Question:

What is a ***force***?

a. A *force* is a push or pull.
b. A *force* is something that can cause acceleration.
c. A *force* is exerted either by direct contact or through a distance.
d. A *force* is a vector quantity; having both magnitude and direction.
e. All of the above

Answer:

e.

a > Although a is an adequate definition of force, a better and more precise definition is one that Newton himself derived; i.e. force is the mechanism by which interactions take place.

b > This is true because it is describing the cause and effect relationship between force and acceleration as given by Newton's 2nd law.

c > In addition to force interactions taking place by direct contact between objects, forces can be exerted without direct contact occurring as in the case with gravity, electricity, magnetism and nuclear forces.

d > Forces are vectors because they possess both magnitude (amount or strength) and directional orientation.

Question:

An unbalanced force can

I. cause a change in an object's direction.
II. cause a change in an object's speed.
III. cause an object to remain at rest.

a. I only
b. II only
c. III only
d. I and II only
e. I, II and III

Answer:

d.

Question:

A rocket burns fuel to accelerate away from the earth and up into space. Which statement regarding the motion of the rocket is true?

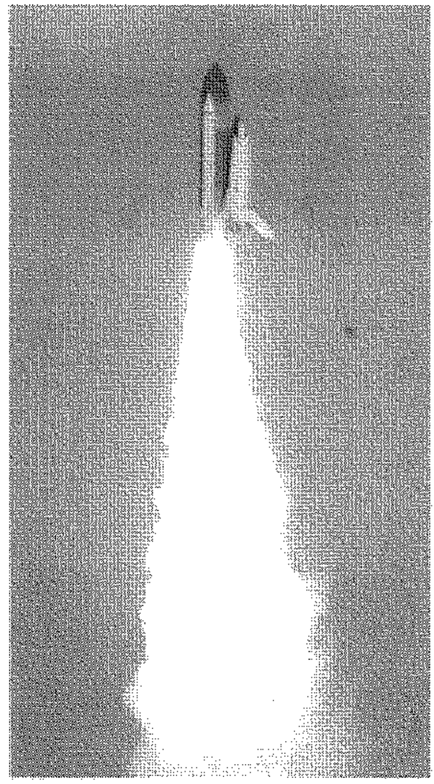
a. Newton's Third Law of Motion states that the force of the burning fuel on the rocket and the force of the rocket on the burning fuel are force pairs.

b. Newton's Third Law of Motion states that force of the fuel on the rocket is greater than the force of earth on the rocket.

c. Newton's Second Law of Motion states that the force of the fuel on the rocket and the force of the rocket on the fuel are force pairs.

d. Newton's Third Law of Motion states that the rocket won't be able to move upwards because all of the force pairs are balanced.

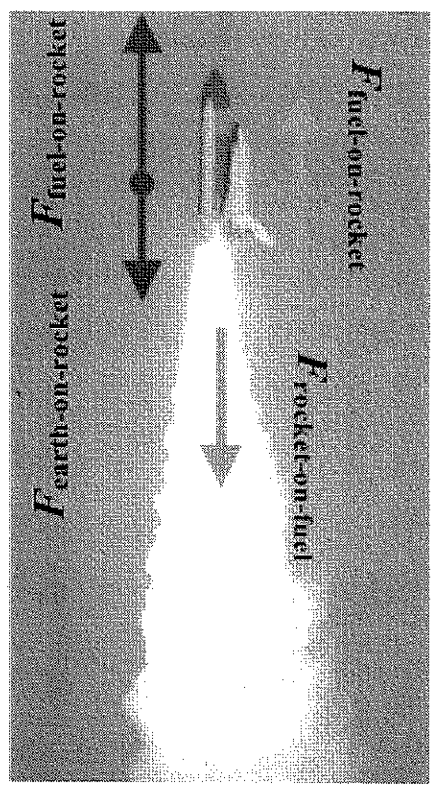
e. Newton's Second Law of Motion states that there won't be any acceleration because the net Force acting on the rocket is zero.



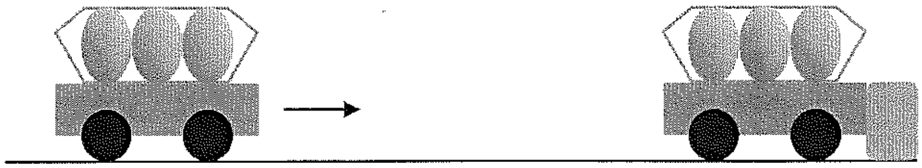
Answer:

The correct answer is a. The force of the burning fuel on the rocket (which causes the rocket to accelerate upwards) is equal to the force of the rocket down on the burning fuel (clearly visible in the photo as exhaust). The reason the rocket is able to accelerate upwards is due to Newton's Second Law of Motion, which says that a net Force on an object's mass causes it to accelerate. In this case, the force of earth's gravity on the rocket is pulling down, but the force of the burning fuel is up, and the force from the fuel is greater. The net force is upwards then, and that's the direction that the rocket accelerates.

