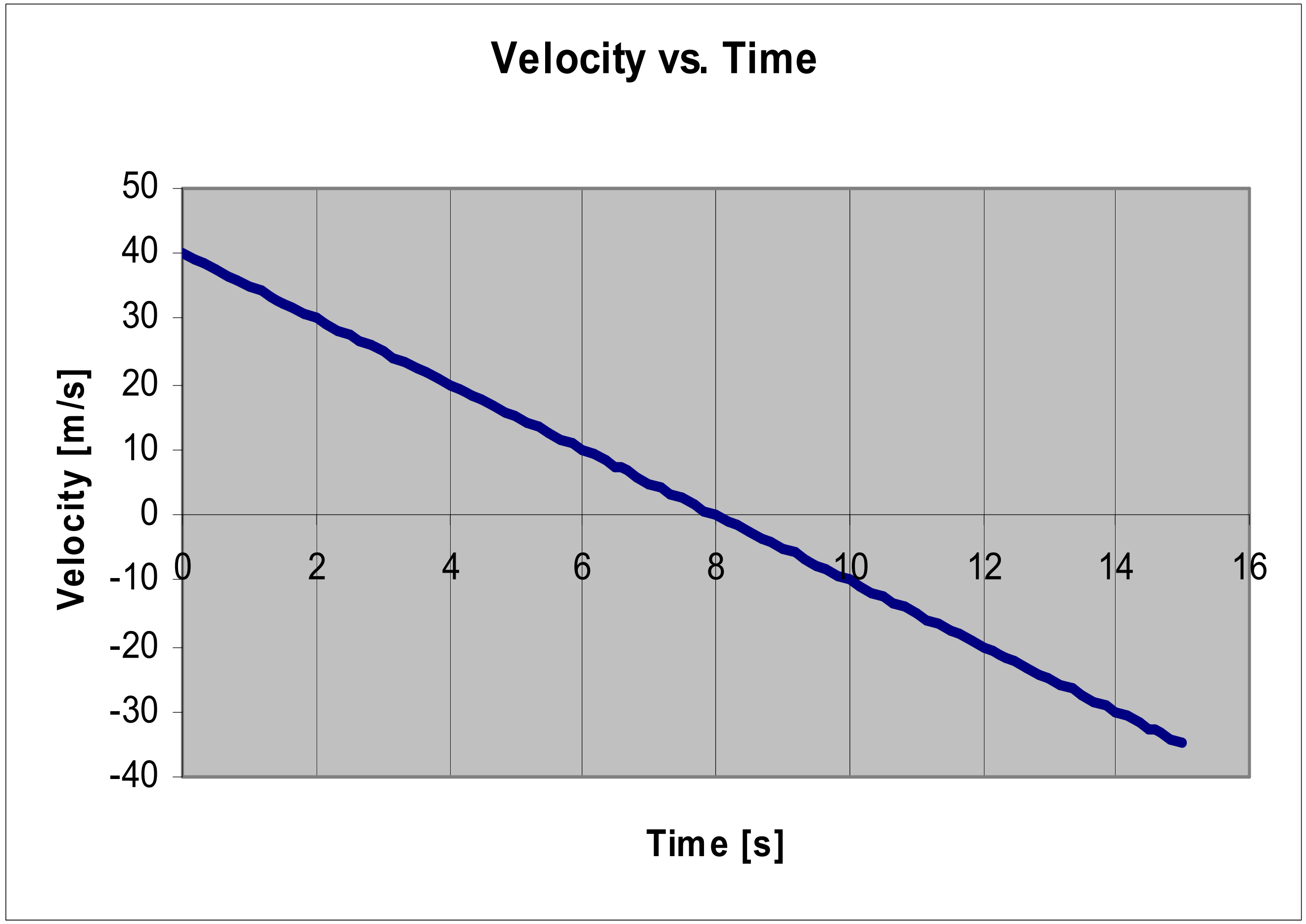
Assuming the car starts at the start line, At what time does the car reach its maximum forward position?

a) 0 s.

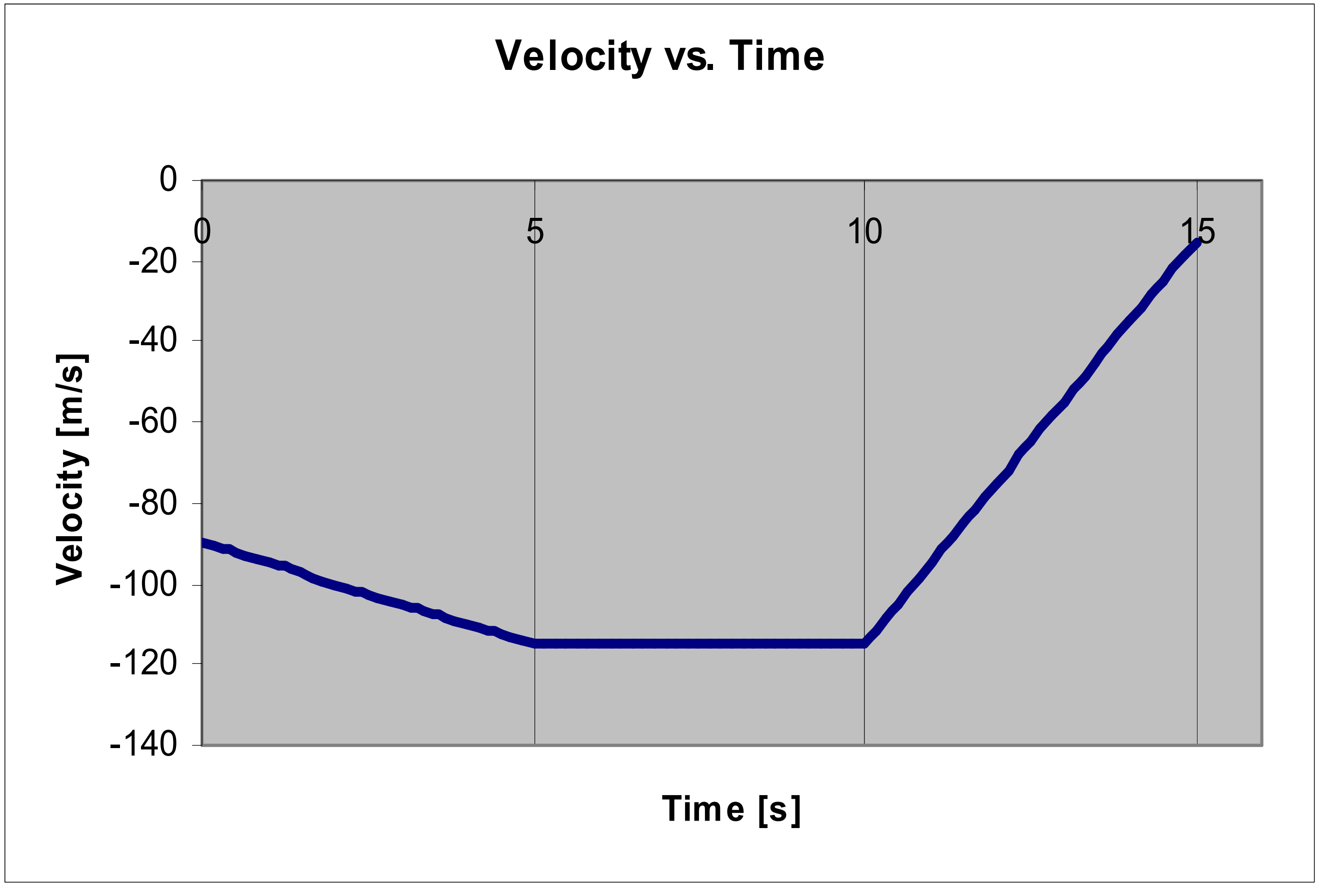
b) 8 s.

c) 15 s.

d) Not enough information is given to distinguish which of the answers, if any, above is correct.



During which time interval, if any, is the car moving forward?



a) 0-5 s.

b) 5-10 s.

c) 10-15 s.

d) Both b and c above are correct.

e) It is not moving forward at any time between 0 and 15 s.

A disk is moving on the surface of the ice at an ice-skating rink. An x-y coordinate system has been defined for the surface of the ice. At time zero, the disk is at the origin and moving with a velocity of 5 m/s at 70°. The disk experiences a constant acceleration of 0.25 m/s^2 in the +x direction. As time goes by, what happens to the x-component of the velocity of the disk?

a) It remains the same as what it was at time zero.

b) It only increases.

c) It only decreases.

d) It increases for a while, then it decreases.

e) It decreases for a while, then it increases.

A disk is moving on the surface of the ice at an ice-skating rink. An x-y coordinate system has been defined for the surface of the ice. At time zero, the disk is at the origin and moving with a velocity of 5 m/s at 70°. The disk experiences a constant acceleration of 0.25 m/s^2 in the +x direction. As time goes by, what happens to the y-component of the velocity of the disk?

a) It remains the same as what it was at time zero.

b) It only increases.

c) It only decreases.

d) It increases for a while, then it decreases.

e) It decreases for a while, then it increases.

A disk is moving on the surface of the ice at an ice-skating rink. An x-y coordinate system has been defined for the surface of the ice. At time zero, the disk is at the origin and moving with a velocity of 5 m/s at 70°. The disk experiences a constant acceleration of 0.25 m/s^2 in the +x direction. As time goes by, what happens to the velocity of the disk?

a) It stays the same.

b) Its magnitude stays the same but the angle characterizing its direction continually decreases.

c) Its magnitude stays the same but the angle characterizing its direction continually increases.

d) Its magnitude only increases while its direction stays the same.

e) None of the above.

Particle 1 and particle 2 are both at the origin at time zero.

Particle 1 has an initial velocity of 25 m/s at 0° and experiences no acceleration.

Particle 2 has an initial velocity of 25 m/s at some unspecified angle between –5° and –85° and experiences a constant acceleration of 12 m/s^2 at +90°.

Is it possible for the particles to collide?

a) Yes

b) No

Particle 1 and particle 2 are both at the origin at time zero.

Particle 1 has an initial velocity of 25 m/s at 0° and experiences no acceleration.

Particle 2 has an initial velocity of 75 m/s at some unspecified angle between –5° and –85° and experiences a constant acceleration of 12 m/s^2 at +90°.

Is it possible for the particles to collide?

a) Yes

b) No

Particle 1:

Initial position: (0, 2 m)

Initial velocity: 15 m/s at 0°

Constant acceleration: 0

Particle 2:

Initial position: (0, 0)

Initial velocity: any speed at 0°

Constant acceleration: 7 m/s^2 at 90°

Is it possible for the particles to collide?

a) Yes

b) No

Particle 1:

Initial position: (2 m, 2 m)

Initial velocity: 15 m/s at 90°

Constant acceleration: 0

Particle 2:

Initial position: (0, 0)

Initial velocity: any speed at 25°

Constant acceleration: 7 m/s^2 at 90°

Is it possible for the particles to collide?

a) Yes

b) No

Did you do the reading assignment?

a) Yes

b) No

c) Sort of.

