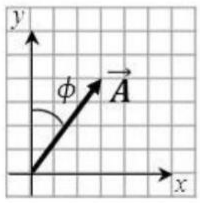
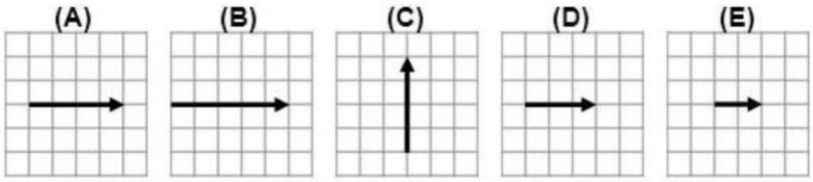
## Apply Vectors

**9.** The figure below shows vector $\vec{A}$ that forms an angle $\phi$ with the vertical axis. Choose the option that shows the $x$-component vector of $\vec{A}$, (i.e., $\vec{A}_x$).




## Conceptual Relationships

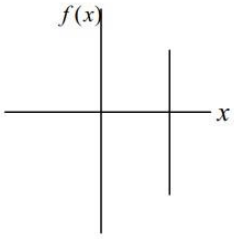
If a function is always positive, then what must be true about its derivative?

a) The derivative is always positive.
b) The derivative is never negative.
c) The derivative is increasing.
d) The derivative is decreasing.
e) You can't conclude anything about the derivative. ANS:_____

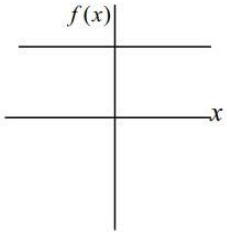
## Visualization

20. A correct sketch of the graph of the function $f(x)$ defined by: $x \cdot f(x) = 12$, could be which of the following?

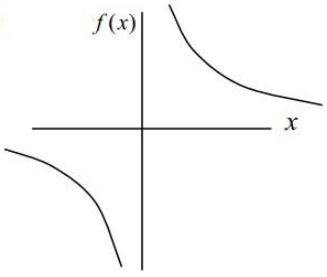
a)



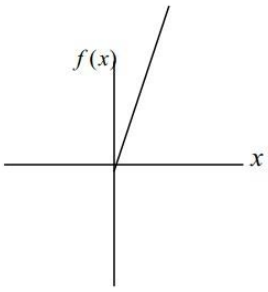

b)




c)




d)




e) None of the above

ANS:_____

## Algebra

**20.** Consider the vector $\boldsymbol{A} = 2\hat{\mathbf{i}} + 2\hat{\mathbf{j}}$. Which option shows the magnitude of this vector?

**(A)** 2
**(B)** $\sqrt{8}$
**(C)** 4
**(D)** $\frac{2}{\sqrt{8}}\,\hat{\imath} + \frac{2}{\sqrt{8}}\,\hat{\jmath}$
**(E)** 8

## Calculus

31. A pool has a horizontal circular bottom of radius $R$. The pool is $D$ meters deep and is being filled with water of density $\rho\frac{kg}{m^3}$. The weight $w$, in Newtons, of the water in the pool when $h$ meters deep is given by

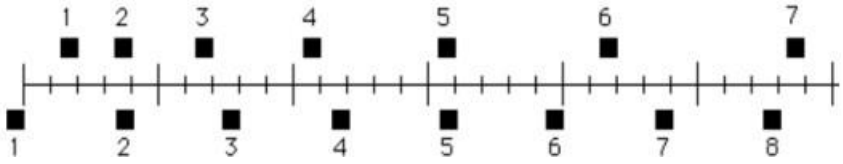
$$w(h) = \pi R^2 \int_0^h \rho g ds,$$

where $g$ is the acceleration of gravity in meters per second squared. The rate of change of the water's weight with respect to its height is:

a) $\rho g$
b) $2\pi R\rho g$
c) $\pi R^2 \rho g$
d) $\pi R^2 \rho g s$
e) $\pi R^2 \rho g h$

## 1-D Kinematics

The positions of two blocks at successive 0.20-second time intervals are represented by the numbered squares in the figure below. The blocks are moving toward the right.



Do the blocks ever have the same speed?

- ◯ No
- ◯ Yes, at instant 2
- ◯ Yes, at instant 5
- ◯ Yes, at instants 2 and 5
- ◯ Yes, at some time during the interval 3 to 4

## Free Fall

Two metal balls are the same size but one weighs twice as much as the other. The balls are dropped from the roof of a single story building at the same instant of time. The time it takes the balls to reach the ground below will be:

(A) about half as long for the heavier ball as for the lighter one.
(B) about half as long for the lighter ball as for the heavier one.
(C) about the same for both balls.
(D) considerably less for the heavier ball, but not necessarily half as long.
(E) considerably less for the lighter ball, but not necessarily half as long.