This diagram shows the Second Law free-body analysis on the rocket in red on the left, and the Third Law force-pairs analysis in green on the right.



Question:



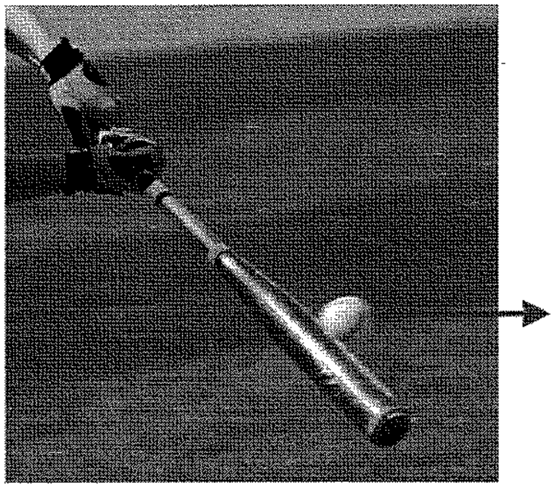
A small cart has a container of eggs placed on it, and the cart and eggs are traveling to the right as shown when a low barrier brings the cart suddenly to a stop. Which statement below is correct?

a. The eggs don't have any inertia when they're moving.
b. The cart doesn't have any inertia when it's moving.
c. The cart doesn't have any inertia after it stops.
d. When the cart comes to a stop, a net force causes the eggs to continue moving to the right.
e. None of the statements above is correct.

Answer:
The correct answer is *e*. The eggs resting on the cart will certainly continue to travel to the right, but not because of a net force pushing them in that direction. It is simply their *inertia*—their tendency to continue traveling at constant speed in a straight line—that carries them off the cart.

Note that all objects with mass have inertia, regardless of whether they're moving or not. In fact, mass *is* a measure of inertia. The more mass something has, the more it tends to maintain its state of motion, and the harder it is to *change* that state of motion.

Question:



A baseball bat comes into contact with a baseball as shown above, applying a force to the right. Which of the following statements is *false*?

a. The force of the bat on the ball is greater than the force of the ball on the bat.
b. The force of the bat causes the ball to accelerate to the right.
c. During the time of contact, the ball applies a force on the bat to the left.
d. During the time of contact, the bat will accelerate to the left.
e. That experiences a greater acceleration than the bat does.

Answer:

The correct answer is ***a***. The force of the bat on the ball is exactly *equal to* the force of the ball back on the bat. The force between these two objects is described by Newton's Third Law of Motion, the law of "force pairs."

It's a common misconception to think that the force on the ball must be greater–that's why the ball accelerates more than the bat, right? It's true that the ball *accelerates* more than the bat, but that's because it has a smaller *mass* than the bat. The *forces* between the two are equal in magnitude, but the masses are different, so the accelerations are different.

It may be helpful to see this relationship written like this, with the size of the letters in the formula proportional to their magnitude.

$$F_{on\ ball} = -F_{on\ bat}$$

$$m_{ball}\,a_{ball} = -m_{bat}\,a_{bat}$$

Question:

Inertia is the tendency of an object

I. initially at rest to stay at rest
II. initially in motion to continue moving with constant speed
III. initially in motion to continue moving in a straight line

a. I only
b. I and II only
c. I and III only
d. II and III only
e. I, II, and III

Answer:

The correct answer is *e*. A complete statement of Newton's Law of Inertia is

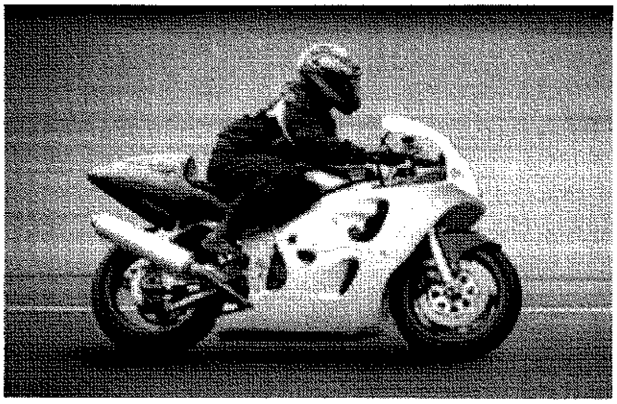
> *An object at rest tends to stay at rest, and an object in motion tends to stay in straight-line motion at constant speed, unless acted upon by a net (external) force.*

Newton's First Law of Motion can be used to describe the behavior of any object that isn't subjected to a net force:

- A hockey puck sliding across an ice rink with negligible friction.
- A comet flying through the vacuum of space.
- A rock sitting on a desk.

All objects tend to continue their state of motion as long as no net force is applied to them. If a net force *is* applied, then we can predict what happens using Newton's Second Law of Motion: $F_{net} = ma$.