A ship at sea is traveling with a compass heading of 0° at (non-zero) speed v_{sw} relative to the water which itself is moving with speed v_{wg} at 15° east of south. In what direction is the ship going?

a) Some northeasterly direction.
b) Some southeasterly direction.
c) Some southwesterly direction.
d) Some northwesterly direction.
e) Not enough information is given.

There is a projectile launcher on a cart on a long straight horizontal track. Way above this is a still camera pointed straight down at the track. It is pitch dark except for a light on the muzzle of the launcher, and, the glow of the projectile itself. The launcher is pointed in a horizontal direction at an angle relative to the track and is then tilted upward at an angle relative to the horizontal. The shutter is opened at an instant when the cart is moving along the track at constant velocity and kept open for several seconds. The launcher is fired at the instant the shutter is opened.

What does the resulting picture look like?

a) **A dot (the muzzle) and a curve (the projectile path).**
b) **A straight line (the muzzle path) and a curve (the projectile path) .**
c) **Two straight lines at an angle to each other.**
d) **A single straight line.**
e) **Two curves.**

Suppose the cart is traveling due northward (due northward means northward) and the launcher is pointed is eastward-and-upward. (Eastward means due eastward.) What would the angle between the line segments in the photograph be?

a) 0°.
b) Between 0 and 90° exclusive.
c) At 90°.
d) Between 90° and 180° exclusive.

Suppose that, in terms of a horizontal Cartesian coordinate system, the cart is traveling in the +x direction and the launcher is aimed in the +y direction (and upward). Assume the projectile was launched at the origin. At what angle would the projectile's apparent path in the photograph extend away from the origin.

a) 0°.
b) Between 0 and 90° exclusive.
c) At 90°.
d) Between 90° and 180° exclusive.
e) None of the above.

An oceanography crew tasked with reporting on ocean currents is headed due east at 8.0 knots (a nautical unit of speed) relative to the water. The crew's radio navigation equipment tells the crew that it is moving at 7.2 knots at a compass bearing of 85 degrees. What is the direction of the ocean current in which the oceanography ship is moving?

a) In some northeasterly direction.
b) Eastward.
c) In some southeasterly direction.
d) Southward.
e) In some southwesterly direction.
f) Westward.
g) In some northwesterly direction.

A boy, riding in a car which is going 27 mph southward points a horizontal BB gun due west and pulls the trigger. The muzzle velocity of the gun is 52 mph. How does the magnitude of the horizontal component of the velocity of the BB relative to the earth compare with the muzzle velocity of the gun? Ignore air resistance.

a) The horizontal component of the velocity of the BB relative to the earth is less than the muzzle velocity of the gun.

b) The horizontal component of the velocity of the BB relative to the earth is equal to the muzzle velocity of the gun.

c) The horizontal component of the velocity of the BB relative to the earth is greater than the muzzle velocity of the gun.

d) Not enough information is provided to determine which of the other answers is most correct.

As part of a traveling act, a former major-league baseball pitcher routinely splits oranges in half by throwing each one 90 feet into a tautly-strung, thin vertical wire. The crowd is amazed to find that the two pieces indeed appear to be the same size. He is, for the first time, about to do is act on a cruise ship. Normally, he throws the orange as if he was pitching a fastball straight at the wire. The ship is moving at a constant velocity of 21 mph due north. He is throwing from a position due west of the wire. Neglect any force that the air might exert on the ball. He should aim:

a) A little to the right of the wire.

b) Straight at the wire.

c) A little to the left of the wire.

Mabel is walking backward at 5 mph on a train which is moving northward at 55 mph as it passes a train moving 45 mph northward on which Herman is running forward at 10 mph. All the other passengers on both trains are sitting in their seats. Relative to the passengers on Herman's train, how fast and which way is Mabel moving?

a) 5 mph southward.

b) 0 mph.

c) 5 mph northward.

d) None of the above.

Mabel is walking backward at 5 mph on a train which is moving northward at 55 mph as it passes a train moving 45 mph northward on which Herman is running forward at 10 mph. All the other passengers on both trains are sitting in their seats. Relative to the passengers on **Mabel's train**, how fast and which way is **Herman** moving?

a) 5 mph southward.

b) 0 mph.

c) 5 mph northward.

d) None of the above.

Mabel is walking backward at 5 mph on a train which is moving northward at 55 mph as it passes a train moving 45 mph northward on which Herman is running forward at 10 mph. All the other passengers on both trains are sitting in their seats. **Relative to Herman**, how fast and which way is **Mabel** moving?

a) 5 mph southward.

b) 0 mph.

c) 5 mph northward.

d) None of the above.

A professor simultaneously drops 2 metal objects from a window of alumni hall. The professor releases both objects from rest at one and the same height (11m above the ground). One object is a lot heavier than the other. Air resistance is negligible. Which object, if either, hits first?

a) The lighter object.
b) The heavier object.
c) They both hit at the same time.

A ball is thrown straight up. After it leaves the throwers hand it goes up and comes back down. On the way up the acceleration of the ball is:

a) upward.

b) zero.

c) downward.

A ball is thrown straight up. After it leaves the throwers hand it goes up and comes back down. At the top, the acceleration of the ball is:

a) upward.

b) zero.

c) downward.

A ball is thrown straight up. After it leaves the throwers hand it goes up and comes back down. On the way down, the acceleration of the ball is:

a) upward.

b) zero.

c) downward.

(Demo) I launch one die forward and at the instant of launch I drop another one from right beside the first one.

Which die hits the floor first?

a) The launched die.

b) The dropped die.

c) Neither; both dice hit at the same time.

A boy throws a rock. It leaves his hand with a velocity that is eastward and 35° above the horizontal. (So the launch velocity is “Eastward and Upward”.)

What is the direction of the velocity of the rock at the highest point in its trajectory?

a) It has no direction because it is zero.
b) Eastward.
c) Eastward and Upward
d) Eastward and Downward
e) Upward or Downward

A boy throws a rock. It leaves his hand at a position above ground level with a velocity that is eastward and 35° above the horizontal. (So the launch velocity is “Eastward and Upward”.)

What is the direction of the velocity of the rock at ground level?

a) It has no direction because it is zero.
b) Eastward.
c) Eastward and Upward
d) Eastward and Downward
e) Upward or Downward

A sailor drops a rock from the crow's nest of a tall ship that is at rest. The rock hits the deck at a point just starboard of the mast. On a different occasion, the sailor drops the rock from the same position on the same ship, but this time while the ship is cruising forward at 5 knots. Where does the rock hit the deck this time? (Neglect any forces that might be exerted on the rock by the air. Assume the mast to be vertical in both cases.)

a) At the same point on the deck.

b) At a point on the deck that is forward of the point that it hit the first time.

c) At a point on the deck that is aft of the point that it hit the first time.

A ball is launched straight upward from a ball launcher on a cart at rest. With no change in how the launcher is oriented, the same ball is launched from the same launcher while the cart is moving forward at constant velocity. Where, ***relative to the floor***, does the ball come down? Call the point on the floor directly below the launch point, point P.

a) It comes down toward point P (and hits point P if the cart is out of the way).

b) It comes down toward a point (on the floor) forward of point P.

c) It comes down toward a point (on the floor) behind point P.

A ball is launched straight upward from a ball launcher on a cart at rest. With no change in how the launcher is oriented, the same ball is launched from the same launcher while the cart is moving forward at constant velocity. Where, ***relative to the cart***, does the ball come down?

a) Right back to the launcher.
b) To a point (on the cart) forward of the launcher.
c) To a point (on the cart) behind the launcher.

A horizontal ball launcher is aimed directly at a can. At the instant the ball is launched the can is released from rest. Does the ball hit the can? (The ball reaches the horizontal position of the can before either object hits the floor.)

a) No. It passes below the can.

b) Yes.

c) No. It passes above the can.

A fully-loaded eighteen-wheel tractor-trailer rig (a.k.a. a big truck) and a small passenger vehicle experience a head-on collision with each other. Which vehicle, if either, exerts a greater force on the other vehicle, during the collision?

a) **The truck exerts a greater force on the car.**
b) **The car exerts a greater force on the truck.**
c) **Neither.**

When a person who knows karate delivers a side-of-the-hand karate chop to a board,

a) **The hand exerts a greater force on the board than the board exerts on the hand.**
b) **The board exerts a greater force on the hand than the hand exerts on the board.**
c) **None of the above.**

When a baseball player hits a baseball,

a) **the force exerted on the ball by the bat is greater than the force exerted on the bat by the ball.**

b) **the force exerted on the ball by the bat is less than the force exerted on the bat by the ball.**

c) **None of the above.**

A person shoots a ball out of a spring-loaded cannon. After the ball leaves the cannon,

a) **the spring force on the ball is in the downward direction.**
b) **the spring force on the ball is in the same direction as the direction in which the ball is going.**
c) **the spring force on the ball is in the direction opposite to the direction in which the ball is going.**
d) **None of the above.**

Consider a cart on a level air track. Suppose I give the cart a shove, releasing it before it gets to the first photogate. It will:

a) go faster through the first photogate.

b) go faster through the second photogate.

c) go at about the same speed through both photogates.

A person shoots an arrow forward. While it is in flight, what keeps the arrow going forward?

a) **The inertia of the arrow.**

b) **The gravitational force of the earth exerted on the arrow.**

c) **Air pressure.**

d) **The force of the bow on the arrow.**

1. a resting object's inherent tendency to stay at rest.
2. a moving object's inherent tendency to slow down.
3. a moving object's inherent tendency to keep moving at its current velocity.
4. a moving object's tendency to maintain a constant positive acceleration.

Inertia is: **a) 1 only.**

b) 1 and 2.

c) 1 and 3.

d) 4 only.

Consider a tugboat tied by cable #1 to the front of barge #1. The back of barge #1 is tied to the front of barge #2 by cable #2. The tugboat is pulling the barges eastward at a constant speed of 2.50 m/s. The water exerts a significant drag force on each object. In which cable is the tension greater?

a) Cable #1

b) Cable #2

c) Neither. The tension is the same in both cables.

Consider a tugboat tied by cable #1 to the front of barge #1. The back of barge #1 is tied to the front of barge #2 by cable #2. The tugboat is pulling the barges eastward at a constant speed of 2.50 m/s. The water exerts a significant drag force on each object. What is the direction of the net force on the tugboat?

a) Eastward

b) Westward

c) Undefined

d) None of the above.

Consider a tugboat tied by cable #1 to the front of barge #1. The back of barge #1 is tied to the front of barge #2 by cable #2. The tugboat is pulling the barges eastward at a constant speed of 2.50 m/s. The water exerts a significant drag force on each object. What is the direction of the net force on barge #1?

a) Eastward

b) Westward

c) Undefined

d) None of the above.