## 2-D Kinematics

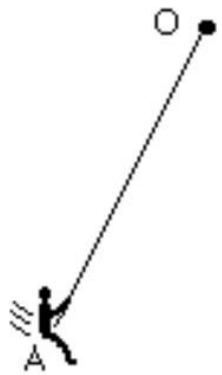
The two metal balls of the previous problem roll off a horizontal table with the same speed. In this situation:

(A) both balls hit the floor at approximately the same horizontal distance from the base of the table.
(B) the heavier ball hits the floor at about half the horizontal distance from the base of the table than does the lighter ball.
(C) the lighter ball hits the floor at about half the horizontal distance from the base of the table than does the heavier ball.
(D) the heavier ball hits the floor considerably closer to the base of the table than the lighter ball, but not necessarily at half the horizontal distance.
(E) the lighter ball hits the floor considerably closer to the base of the table than the heavier ball, but not necessarily at half the horizontal distance.

## Free Body Diagrams

The figure below shows a boy swinging on a rope, starting at a point higher than A.
Consider the following distinct forces:

1. A downward force of gravity.
2. A force exerted by the rope pointing from A to O.
3. A force in the direction of the boy's motion.
4. A force pointing from O to A.



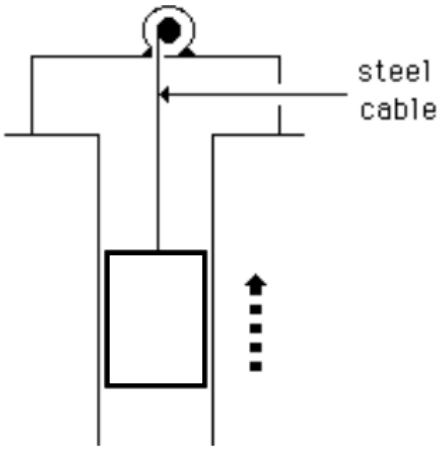

Which of the above forces is (are) acting on the boy when he is at position A?

(A) 1 only.
(B) 1 and 2.
(C) 1 and 3.
(D) 1, 2, and 3.
(E) 1, 3, and 4.

## Newton's Second Law

An elevator is being lifted up an elevator shaft at a constant speed by a steel cable as shown in the figure below. All frictional effects are negligible. In this situation, forces on the elevator are such that:

(A) the upward force by the cable is greater than the downward force of gravity.
(B) the upward force by the cable is equal to the downward force of gravity.
(C) the upward force by the cable is smaller than the downward force of gravity.
(D) the upward force by the cable is greater than the sum of the downward force of gravity and a downward force due to the air.
(E) none of the above. (The elevator goes up because the cable is being shortened, not because an upward force is exerted on the elevator by the cable).




Elevator going up
at constant speed

## Newton's Third Law

A large truck breaks down out on the road and receives a push back into town by a small compact car as shown in the figure below.


While the car, still pushing the truck, is speeding up to get up to cruising speed:

(A) the amount of force with which the car pushes on the truck is equal to that with which the truck pushes back on the car.

(B) the amount of force with which the car pushes on the truck is smaller than that with which the truck pushes back on the car.

(C) the amount of force with which the car pushes on the truck is greater than that with which the truck pushes back on the car.

(D) the car's engine is running so the car pushes against the truck, but the truck's engine is not running so the truck cannot push back against the car. The truck is pushed forward simply because it is in the way of the car.

(E) neither the car nor the truck exert any force on the other. The truck is pushed forward simply because it is in the way of the car.

## Work

You lift a suitcase from the floor to a table. In addition to the weight of the suitcase, select all of the following factors that determine the work done by the gravitational force on the suitcase.

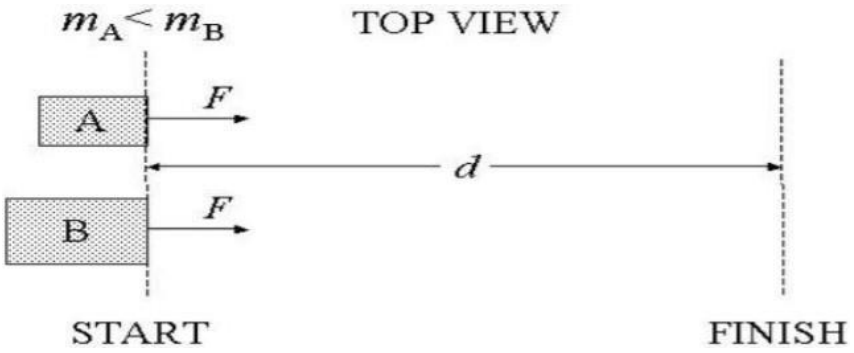
(1) whether you lift it directly up to the table or along a longer path