Consider a tugboat tied by a single cable to the front of a barge. The tugboat is pulling the barge forward at an increasing speed. The water exerts a significant drag force on each object. How is it possible for the tugboat to be accelerating forward?

a) The tugboat pulls forward on the barge harder than the barge pulls backward on the tugboat.

b) The cable pulls forward on the barge harder than the cable pulls backward on the tugboat.

c) The net force exerted on the tugboat by the water is forward and greater in magnitude than the force exerted on the tugboat by the cable.

d) The given process is not possible. Consider the cable to be part of the tugboat. The force exerted on the tugboat by the barge is equal and opposite to the force exerted on the barge by the tugboat. Thus, the tugboat cannot accelerate forward. With the tugboat attached, the best it can do is to move forward at constant speed.

A person weighing 550 N positions a 12-meter ladder weighing 350 N against the north-facing side of her house and climbs 75% of the way to the top of the ladder. What is the horizontal component of the combined force exerted on the ladder by everything that is in contact with the ladder.

- **a) 900 newtons northward.**
- **b) 900 newtons southward.**
- **c) 350 newtons northward.**
- **d) 350 newtons southward.**
- **e) 0 newtons.**
- **f) None of the above.**

A person weighing 550 N positions a 12-meter ladder weighing 350 N against the north-facing side of her house and climbs 75% of the way to the top of the ladder. What is the vertical component of the combined force exerted on the ladder by everything that is in contact with the ladder.

a) 900 newtons upward.

b) 900 newtons downward.

c) 350 newtons upward.

d) 350 newtons downward.

e) 0 newtons.

f) None of the above.

A board is lying flat on a floor. A person puts a brick on the board and raises one end of the board until the board makes an angle of 41° with the horizontal, slides a support under that end of the board, and then lowers the end of the board down onto the support. With the end of the board resting on the support, the board makes an angle of 33° with the horizontal. Throughout the process, the brick's position on the board never changes. What is the frictional force **on the <u>board</u>?**

a) It is $\mu_K N$ in the up-the-incline direction.

b) It is $\mu_K N$ in the down-the-incline direction.

c) It is $\mu_S N$ in the up-the-incline direction.

d) It is $\mu_S N$ in the down-the-incline direction.

e) None of the above.

A person is pulling a crate of mass *m* across a flat horizontal wooden floor by means of a rope that extends away from the crate at an angle of 32° above the horizontal. Neglecting forces exerted on the crate by the air, is the normal force equal to *mg* ?

a) Yes

b) No

A chair is sliding, across a flat horizontal linoleum-tile floor. Neglecting forces exerted on the chair by the air, is the magnitude of the normal force equal to *mg* ?

a) Yes

b) No

A block is sliding down a flat inclined plane. Neglecting forces exerted on the block by the air, is the magnitude of the normal force equal to *mg* ?

a) Yes

b) No

(Ring on Disk Demo)

While the ring is rolling on the disk, is there a normal force exerted on the ring?

a) Yes

b) No

Demonstration: Ring on Disk

While the ring of mass m is rolling on the disk, neglecting forces exerted on the ring by the air, is the magnitude of the normal force exerted on the ring, in general, equal to mg ?

a) Yes

b) No

Suppose you give a cart, that is at rest on a horizontal frictionless track, a horizontal shove, in the forward direction, with your hand. After the cart leaves your hand:

a) **The force of your hand on the cart is forward.**
b) **The force of your hand on the cart is backward.**
c) **The force of your hand on the cart is downward.**
d) **There is no force of your hand on the cart.**

A car is traveling along a straight level road at a steady 55 mph. What is the direction of the net force on the car.

a) **Forward**
b) **Backward**
c) **Upward**
d) **Downward**
e) **The net force has no direction because it is zero.**

Consider the two erasers on the whiteboard tray. Are they exerting a gravitational force on each other?

a) Yes.

b) No.

Consider the two erasers on the whiteboard tray. Are they accelerating toward each other?

a) Yes.
b) No.

Consider the two erasers on the whiteboard tray. Why aren't they accelerating toward each other?

a) **The net force on either eraser is zero.**
b) **The gravitational force exerted on the eraser on the right by the eraser on the left is canceled by the gravitational force exerted on the eraser on the left by the eraser on the right.**
c) **None of the above.**

The weight of a rock at the surface of the earth is 32 newtons. How much would the rock weigh at a distance beyond the surface of the earth that is equal to the radius of the earth?

a) 4 N
b) 8 N
c) 16 N
d) 32 N
e) 64 N
f) 128 N
g) 256 N
h) None of the above.

Consider two lead balls at a center-to-center separation *d*. What happens to the gravitational force exerted on one ball by the other if the center-to-center separation is doubled?

a) **It becomes 1/8 what it was.**
b) **It becomes 1/4 what it was.**
c) **It becomes 1/2 what it was.**
d) **It remains what it was.**
e) **It becomes twice what it was.**
f) **It becomes four times what it was.**
g) **It becomes eight times what it was.**
h) **None of the above**

Consider two lead balls at a center-to-center separation *d*. What happens to the gravitational potential energy of the system if the center-to-center separation is doubled?

a) It becomes 1/8 what it was.
b) It becomes 1/4 what it was.
c) It becomes 1/2 what it was.
d) It remains what it was.
e) It becomes twice what it was.
f) It becomes four times what it was.
g) It becomes eight times what it was.

Does the moon-earth system have more potential energy than it would have if the moon were at the surface of the earth?

a) Yes.

b) No, it has less.

c) No, it has the same potential energy.

Consider a uniform wood sphere and a uniform lead sphere of the same mass. At the surface of which sphere would a grain of sand have the lower gravitational potential energy?

a) The wood sphere.

b) The lead sphere.

c) Neither.

Is it appropriate to say that a disk is spinning at a rate of 15 m/s?

a) Yes.
b) No.

Is it possible for a particle to have a non-zero acceleration while it is moving at a constant speed?

a) Yes.

b) No.

A person ties a rock to the end of a piece of string and swings the rock around over her head in a circle. What is the agent of the force that makes the rock go around in a circle?

a) The earth's gravitational field.
b) The person.
c) The string.
d) There is no agent.
e) None of the above.

A person ties a rock to the end of a piece of string and swings the rock around over her head in a circle. What is the direction of the force that makes the rock go around in a circle?

a) **In the forward direction, the direction of the velocity of the rock.**
b) **Outward, away from the center of the circle.**
c) **Inward, toward the center of the circle.**
d) **There is no actual force.**
e) **None of the above.**

Pretend that you are looking at a windmill, face on. You are looking due west. You see the windmill spinning clockwise. The wind has just died. The windmill is slowing down. At the instant in question, one blade of the windmill extends horizontally from the center of the windmill, northward. What is the direction of the acceleration of the tip of that blade?

a) Southward
b) Southward and downward.
c) Southward and upward.
d) Northward
e) Northward and downward.
f) Northward and upward.

(Trick question?) A Merry-Go-Round is spinning at a constant rate. How does the magnitude of the angular velocity of point A on the rim compare with the magnitude of the angular velocity of point B which is half the distance to the rim out from the center?

a) **The magnitude of the angular velocity of point A is greater.**
b) **The magnitude of the angular velocity of point B is greater.**
c) **They are both the same.**

A Merry-Go-Round is spinning at a constant rate. How does the magnitude of the velocity of point A on the rim compare with the magnitude of the velocity of point B which is half the distance to the rim out from the center?

a) **The magnitude of the velocity of point A is greater.**
b) **The magnitude of the velocity of point B is greater.**
c) **They are both the same.**

A Merry-Go-Round is spinning at a constant rate. How does the magnitude of the angular acceleration of point A on the rim compare with the magnitude of the angular acceleration of point B which is half the distance to the rim out from the center?

a) The magnitude of the angular acceleration of point A is greater.
b) The magnitude of the angular acceleration of point B is greater.
c) They are both the same.

A Merry-Go-Round is spinning at a constant rate. How does the magnitude of the acceleration of point A on the rim compare with the magnitude of the acceleration of point B which is half the distance to the rim out from the center?

a) **The magnitude of the acceleration of point A is greater.**
b) **The magnitude of the acceleration of point B is greater.**
c) **They are both the same.**

What happens to the magnitude of the centripetal acceleration of a point on the rim of a spinning disk if one doubles the angular speed of the disk?

a) It becomes ¼ what it was.
b) It becomes ½ what it was.
c) It remains the same.
d) It becomes twice what it was.
e) It becomes four times what it was.

Did you do the reading assignment?

a) **Yes**
b) **No**
c) **Sort of.**

A person inverts a bicycle and gives the wheel a spin. If I ask you how many revolutions it will complete before it comes to rest, I am asking you to find the value of:

- **a)** θ
- **b)** ω
- **c)** `I`
- **d) None of the above.**

A person inverts a bicycle and gives the wheel a spin. If I tell you how fast it is spinning, I am giving you a value of:

a) θ

b) ω

c) **`I`**

d) None of the above.

What does `I` represent?:

a) **Inertia**
b) **Moment of Inertia**
c) **None of the above.**

The angular velocity of a rotating rigid body, as a function of time, is given by:

$$\omega = 15\frac{\text{rad}}{\text{s}} + 2.0\frac{\text{rad}}{\text{s}^2}t$$

Is the angular acceleration of the rigid body constant?

a) Yes
b) No

The angular position of a rotating rigid body, as a function of time, is given by:

$$\theta = 15\,\mathbf{rad} + \mathbf{2.0}\,\frac{\mathbf{rad}}{\mathbf{s}^2}\,t^2$$

Is the angular acceleration of the rigid body constant?

a) Yes
b) No

For a rotating rigid body, the magnitude of the angular velocity as a function of time is given by:

$$\omega = 88\,\frac{\text{rad}}{\text{s}}\left(1 - e^{-\frac{t}{4.0\,\text{s}}}\right)$$

What is the magnitude of the angular velocity of the rigid body at time zero?

a) 0
b) 88 rad/s
c) 44 rad/s
d) infinity

For a rotating rigid body, the magnitude of the angular velocity as a function of time is given by:

$$\omega = 88\,\frac{\text{rad}}{\text{s}}\left(1 - e^{-\frac{t}{4.0\,\text{s}}}\right)$$

What value does the magnitude of the angular velocity of the rigid body approach as *t* approaches infinity?

a) 0
b) 88 rad/s
c) 44 rad/s
d) infinity

A man is spinning on a bar stool with arms and legs extended. A friend got him going but at this point, no one and nothing is applying a torque to the spinning seat-plus-man. Consider the direction of his angular velocity at this point to be the positive direction for all rotational quantities. The man pulls his arms and legs in close to his body. What happens to his angular acceleration?

a) It increases.
b) It decreases.
c) It stays the same.
d) Based on the given information, no other answer provided can be identified as the one best answer.

A person turns her bicycle upside down and starts spinning one of the wheels. The rest of the bicycle is fixed in position but the person is free to get the wheel spinning in either direction. This question is about the motion of the tire valve cap near the rim of the wheel on the end of a rigid valve stem which is rigidly attached to the rim of the wheel. It is the little plastic screw-on cap that covers up the valve through which you put the air in the tire. It undergoes circular motion. Is it possible for the person to control the rotational motion of the wheel such that, at some instant in time, the valve cap has centripetal acceleration but no tangential acceleration?

a) Yes

b) No

A person turns her bicycle upside down and starts spinning one of the wheels. The rest of the bicycle is fixed in position but the person is free to get the wheel spinning in either direction. This question is about the motion of the tire valve cap near the rim of the wheel on the end of a rigid valve stem which is rigidly attached to the rim of the wheel. It is the little plastic screw-on cap that covers up the valve in which you put the air in the tire. It undergoes circular motion. Is it possible for the person to control the rotational motion of the wheel such that, at some instant in time, the valve cap has tangential acceleration but no centripetal acceleration?

a) Yes
b) No

A car is traveling around a flat horizontal circular track at constant speed. As you know, the centripetal force is not some new kind of mysterious force that arises because an object is in circular motion, but rather, an ordinary force, exerted on the object by some ordinary agent, causing the object to travel in a circle rather than along the straight path that it would travel in if there were no forces acting on it. What kind of force is the centripetal force in this case? (Note that the adjective "centripetal" doesn't tell you what kind of force it is, it tells you what the direction of the force is.)

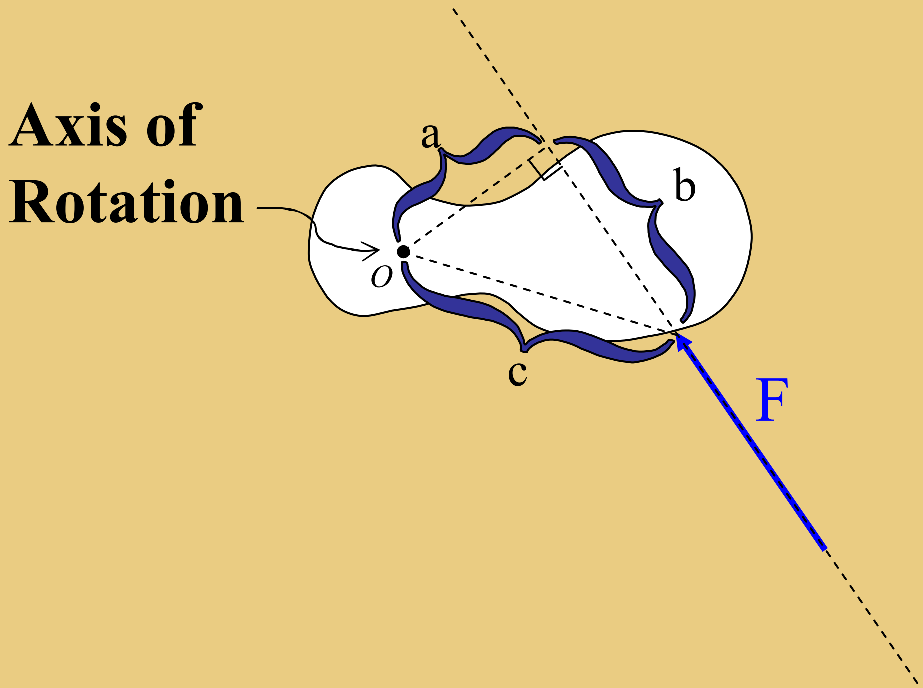
a) It is a normal force.
b) It is a frictional force.
c) It is a gravitational force.
d) It is a spring force.

A car is traveling around a flat horizontal circular track at constant speed. As you know, the centripetal force is not some new kind of mysterious force that arises because an object is in circular motion, but rather, an ordinary force, exerted on the object by some ordinary agent, causing the object to travel in a circle rather than along the straight path that it would travel in if there were no forces acting on it. Who or what is the agent of the centripetal force exerted on the car?

a) Gravity.
b) The driver.
c) The motor.
d) The track.

What is the direction of the angular velocity of the second hand of the clock on the wall in this room?

a) **Northward**
b) **Southward**
c) **Eastward**
d) **Westward**
e) **Upward**
f) **Downward**



Which distance in the diagram above is the moment arm of the force with respect to rotation about O?

a) a
b) b
c) c

The symbol $\mathtt{I}$ represents

a) mass

b) inertia

c) rotational inertia

d) moment of inertia

e) both a and b above

f) both c and d above

While a pitcher is accelerating a baseball in his hand forward in the act of throwing the ball, how does the magnitude of the force exerted on the baseball by the hand of the pitcher compare with the magnitude of the force exerted by the baseball on the hand of the pitcher?

a) They are the same.

b) There is no force exerted on the hand by the baseball so of course the force of the hand on the baseball is greater.

c) There is a force exerted on the hand by the baseball but the force of the hand on the baseball is greater.

d) The force exerted on the hand by the baseball is greater.

I is to rotational motion as _______ is to translational motion.

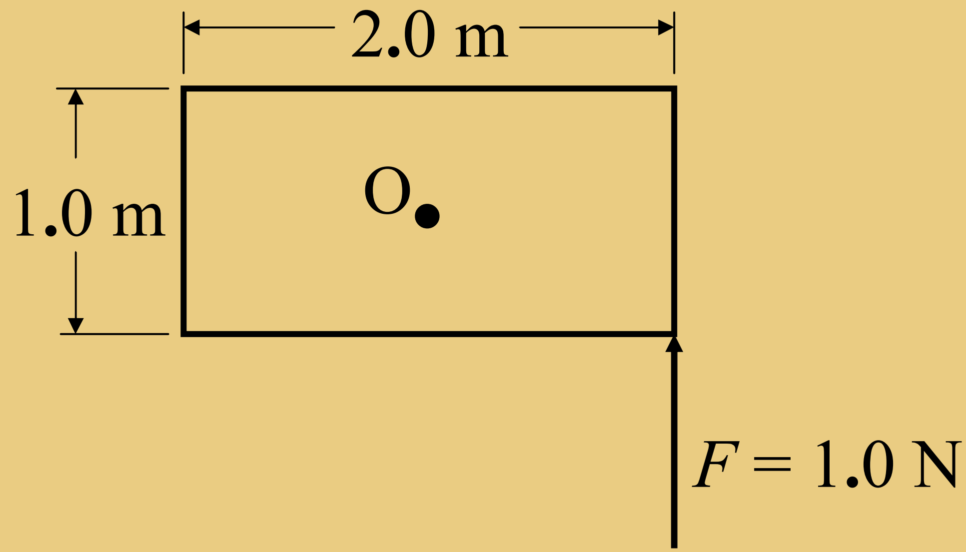
a) ω
b) $\boldsymbol{a}$
c) I
d) $\boldsymbol{t}$
e) $\boldsymbol{m}$

To loosen the screw holding the electrical outlet cover plate on the socket on the east wall of your classroom, an electrician would use a screwdriver to exert a torque on the screw in what direction?

a) **Northward**
b) **Southward**
c) **Eastward**
d) **Westward**
e) **Upward**
f) **Downward**

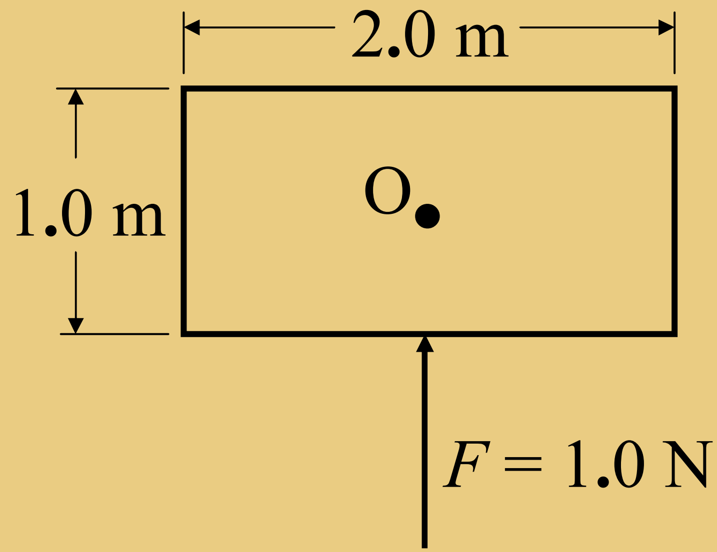
A lawn sprinkler is functioning normally on flat level ground. When a tip of the rotor of the sprinkler is at a point due north of the axis about which the rotor spins, the velocity of that tip is eastward. What is the direction of the angular velocity of the rotor?

- **a) Northward**
- **b) Southward**
- **c) Eastward**
- **d) Westward**
- **e) Upward**
- **f) Downward**



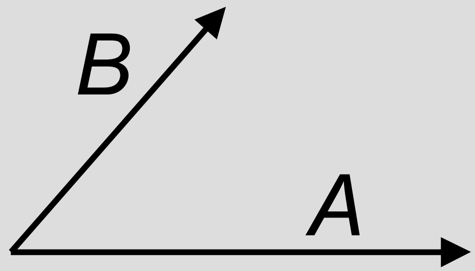
From your viewpoint, what is the torque about O (at the center of the plate) due to the 1.0 N force depicted?

a) 0
b) 0.5 N m clockwise
c) 0.5 N m counterclockwise
d) 1 N m clockwise
e) 1 N m counterclockwise
f) 2 N m clockwise
g) 2 N m counterclockwise



From your viewpoint, what is the torque about O due to the 1.0 N force depicted?

a) 0
b) 0.5 N m clockwise
c) 0.5 N m counterclockwise
d) 1 N m clockwise
e) 1 N m counterclockwise
f) 2 N m clockwise
g) 2 N m counterclockwise



What is the direction of $\vec{\mathbf{B}} \times \vec{\mathbf{A}}$?

a) Toward the right side of the page.

b) Toward the left side of the page.

c) Toward the top of the page.

d) Toward the bottom of the page.

e) Out of the page.

f) Into the page.

A small telescope is mounted on a ball and socket joint. The center of the ball forms the origin of our coordinate system. A northeastward force is applied to a point (on the telescope) whose position vector is directed eastward. What is the direction of the torque (about the center of the ball) exerted on the telescope by the agent of the force?

a) Northward

b) Eastward

c) Upward

d) Toward the top of the page

e) None of the above

While its not called that, you can think of a torque as a "rotational force". If you do, than you can think of the right side of the expression $\vec{\boldsymbol{\tau}} = \vec{\mathbf{r}} \times \vec{\mathbf{F}}$ as an abbreviation for "rotational force." This will help you keep the vectors in the correct order. What do you get if you reverse the order of the vectors in the cross product?

a) The result of such an error is unpredictable.

b) You still get the torque. The order of the vectors is not important.

c) You get a vector in the same direction as the torque, but, having the reciprocal of the magnitude of the torque.

d) You get the negative of the torque vector. (Same magnitude, opposite direction.)