(2) whether you lift it quickly or slowly

(3) the height of the table above the floor

## Kinetic Energy

Two blocks are initially at rest on a frictionless horizontal surface. The mass $m_A$ of block A is less than the mass $m_B$ of block B. You apply the same constant force **F** and pull the blocks through the same distance *d* along a straight line as shown below (force **F** is applied for the entire distance *d*).



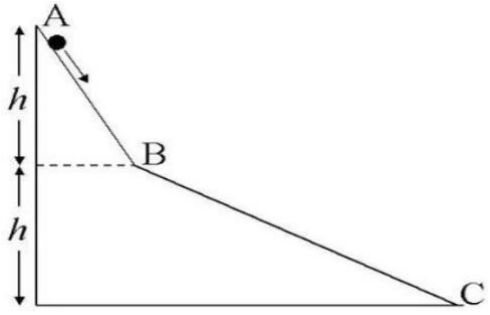

Which one of the following statements correctly compares the kinetic energies of the blocks after you pull them the same distance *d*?

- The kinetic energies of both blocks are identical.
- The kinetic energy is greater for the smaller mass block because it achieves a larger speed.
- The kinetic energy is greater for the larger mass block because of its larger mass.
- Not enough information, need to know the actual mass of both blocks to compare the kinetic energies.
- Not enough information, need to know the actual magnitude of force **F** to compare the kinetic energies.

## Potential Energy

You slide down two consecutive slopes of frictionless ice whose vertical heights *h* are identical, as shown below. Select all of the following statements that must be true.

(1) The change in your kinetic energy is identical for the motion from A to B and from B to C.
(2) The work done on you by the gravitational force is smaller for the motion from A to B than from B to C.
(3) The work done on you by the gravitational force is greater for the motion from A to B than from B to C.

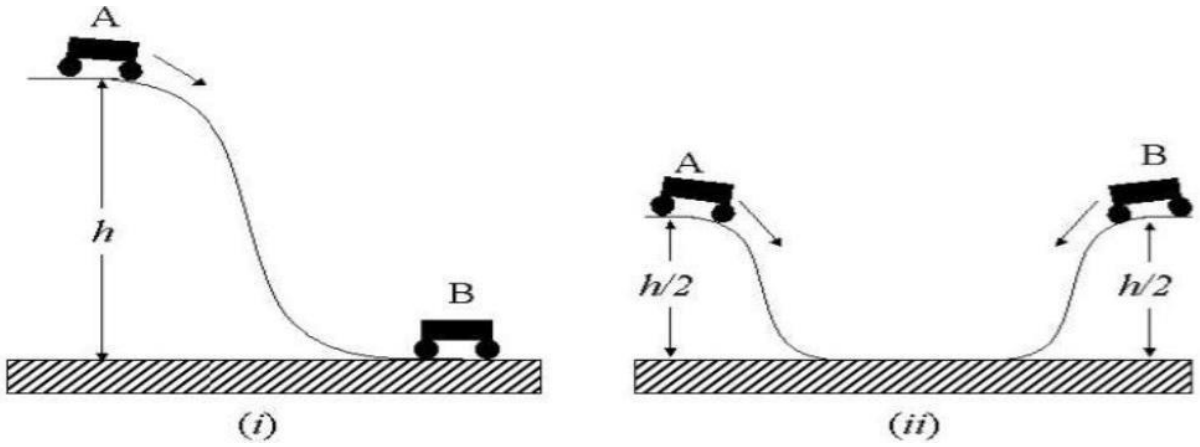


- (1) only
- (2) only
- (3) only
- (1) and (2) only
- (1) and (3) only

## Conservation of Energy

Carts A and B are identical in all respects before the collision.

**Figure (i):** Cart A starts from rest on a hill at a height *h* above the ground. It rolls down and collides "head-on" with cart B which is initially at rest on the ground. The two carts stick together.
**Figure (i):** Cart A starts from rest on a hill at a height *h* above the ground. It rolls down and collides "head-on" with cart B which is initially at rest on the ground. The two carts stick together.