Particles 1 and 2, having masses $m_1 = m$ and $m_2 = 2m$ respectively, lie on the x axis at (0, 0, 0) and (1.00 m, 0, 0) respectively. Where is the center of mass?

a) **Midway between the two particles.**

b) **Between the two particles, closer to particle 1.**

c) **Between the two particles, closer to particle 2.**

d) **None of the above.**

Two point masses, $m_1 = m$ and $m_2 = 2m$ lie on the x axis at (0,0,0) and (1.00 m, 0, 0) respectively. Where is the center of mass?

a) At (0.5, 0, 0)

b) At (0.25, 0, 0)

c) At (0.75, 0, 0)

d) None of the above.

Two point masses, $m_1 = m$ and $m_2 = 2m$ at (0, 0, 0) and (b, 0, 0) respectively are attached to a massless axis that lies on the x axis. Where on the x axis is the center of mass?

a) at $x = b$

b) at $x = \frac{1}{4}b$

c) at $x = \frac{1}{2}b$

d) at $x = \frac{3}{4}b$

e) None of the above.

Two point masses, $m_1 = m$ and $m_2 = 2m$ at (0, 0, 0) and (b, 0, 0) respectively are attached to a massless axis that lies on the x axis. What is the moment of inertia?

a) mb^2

b) $\frac{1}{4}mb^2$

c) $\frac{1}{2}mb^2$

d) **Insufficient information is provided.**

Two point masses, $m_1 = m$ and $m_2 = 2m$ at (0, 0, 0) and (b, 0, 0) respectively are attached to a massless axis that lies on the x axis. What is the moment of inertia with respect to the x axis?

a) mb^2

b) $\frac{1}{3}mb^2$

c) $\frac{2}{3}mb^2$

d) None of the above.

Two point masses, $m_1 = m$ and $m_2 = 2m$ at (0, 0, 0) and (b, 0, 0) respectively are attached to a massless axis that lies on the x axis. What is the moment of inertia with respect to the y axis?

a) mb^2

b) $2mb^2$

c) $3mb^2$

d) $4mb^2$

e) None of the above.

Two point masses, $m_1 = m$ and $m_2 = 2m$ at (0, 0, 0) and (b, 0, 0) respectively are attached to a massless axis that lies on the x axis. What is the moment of inertia with respect to the z axis?

a) mb^2

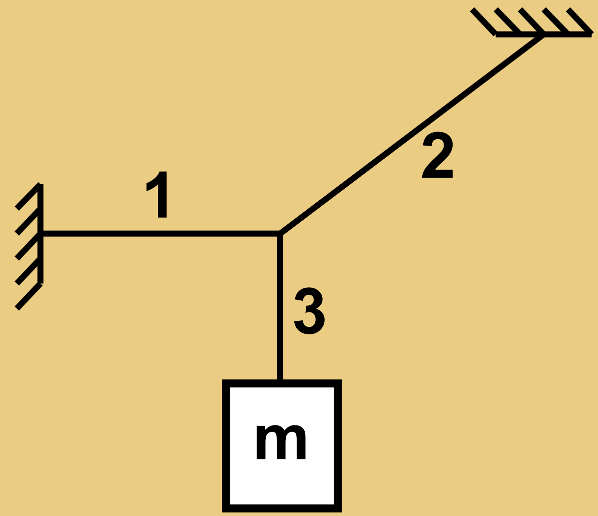
b) $2mb^2$

c) $3mb^2$

d) $4mb^2$

e) None of the above.

The diagram shows an object suspended vertically by string 3 which is tied to two other strings, string 1 and string 2. In which string is the tension greatest?



a) String 1

b) String 2

c) String 3

d) Not enough information is given.

A bowling ball and a tennis ball hang side by side by two strings such that the center of the bowling ball is at the same elevation as the center of the tennis ball. The two strings are parallel to each other. The distance between the two strings is equal to the sum of the radii of the two balls, so, the two balls are just barely touching. A person pulls the bowling ball away from the tennis ball, keeping the string taut. Naturally, the elevation of the bowling ball increases as she does so. The tennis ball remains hanging at rest. Then the person releases the bowling ball. The bowling ball swings downward and over toward the tennis ball. A collision ensues. During the collision, which ball, if either, exerts a greater force on the other?

a) The bowling ball exerts a greater force on the tennis ball than the tennis ball exerts on the bowling ball.

b) The tennis ball exerts a greater force on the bowling ball than the bowling ball exerts on the tennis ball.

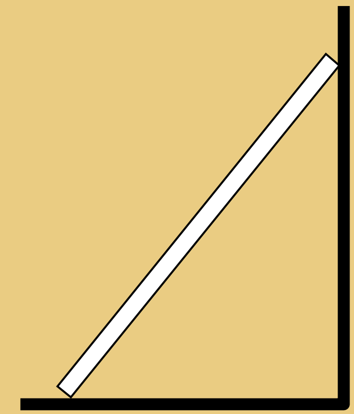
c) The force exerted by the tennis ball on the bowling ball has the same magnitude as the force exerted by the bowling ball on the tennis ball.

d) Neither ball exerts any force on the other.

Regarding the aforementioned tennis ball and bowling ball: Which ball, if either, experiences the greater acceleration during the collision?

- **a) The bowling ball.**
- **b) The tennis ball.**
- **c) Both have the same non-zero magnitude of acceleration during the collision.**
- **d) Neither ball experiences any acceleration during the collision.**

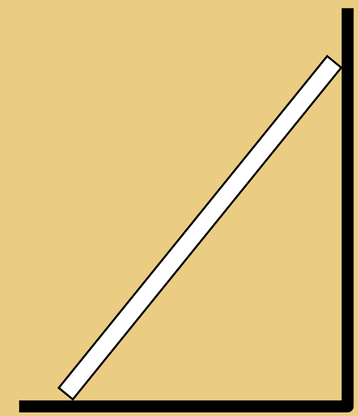
At right is a side view of a ladder leaning up against a wall. The center of mass of the ladder is at the geometric center of the ladder. Is it possible for the ladder to be in equilibrium if the wall is frictionless? In other words, as long as the friction between the floor and the ladder is great enough, will the ladder stay in place?



a) Yes.

b) No

At right is a side view of a ladder leaning up against a wall. The center of mass of the ladder is at the geometric center of the ladder. Is it possible for the ladder to be in equilibrium if the floor is frictionless? In other words, as long as the friction between the wall and the ladder is great enough, will the ladder stay in place?



a) Yes.

b) No

Regarding a situation in which work is done on a massive particle: What is work? (You are not being asked what it is equal to but what it, by definition, is.)

a) Force along the path times the length of the path.

b) The negative of the change in potential energy.

c) The change in the kinetic energy of the particle.

d) None of the above.

Regarding a situation in which work is done, by conservative forces only, on a massive particle: Which of the following is either work itself (by definition), or equivalent to the work done on the particle.

a) Force along the path times the length of the path.

b) The negative of the change in potential energy of the particle.

c) The change in the kinetic energy of the particle.

d) None of the above.

What is the Work-Energy Relation?

a) The work done on a particle is equal to the change in the kinetic energy of that particle.

b) Force causes acceleration governed by mass.

c) For every action there is an equal and opposite reaction.

d) As long as no work is done on a system by its surroundings, the total momentum of the system doesn’t change.

What does the dot product of two vectors yield?

a) A vector.

b) A scalar

c) None of the above.

“Work is Force times Distance” is a convenient mnemonic for remembering what work is, but, it does not tell the whole story. What’s wrong with it?

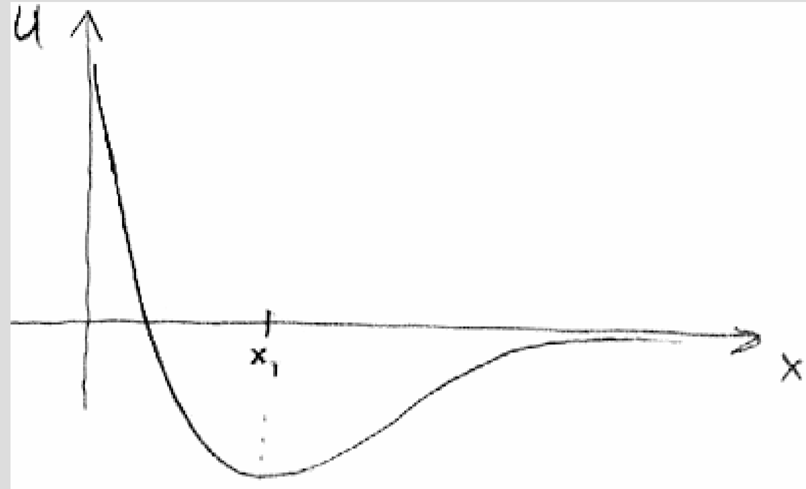
a) Nothing. It does tell the whole story.

b) Work is really the force along the path (rather than the whole force) times the distance the particle moves along the path.

c) If the force-along-the-path varies with position, calculating the work involves doing an integral rather than a product.

d) Both b and c above.

Depicted is the potential energy function for a particle confined to the x axis. Where must the particle be in order for the force on it to be in the +x direction?



a) At any $x < x_1$

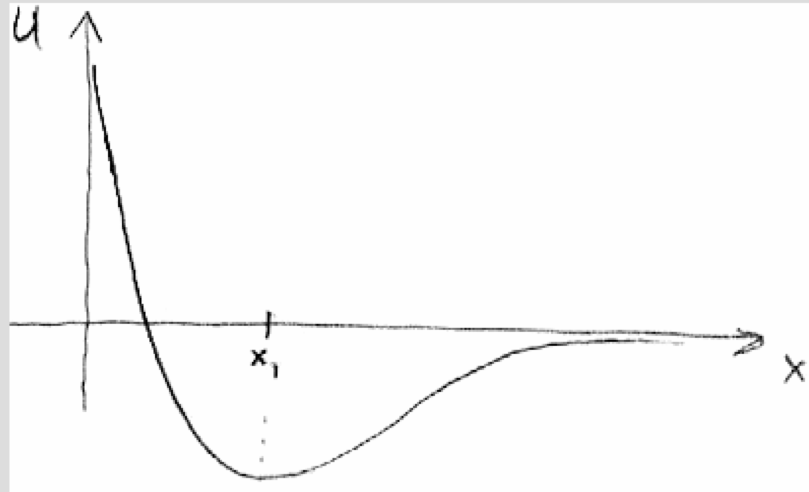
b) At any $x > x_1$

c) At $x = 0$

d) At $x = x_1$

e) There is no position at which the force on the particle would be in the +x direction.

Depicted is the potential energy function for a particle confined to the x axis. Where must the particle be in order for the force on it to be zero?



a) At any $x < x_1$

b) At any $x > x_1$

c) At $x = x_1$

d) At $x = 0$

f) There is no such position.

g) At least 2 of the answers above are correct.

Is $W = -\Delta U$ (the work done on a particle is the negative of the change in the potential energy of that particle) a cause and effect relation?

a) Yes

b) No

For the special case in which the power is constant, how do you calculate the amount of energy delivered to a system in time Δt?

a) Multiply the power by the time interval.

b) Divide the power by the time interval.

c) Take the time derivative of the energy.

d) Take the time derivative of the power.

In applying the principle of the conservation of mechanical energy, what kind of diagram or diagrams are you required to draw?

a) A free body diagram.

b) A before and after picture.

A particle of mass m is launched from a height h at a velocity of 15 m/s at an angle of 35° above the horizontal over flat level ground. When or where in the trajectory of the particle is the potential energy of the particle greatest?

a) At the first instant after launch.

b) While it is on the way up.

c) At the highest point in its trajectory.

d) While it is on the way down.

e) At ground level, the lowest point achieved prior to actual contact with the ground.

f) Nowhere.

A particle of mass *m* is launched from a height *h* at a velocity of 15 m/s at an angle of 35° above the horizontal over flat level ground. When or where in the trajectory of the particle is the potential energy of the particle a minimum?

a) At the first instant after launch.

b) While it is on the way up.

c) At the highest point in its trajectory.

d) While it is on the way down.

e) At ground level, the lowest point achieved prior to actual contact with the ground.

f) Nowhere.

A particle of mass *m* is launched from a height *h* at a velocity of 15 m/s at an angle of 35° above the horizontal over flat level ground. When or where in the trajectory of the particle is the <u>kinetic energy</u> of the particle <u>zero</u>?

a) At the first instant after launch.

b) While it is on the way up.

c) At the highest point in its trajectory.

d) While it is on the way down.

e) At ground level, the lowest point achieved prior to actual contact with the ground.

f) Nowhere.

A particle of mass m is launched from a height *h* at a velocity of 15 m/s at an angle of 35° above the horizontal over flat level ground. When or where in the trajectory of the particle is the kinetic energy of the particle greatest?

a) At the first instant after launch.

b) While it is on the way up.

c) At the highest point in its trajectory.

d) While it is on the way down.

e) At ground level, the lowest point achieved prior to actual contact with the ground.

f) Nowhere.

A particle of mass m is launched from a height h at a velocity of 15 m/s at an angle of 35° above the horizontal over flat level ground. When or where in the trajectory of the particle is the <u>speed</u> of the particle greatest?

a) At the first instant after launch.

b) While it is on the way up.

c) At the highest point in its trajectory.

d) While it is on the way down.

e) At ground level, the lowest point achieved prior to actual contact with the ground.

f) Nowhere.

A particle of mass m is launched from a height h at a velocity of 15 m/s at an angle of 35° above the horizontal over flat level ground. When or where in the trajectory of the particle is the speed of the particle <u>smallest</u>?

a) At the first instant after launch.

b) While it is on the way up.

c) At the highest point in its trajectory.

d) While it is on the way down.

e) At ground level, the lowest point achieved prior to actual contact with the ground.

f) Nowhere.

Object 2 has twice the mass and half the speed that object 1 has. Which object, if either, has the greater kinetic energy?

a) Object 1.

b) Object 2.

c) Neither.

Object 2 has the same mass but twice the speed of object 1. What is the ratio of the kinetic energy of object 2 to that of object 1?

a) $\frac{1}{4}$

b) $\frac{1}{2}$

c) 1

d) 2

e) 4

What is impulse? Choose the one **best** answer.

a) **Force times time.**
b) **Force times distance.**
c) **Momentum.**
d) **Change in momentum.**
e) **Force.**
f) **Energy.**

What is the Impulse Momentum relation?

a) **Force times distance equals momentum.**
b) **Force times distance equals change in momentum.**
c) **Force times time equals momentum.**
d) **Force times time equals change in momentum**
e) **Momentum times time equals impulse.**
f) **Momentum times time equals change in impulse.**

The Impulse Momentum relation can be viewed as a cause and effect relation. What is the cause?

a) Force times time.
b) Momentum.
c) Change in momentum.

Is impulse a vector? Is impulse a scalar?

a) Both.

b) Vector.

c) Scalar.

d) Neither.

A pitcher throws a ball over home plate. The batter hits the ball back at the pitcher. How does the impulse delivered to the ball by the bat compare with the momentum of the ball just before it got hit? The impulse...

a) is the same.

b) has the same magnitude but opposite direction.

c) has smaller magnitude and same direction.

d) has smaller magnitude and opposite direction.

e) has bigger magnitude and same direction.

f) has bigger magnitude and opposite direction.

A pitcher throws a ball over home plate. The batter hits the ball back at the pitcher. How does the force exerted on the ball by the bat compare with the force exerted on the bat by the ball. The force exerted on the ball by the bat...

a) is the same.
b) has the same magnitude but opposite direction.
c) has smaller magnitude and same direction.
d) has smaller magnitude and opposite direction.
e) has bigger magnitude and same direction.
f) has bigger magnitude and opposite direction.

An ongoing push or pull is ...

a) **Impulse.**
b) **Mass times acceleration.**
c) **Force.**
d) **Work.**
e) **Momentum.**
f) **Change in momentum.**

A shove is ...

a) Impulse.
b) Mass times acceleration.
c) Force.
d) Momentum.
e) Change in momentum.

What happens to the period of an ideal mass-on-a-spring system when the amplitude is doubled?

a) The period remains the same as it was.
b) The period becomes twice what it was
c) The period becomes one-half what it was.
d) The period becomes four times what it was.
e) The period becomes one-fourth what it was.
f) The period becomes the-square-root-of-two times what it was.
g) The period becomes one-over-the-square-root-of-two times what it was.

What happens to the period of an ideal mass-on-a-spring system when the *mass* is doubled?

a) The period remains the same as it was.

b) The period becomes twice what it was

c) The period becomes one-half what it was.

d) The period becomes four times what it was.

e) The period becomes one-fourth what it was.

f) The period becomes the-square-root-of-two times what it was.

g) The period becomes one-over-the-square-root-of-two times what it was.

What happens to the period of an ideal mass-on-a-spring system when the spring constant is doubled?

a) The period remains the same as it was.
b) The period becomes twice what it was
c) The period becomes one-half what it was.
d) The period becomes four times what it was.
e) The period becomes one-fourth what it was.
f) The period becomes the-square-root-of-two times what it was.
g) The period becomes one-over-the-square-root-of-two times what it was.

In an ideal block-on-a-horizontal spring system, how does the direction of the displacement of the block from its equilibrium position (when not zero) at a particular instant in time compare with the direction of the block's acceleration at that same instant?

a) The directions are the same.
b) The directions are opposite each other.
c) None of the above.

In an ideal block-on-a-horizontal spring system, how is the magnitude of the displacement of the block from its equilibrium position (when not zero) at a particular instant in time related to the magnitude of the block's acceleration at that same instant?

a) The acceleration is proportional to the square of the displacement.

b) The displacement is proportional to the square of the acceleration.

c) None of the above.

Where in the simple harmonic motion of a block on a spring is the speed of the block greatest?

a) At the end points. (The positions of maximum displacement from the equilibrium position.)

b) At the equilibrium position.

c) It has one and the same value everywhere.

d) None of the above.

Where in the simple harmonic motion of a block on a spring is the acceleration of the block greatest?

a) At the end points.

b) At the equilibrium position.

c) It has one and the same value everywhere.

d) None of the above.

Where in the simple harmonic motion of a block on a spring is the velocity of the block zero?

a) At the end points.

b) At the equilibrium position.

c) It has one and the same value everywhere.

d) None of the above.

Where in the simple harmonic motion of a block on a spring is the acceleration of the block zero?

a) At the end points.

b) At the equilibrium position.

c) It has one and the same value everywhere.

d) None of the above.

Where in the simple harmonic motion of a block on a spring is the kinetic energy of the block zero?

a) At the end points.

b) At the equilibrium position.

c) It has one and the same value everywhere.

d) None of the above.

Where in the simple harmonic motion of a block on a spring is the kinetic energy of the block maximum?

a) At the end points.

b) At the equilibrium position.

c) It has one and the same value everywhere.

d) None of the above.

Where in the simple harmonic motion of a block on a spring is the total energy of the block maximum?

a) At the end points.

b) At the equilibrium position.

c) It has one and the same value everywhere.

d) None of the above.

Where in the simple harmonic motion of a block on a spring is the potential energy of the block maximum?

a) At the end points.

b) At the equilibrium position.

c) It has one and the same value everywhere.

d) None of the above.

Where in the simple harmonic motion of a block on a spring is the potential energy of the block zero?

a) At the end points.

b) At the equilibrium position.

c) It has one and the same value everywhere.

d) None of the above.

What happens to the period of a simple pendulum if you double the mass of the bob?

a) The period remains the same as it was.
b) The period becomes twice what it was
c) The period becomes one-half what it was.
d) The period becomes four times what it was.
e) The period becomes one-fourth what it was.
f) The period becomes the-square-root-of-two times what it was.
g) The period becomes one-over-the-square-root-of-two times what it was.

What happens to the period of a simple pendulum if you double the length of the pendulum?

a) The period remains the same as it was.
b) The period becomes twice what it was
c) The period becomes one-half what it was.
d) The period becomes four times what it was.
e) The period becomes one-fourth what it was.
f) The period becomes the-square-root-of-two times what it was.
g) The period becomes one-over-the-square-root-of-two times what it was.

What causes waves?

a) An arrangement of the elements of a medium that is an oscillatory function of both time and position.

b) The motion of matter through space.

c) Light.

d) Sound

e) Something oscillating.

What is a definition of a wave?

a) An arrangement of the elements of a medium that is an oscillatory function of both time and position.

b) The motion of matter through space.

c) Light.

d) Sound

e) Something oscillating.

Demo: What kind of wave is being demonstrated?

a) Longitudinal.

b) Transverse.

c) Amplitudinal.

d) Frequential.

(Demo) What will happen to the wave speed if I increase the frequency (keeping everything else the same)?

a) It will increase.

b) It will decrease.

c) It will stay the same.

(Demo) What will happen to the wavelength if I increase the frequency (keeping everything else the same)?

a) It will increase.

b) It will decrease.

c) It will stay the same.

(Demo) What will happen to the wave speed if I increase the tension (keeping everything else the same)?

a) It will increase.

b) It will decrease.

c) It will stay the same.

(Demo) What will happen to the wave speed if I increase the amplitude (keeping everything else the same)?

a) It will increase.

b) It will decrease.

c) It will stay the same.

(Demo) What happens to the wave speed in a string as the wave goes from a low-linear-mass-density string to a high-density string with the same tension?

a) It increases.

b) It decreases.

c) It stays the same.

(Demo) What happens to the frequency in a string as the wave goes from a low-linear-mass-density string to a high-density string with the same tension?

a) It increases.

b) It decreases.

c) It stays the same.

(Demo) What happens to the wavelength in a string as the wave goes from a low-linear-mass-density string to a high-density string with the same tension?

a) It increases.

b) It decreases.

c) It stays the same.