Which one of the following statements is true about the two-cart system just before the carts collide in the two cases? Just before the collision on the ground,

- the kinetic energy of the system is zero in case (ii).
- the kinetic energy of the system is greater in case (i) than in case (ii).
- the kinetic energy of the system is the same in both cases.
- the momentum of the system is greater in case (ii) than in case (i).
- the momentum of the system is the same in both cases.

## Work Energy Theorem

A box slides with an initial speed $v0$ on a horizontal surface with friction and eventually comes to a stop. Which one of the following is equal to the change in the kinetic energy of the box?


- The momentum of the box multiplied by the distance traveled before coming to rest.
- The momentum of the box multiplied by the time elapsed before coming to rest.
- The momentum of the box multiplied by the deceleration of the box.
- The mass of the box multiplied by the deceleration of the box.
- None of the above.

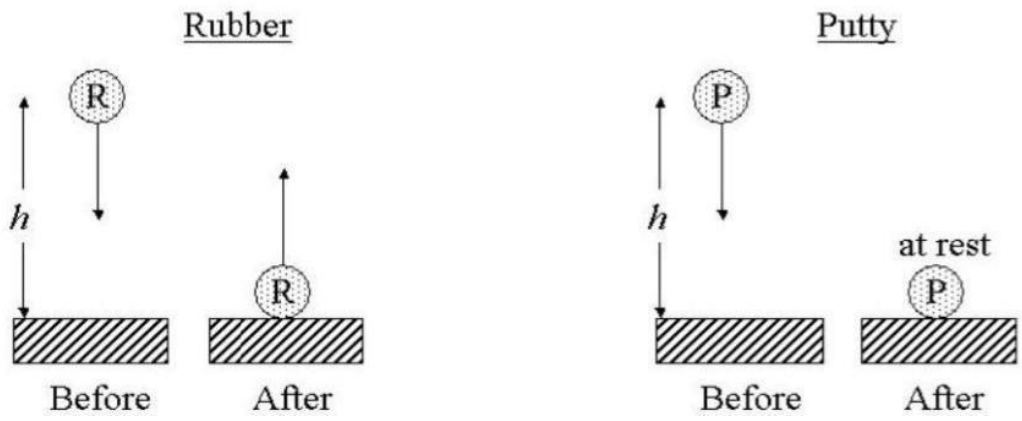
## Linear Momentum

Which one of the following statements is true concerning linear momentum?

- Momentum is a force.
- The momentum of an object is always positive.
- Momentum is a scalar quantity.
- The SI unit of momentum is kg m2/s.
- Momentum and impulse have the same units.

## Impulse

You drop two balls of equal mass, made of rubber and putty, from the same height $h$ above a horizontal surface (see Figure). The rubber ball bounces up after it strikes the surface while the putty ball comes to rest after striking it. Assume that in both cases the velocity of the ball takes the same time $\Delta t$ to change from its initial to its final value due to contact with the surface. Compare the average forces $\boldsymbol{F_R}$ and $\boldsymbol{F_P}$ exerted on the surface by the rubber and putty balls, respectively, during time $\Delta t$.

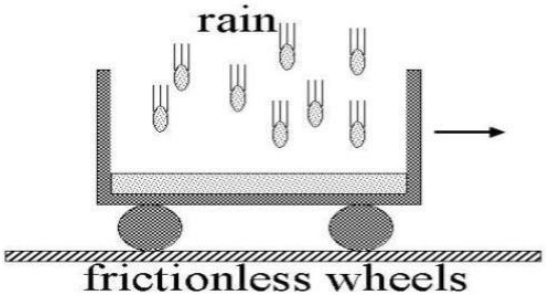



- $\boldsymbol{F_R = F_P}$
- $\boldsymbol{F_R > F_P}$
- $\boldsymbol{F_R < F_P}$
- $\boldsymbol{F_R}$ may be smaller or larger than $\boldsymbol{F_P}$ depending upon the relative size of the balls.
- $\boldsymbol{F_R}$ may be smaller or larger than $\boldsymbol{F_P}$ depending upon the actual height $h$ from which the balls are dropped.

## Conservation of Momentum

Rain starts falling vertically down into a cart with frictionless wheels which is initially moving at a constant velocity on a horizontal surface. The rain drops to rest with respect to the cart after striking it, and rain water accumulates in the cart. Select all of the following statements that must be true about this situation.

(1) The cart will continue to move at a constant velocity because the rain is falling vertically while the cart is moving horizontally.
(2) The cart will continue to move at a constant velocity because the total mechanical energy of the cart-rain system is conserved.
(3) The cart will slow down because the horizontal momentum of the cart-rain system is conserved.



- (1) only
- (2) only
- (3) only
- (1) and (2) only
- None of the above