On which kind of graph can you demarcate the amplitude of a wave?

a) Displacement vs. Time.

b) Displacement vs. Position

c) Both.

d) Neither.

On which kind of graph can you demarcate the frequency of a wave?

a) Displacement vs. Time.

b) Displacement vs. Position

c) Both.

d) Neither.

On which kind of graph can you demarcate the wavelength of a wave?

a) Displacement vs. Time.

b) Displacement vs. Position

c) Both.

d) Neither.

On which kind of graph can you demarcate the period of a wave?

a) Displacement vs. Time.

b) Displacement vs. Position

c) Both.

d) Neither.

$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}$$

What kind of equation is this?

a) A wave equation.
b) An algebraic equation.
c) A partial differential equation.
d) All of the above.
e) Both a and b.
f) Both a and c.
g) Both b and c.
h) None of the above.

$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}$$

What does the y stand for?

a) Position along the length of the medium.
b) Displacement from equilibrium.
c) Period.
d) Wavelength.
e) Time.
f) Wave Speed.
g) Velocity of a an infinitesimal bit of the medium.
h) None of the above.

$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}$$

What does the x stand for?

a) Position along the length of the medium.
b) Displacement from equilibrium.
c) Period.
d) Wavelength.
e) Time.
f) Wave Speed.
g) Velocity of a an infinitesimal bit of the medium.
h) None of the above.

$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}$$

What does the v stand for?

a) Position along the length of the medium.
b) Displacement from equilibrium.
c) Period.
d) Wavelength.
e) Time.
f) Wave Speed.
g) Velocity of a an infinitesimal bit of the medium.
h) None of the above.

$$y = y_{\max} \cos\left(\frac{2\pi}{\lambda} x - \frac{2\pi}{T} t\right)$$

Which way is the wave traveling?

a) In the +x direction.

b) In the –x direction.

Upon reflection from a fixed end, a wave in a string undergoes:

a) Phase reversal.

b) No phase reversal.

What do we call it when two waves traveling in opposite directions arrive at the same position in a string at the same time.

a) Wave merging.

b) Wave interference.

c) Diffraction.

d) Refraction.

e) None of the above.

What causes standing waves?

What does it mean for a wave in a string to be reflected?

a) **It reaches the end of the string and bounces back.**

b) **All parts of the wave become the opposite of what they were. All crests become troughs and all troughs become crests.**

c) **A transverse wave becomes a longitudinal wave, or, a longitudinal wave becomes a transverse wave.**

What does it mean for a wave to undergo phase reversal upon reflection?

a) **The wave travels in the direction opposite its original direction of travel.**

b) **Upon reflection, a crest becomes a trough and a trough becomes a crest.**

c) **Upon reflection, a longitudinal wave becomes a transverse wave and a transverse wave becomes a longitudinal wave.**

For the case of a wave in a string that is fixed at both ends, will there always be a node at each end?

a) Yes

b) No

In the case of standing waves in a medium, what is an antinode?

a) **A position along the length of the medium at which the displacement is always a maximum (peak of crest or bottom of trough).**

b) **A position along the length of the medium at which the amplitude of the oscillations is greater than or equal to the amplitude anywhere else.**

c) **A part of the medium that undergoes no displacement.**

For the case of standing waves in a tube that is open at one end, is there always an antinode at the open end?

a) Yes.

b) No.

Is the wavelength of the first harmonic of a standing wave always greater than the length of (that part of) the medium in which it persists?

a) Yes.

b) No.

What part of a period of a standing wave is the distance from a node to the nearest antinode?

a) One quarter.

b) One half.

c) One whole.

d) A period is not a distance.

What part of the wavelength of a standing wave is the distance from a node to the nearest antinode?

a) One quarter.

b) One half.

c) One whole.

d) A wavelength is not a distance.

For a wave in a medium that is in contact with a second medium, and the resulting wave in that second medium, what is the same?

a) The wavelength.

b) The frequency.

c) The wave speed.

What does the v (with no subscript) in the equation

$$f' = \frac{v \pm v_{\mathrm{R}}}{v \mp v_{\mathrm{S}}} f$$

stand for?

a) The velocity of the source.

b) The velocity of the receiver.

c) None of the above.

What does the v_R in the equation

$$f' = \frac{v \pm v_{\mathrm{R}}}{v \mp v_{\mathrm{S}}} f$$

stand for?

a) **The velocity of the receiver relative to the source.**
b) **The velocity of the source relative to the receiver.**
c) **None of the above.**

What is the proper way of rendering the equation

$$f' = \frac{v \pm v_{\mathrm{R}}}{v \mp v_{\mathrm{S}}} f$$

in the case of a receiver moving away from a stationary source?

a) $f' = \dfrac{v + v_{\mathrm{R}}}{v} f$

b) $f' = \dfrac{v - v_{\mathrm{R}}}{v} f$

c) $f' = \dfrac{v}{v + v_{\mathrm{S}}} f$

d) $f' = \dfrac{v}{v - v_{\mathrm{S}}} f$

e) $f' = \dfrac{v + v_{\mathrm{R}}}{v - v_{\mathrm{S}}} f$

f) $f' = \dfrac{v - v_{\mathrm{R}}}{v + v_{\mathrm{S}}} f$

What is the proper way of rendering the equation

$$f' = \frac{v \pm v_{\mathrm{R}}}{v \mp v_{\mathrm{S}}} f$$

in the case of a source moving away from a stationary receiver?

a) $f' = \dfrac{v + v_{\mathrm{R}}}{v} f$

b) $f' = \dfrac{v - v_{\mathrm{R}}}{v} f$

c) $f' = \dfrac{v}{v + v_{\mathrm{S}}} f$

d) $f' = \dfrac{v}{v - v_{\mathrm{S}}} f$

e) $f' = \dfrac{v + v_{\mathrm{R}}}{v - v_{\mathrm{S}}} f$

f) $f' = \dfrac{v - v_{\mathrm{R}}}{v + v_{\mathrm{S}}} f$

What is the proper way of rendering the equation

$$f' = \frac{v \pm v_{\mathrm{R}}}{v \mp v_{\mathrm{S}}} f$$

in the case of a source moving toward a receiver that is moving toward the source?

a) $f' = \dfrac{v + v_{\mathrm{R}}}{v} f$

b) $f' = \dfrac{v - v_{\mathrm{R}}}{v} f$

c) $f' = \dfrac{v}{v + v_{\mathrm{S}}} f$

d) $f' = \dfrac{v}{v - v_{\mathrm{S}}} f$

e) $f' = \dfrac{v + v_{\mathrm{R}}}{v - v_{\mathrm{S}}} f$

f) $f' = \dfrac{v - v_{\mathrm{R}}}{v + v_{\mathrm{S}}} f$

In which case is the observed frequency of a single frequency source is greater?

a) **When the source is moving toward the (stationary) receiver.**
b) **When the receiver is moving (at the same speed) toward the (stationary) source.**

The tank atop a water tower has the shape of a right circular cylinder with vertical walls. To quadruple the capacity, the tank is replaced with another tank of twice the diameter but the same height. Extra columns, are added to support the additional weight on the assumption that the weight of the water in the new tank will be four times the weight of the water in the original tank. What physical quantity is under consideration when one discusses the capacity of the tank?

a) Volume

b) Area

c) Diameter

d) Density

The tank atop a water tower has the shape of a right circular cylinder with vertical walls. To quadruple the capacity, the tank is replaced with another tank of twice the diameter but the same height. Extra columns, are added to support the additional weight on the assumption that the weight of the water in the new tank when it is full will be four times the weight of the water in the original tank when it was full. Will the capacity of the tank indeed be quadrupled?

a) Yes

b) No, it will be doubled.

c) No, the capacity of the new tank will actually be eight times the capacity of the original tank.

The tank atop a water tower has the shape of a right circular cylinder with vertical walls and an open top. To quadruple the capacity, the tank is replaced with a tank of twice the diameter but the same height. A 10-inch-diameter pipe extends from the tank straight down to the ground. The bottom end of the pipe is capped and there are four capped fire hose connections very near that end of the pipe. An engineer argues that the large vertical pipe has to be replaced with a thicker-walled vertical pipe because the pressure in the pipe is greater with the new tank than it was with the old. Is the pressure greater?

a) Yes.

b) No.

(Demo) Which of the following statements about the wooden block and the lead ball are true?

i) The wooden block has the greater mass.

ii) The wooden block has the greater volume.

iii) The wooden block has the greater density.

a) All three.

b) i and ii only.

c) ii and iii only.

d) iii only.

Two 15-meter-long hoses are being used to fill a swimming pool. Hose 1 is attached, at one end, to a water main. Hose 2 is attached to the other end of hose 1. Thus the water flows from the water main into hose 1, through hose 1, into hose 2, through hose 2, and finally, into the pool. There are no leaks. The interior diameter of hose 1 is 5.0 cm. The interior diameter of hose 2 is 2.5 cm. Consider the flow to be non-viscous. The water main and the hoses are always completely full of water. Assume that the fluid velocity at any point on any one cross-section of the main or either hose, has the same value that it has everywhere else on that one cross section. How does the water flow rate, one meter away from the water main, in the 5.0 cm hose, compare with the water flow rate, one meter away from the point where the two hoses are connected, in the 2.5 cm hose?

a) The flow rate in the 5.0 cm hose is one-fourth that in the 2.5 cm hose

b) The flow rate in the 5.0 cm hose is one-half that in the 2.5 cm hose

c) The flow rate in the 5.0 cm hose is twice that in the 2.5 cm hose.

d) The flow rate in the 5.0 cm hose is four times that in the 2.5 cm hose.

e) With the given information, no other answer provided can be determined to be the correct answer.

Two 15-meter-long hoses are being used to fill a swimming pool. both hoses are attached at the same elevation to the same side of a horizontal water main, about 15-cm apart from each other. The two hoses extend parallel to each other from the water main to the swimming pool. The interior diameter of hose 1 is 5.0 cm. The interior diameter of hose 2 is 2.5 cm. Consider the flow to be non-viscous. The water main and the hoses are always completely full of water. Assume that the fluid velocity at any point on any one cross-section of the main or either hose, has the same value that it has everywhere else on that one cross section. How does the water speed, one meter away from the water main, in the 5.0 cm hose, compare with the water speed, one meter away from the water main, in the 2.5 cm hose?

a) The water speed in the 5.0 cm hose is one-fourth that in the 2.5 cm hose.

b) The water speed in the 5.0 cm hose is one-half that in the 2.5 cm hose.

c) The water speed in the 5.0 cm hose is twice that in the 2.5 cm hose.

d) The water speed in the 5.0 cm hose is four times that in the 2.5 cm hose.

e) With the given information, no other answer provided can be determined to be the correct answer.

If 475 J of heat flows into a 225 gram sample of water,

a) the heat of the sample decreases by 475 J.
b) the heat of the sample increases by 475 J.
c) None of the above.

Whenever heat flows into a substance, the temperature of that substance increases.

a) True
b) False

Whenever heat flows into a substance, the internal energy of that substance increases.

a) True
b) False

Whenever the internal energy of a substance decreases, the temperature of that substance decreases.

a) True
b) False

Whenever the internal <u>kinetic</u> energy of a substance decreases, the temperature of that substance decreases.

a) True
b) False

Heat is a fluid.

a) True
b) False

Heat is energy in transit.

a) True
b) False

A chunk of cold iron is dropped into a cup of warmer water. The iron-plus-water system is thermally isolated from the surroundings. Enough time passes for the system to come to thermal equilibrium. Let Q_{water} and Q_{iron} represent the amount of heat that flows *into* the water and the amount heat that flows *into* the iron, respectively. Which, if either, is negative?

- **a) Q_{water}**
- **b) Q_{iron}**
- **c) Both**
- **d) Neither**

A chunk of cold iron is dropped into a cup of warmer water. The iron-plus-water system is thermally isolated from the surroundings. Enough time passes for the system to come to thermal equilibrium. Let ΔT_{water} and ΔT_{iron} represent the temperature change of the iron and the water, respectively. Which, if either, is negative?

a) ΔT_{water}
b) ΔT_{iron}
c) Both
d) Neither

A chunk of cold iron is dropped into a cup of warmer water. The iron-plus-water system is thermally isolated from the surroundings. The mass of the water is twice that of the iron. Is the final temperature of the water the same as the final temperature of the iron?

a) Yes
b) No

A chunk of cold iron is dropped into a cup of warmer water. The iron-plus-water system is thermally isolated from the surroundings. The mass of the water is <u>the same as</u> that of the iron. Is the final temperature of the water midway between the initial temperature of the water and the initial temperature of the iron?

a) Yes
b) No

A chunk of cold iron is dropped into a cup of warmer water. The iron-plus-water system is thermally isolated from the surroundings. Enough time passes for the system to come to thermal equilibrium. How does the increase in the internal energy of the iron compare with the decrease in the internal energy of the water?

a) They are the same.
b) The increase in the internal energy of the iron is greater.
c) The decrease in the internal energy of the water is greater.

Is it possible to warm up an ice cube without melting it?

a) Yes

b) No

Is it possible to heat up water vapor beyond 100°C?

a) Yes

b) No

If heat flows into liquid water, and there is no other exchange of energy between the liquid water and the surroundings, will the temperature of the water necessarily increase?

a) Yes

b) No

If heat flows into liquid water, and there is no other exchange of energy between the liquid water and the surroundings, will the internal kinetic energy of the water necessarily increase?

a) Yes

b) No

If heat flows into liquid water, and there is no other exchange of energy between the liquid water and the surroundings, will the internal energy of the water necessarily increase?

a) Yes

b) No

If I combine 100 g of liquid water at 0°C with 100 g of ice at 0°C, what will happen? (Assume the H_2O to be thermally isolated from the surroundings.)

a) **Some of the ice will melt.**

b) **Some of the liquid water will freeze.**

c) **Nothing.**

If I combine 100 g of liquid water at 5°C with 100 g of ice at 0°C, what will happen? (Assume the H_2O to be thermally isolated from the surroundings.)

a) **Some of the ice will melt.**

b) **Some of the liquid water will freeze.**

c) **Nothing.**

If I combine 100 g of liquid water at 5°C with 100 g of ice at -5°C, what will happen? (Assume the H_2O to be thermally isolated from the surroundings.)

a) **Some of the ice will melt.**

b) **Some of the liquid water will freeze.**

c) **Nothing.**

A student drops an ice cube of mass m_1 at a temperature T_1 (where $T_1 < 0°C$) into a polystyrene cup containing mass m_2 of hot water at temperature T_2 (where $T_2 < 100°C$). Consider the system to be the H_2O only and assume no heat exchange with the surroundings. At equilibrium, the system is all liquid water. The student wants to calculate the final temperature of the system and starts by writing:

$$Q_1 + Q_2 = 0$$

What is wrong with this expression for the case at hand?

a) Nothing

b) A minus sign is needed in front of the Q_2 .

A student drops an ice cube of mass m_1 at a temperature T_1 (where $T_1 < 0°C$) into a polystyrene cup containing mass m_2 of hot water at temperature T_2 (where $T_2 < 100°C$). Consider the system to be the H_2O only and assume no heat exchange with the surroundings. At equilibrium, the system is all liquid water. She wants to calculate the final temperature of the system and starts by writing:

$$Q_1 + Q_2 = 0$$

$$m_1 c_1 \Delta T_1 + m_2 c_2 \Delta T_2 = 0$$

What is wrong with the latter expression for the case at hand?

a) **Nothing.**
b) **There should be no subscripts on the temperature changes because they are both the same.**
c) **The heat flow into the part of the sample that is originally ice cannot be written as $m_1 c_1 \Delta T_1$. There is more to it than that.**
d) **None of the above.**

A student drops an ice cube of mass m_1 at a temperature T_1 (where $T_1 < 0°C$) into a polystyrene cup containing mass m_2 of hot water at temperature T_2 (where $T_2 < 100°C$). Consider the system to be the H_2O only and assume no heat exchange with the surroundings. At equilibrium, the system is all liquid water. The student wants to calculate the final temperature of the system and starts by writing:

$$Q_1 + Q_2 = 0$$

$$Q_1^{\text{ice warming}} + Q_1^{\text{melting}} + Q_1^{\text{liquid warming}} + Q_2 = 0$$

What is wrong with the latter expression for the case at hand?

a) Nothing

b) The third term does not belong in the expression.

c) None of the above.

A student drops an ice cube of mass m_1 at a temperature T_1 (where $T_1 < 0°C$) into a polystyrene cup containing mass m_2 of hot water at temperature T_2 (where $T_2 < 100°C$). Consider the system to be the H_2O only, and assume no heat exchange with the surroundings. At equilibrium, the system is all liquid water. The student wants to calculate the final temperature of the system and starts by writing:

$$Q_1 + Q_2 = 0$$

$$Q_1^{\text{ice warming}} + Q_1^{\text{melting}} + Q_1^{\text{liquid warming}} + Q_2 = 0$$

$$m_1 c_{\text{ice}} \Delta T_1^{\text{ice}} + m_1 \ell_1 \Delta T_1^{\text{ice}} + m_1 c_{\text{liq}} \Delta T_1^{\text{liq}} + m_2 c_{\text{liq}} \Delta T_2^{\text{liq}} = 0$$

What is wrong with the latter expression for the case at hand?

a) Nothing.

b) The 4th term should have a negative sign in front of it.

c) None of the above.

A piston is used to keep a gas compressed in a cylinder such that the pressure of the gas is greater than atmospheric pressure. The piston is on top of the gas with the face of the piston facing downward. A person is holding the piston down. The person relaxes her hold on the piston and the piston rises because of the force of the gas acting on it. There is no heat flow into or out of the gas. What happens to the internal energy of the gas in this process?

a) It increases.

b) It decreases.

c) It stays the same.

A person is holding a rubber band so that it is stretched. The person allows the rubber band to contract. Consider the rubber band to be the system. What is the algebraic sign of the work being done by the rubber band on the surroundings?

a) +
b) –
c) There is no work being done by or on the rubber band so there is no algebraic sign.

A person is using a cylinder of compressed helium gas to inflate a large number of balloons. The person notices that the cylinder is getting cold. Why is that?

a) **Heat is flowing out of the gas-plus-cylinder to the surroundings.**

b) **Work is being done by the helium in the cylinder. This cools the helium and heat flows from the cylinder walls into the helium.**

A physics professor wishes to demonstrate that applying the same force to two different objects over the same distance results in a bigger impulse to the more massive object. He sets up <u>two horizontal tracks</u> with two identical carts. A string extends horizontally from each cart and passes over a pulley. A 50 gram object is attached to the other end of each string. On one cart the professor puts two bars of metal, making that cart much more massive then the empty cart. The professor pulls the carts back the same distance and releases them from rest. It obviously takes longer for the more massive cart to travel 1 meter, so, the professor says, the "one and the same force" acting on each cart, acts on the more massive cart for a longer time interval, and, since Impulse = F Δt, the more massive cart must have received the greater impulse." What is the professor's mistake (if any)?

What is the professor's mistake (if any)?

a) There is no mistake.

b) Impulse is about distance, not time.

c) The forces exerted on the carts are not the same.

d) None of the above.

A physics professor wishes to demonstrate that applying the same force to two different objects over the same distance results in a bigger impulse to the more massive object. He sets up <u>two horizontal tracks</u> with two identical carts. A string extends horizontally from each cart and passes over a pulley. A 50 gram object is attached to the other end of each string. On one cart the professor puts two bars of metal, making that cart much more massive then the empty cart. The professor pulls both carts back the same distance and releases them from rest.

In the first meter of travel of each cart, does the more massive cart receive a bigger impulse?

a) Yes.

b) No.

A person sets up two horizontal tracks with two identical carts. A string extends horizontally from each cart and passes over a pulley. A 50 gram object is attached to the other end of each string. On one cart the person puts two bars of metal, making that cart-plus-contents much more massive then the empty cart. The person pulls both carts back the same distance and simultaneously releases them from rest.

In the first second of travel subsequent to release, does the more massive cart (considering the bars to be part of the cart) receive a bigger impulse?

a) Yes.

b) No.

A person sets up two horizontal tracks with two identical carts. A string extends horizontally from each cart and passes over a pulley. A 50 gram object is attached to the other end of each string. On one cart the person puts two bars of metal, making that cart much more massive then the empty cart. The person pulls both carts back the same distance and releases them from rest.

In the first meter of cart travel subsequent to release, upon which system (50 gram descending mass plus cart) is more work done?

a) The system with the more massive cart.

b) The system with the less massive cart.

c) Neither.

A person sets up two horizontal tracks with two identical carts. A string extends horizontally from each cart and passes over a pulley. A 50 gram object is attached to the other end of each string. On one cart the person puts two bars of metal, making that cart much more massive then the empty cart. The person pulls both carts back the same distance and releases them from rest.

Upon which cart is more work done in the first meter of cart travel subsequent to release?

a) The more massive cart.

b) The less massive cart.

c) Neither.

A person sets up two horizontal tracks with two identical carts. A string extends horizontally from each cart and passes over a pulley. A 50 gram object is attached to the other end of each string. On one cart the person puts two bars of metal, making that cart much more massive then the empty cart. The person pulls both carts back the same distance and releases them from rest.

In the first <u>second</u> of cart travel subsequent to release, <u>upon which system</u> (50 gram descending mass plus cart) is more work done?

a) The system with the more massive cart.

b) The system with the less massive cart.

c) Neither.

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Upon <u>which cart</u> is more work done in the first second of cart travel subsequent to release?

a) The more massive cart.

b) The less massive cart.

c) Not enough information is provided.