Question:

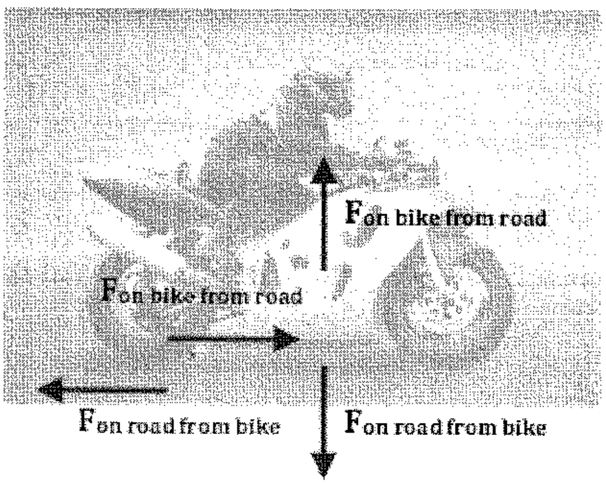


The motorcycle above is accelerating to the right. Which of the following statements is *false*?

a. There is a friction force between the tires and the road that pushes the road to the left.
b. There is a friction force between the tires and the road that pushes the motorcycle to the right.
c. There is a force equal to its weight that the motorcycle applies down on the road.
d. There is a force that the road applies upward on the motorcycle, that is equal to the its weight.
e. The force of the road on the bike is greater than the force of the motorcycle on the road.

Answer:

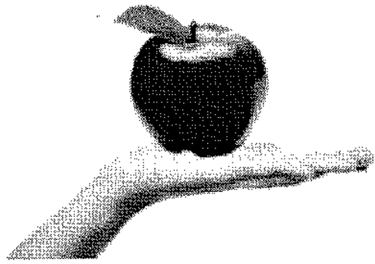
The correct answer is *e*. This is a problem involving Newton's Third Law of Motion and the force pairs that exist between objects. A diagram of the force pairs acting between the motorcycle and the road is shown here.



The red vectors show the horizontal forces between the motorcycle and the road. Just as the motorcycle pushes back on the road (imagine the rear tire spinning and throwing up dirt and rocks), the road pushes *forward* on the bike, which makes it move forward. These equal and opposite horizontal forces between the motorcycle and road are one set of force pairs.

Similarly, another set of force pairs between the motorcycle and the road act in the vertical direction. The bike, pulled down by gravity, presses *down* on the road, and the road pushes back *up* on the bike, exerting a "Normal" force to support it.

Question:



Newton's Third Law of Motion states that, for every force exerted on one object by a second object, the second object exerts an equal force *back* on the first. In the picture above, the force of earth's gravity is pulling downwards on the apple. The "equal and opposite" force pair that accompanies the force of earth's gravity pulling down on the apple is

a. the force of the apple down on the hand
b. the force of the hand up on the apple
c. the weight of the apple down
d. the force of the atmosphere down on the apple
e. the force of the apple up on the earth

Answer:
The correct answer is *e*. There is a force of gravitational attraction between the apple and earth. The earth pulls down on the apple (the force of earth's gravity on the apple), and *the apple pulls up on the earth* (via that same force of gravitational attraction).

This may seem a bit odd at first, but it's absolutely true. The earth and the apple are attracted to each other. If we drop the apple, the apple will accelerate toward the earth, and the earth accelerates towards the apple. Of course we don't notice the earth's acceleration in this situation–the earth's mass is so large that it's acceleration is so small as to be unnoticeable.

If you thought that the answer was *b*, well, it is sometimes the case that the force upwards from the hand is equal to the force down from gravity. But those are two different forces acting on a single object, which will allow us to determine its acceleration–*those two forces are not the "equal and opposite" forces of Newton's Third Law*. One way to remember this is that Newton's Third Law "force pairs" act between *two* different objects: "the force of A on B is equal to the force of B on A."

FOLLOW-UP QUESTION: What is the "force-pair" associated with the force of the apple down on the hand?

FOLLOW-UP ANSWER: The force of the hand back up on the apple, i.e. the Normal force.

Question:

An unbalanced force can

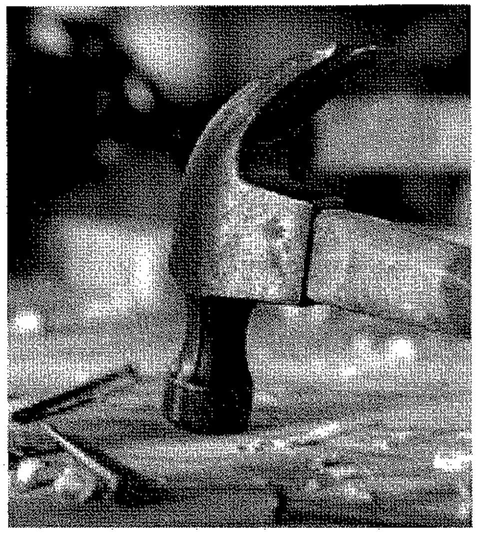
I. cause a change in an object's direction.
II. cause a change in an object's speed.
III. cause an object to remain at rest.

a. I only
b. II only
c. III only
d. I and II only
e. I, II and III

Answer:

d.

Question:



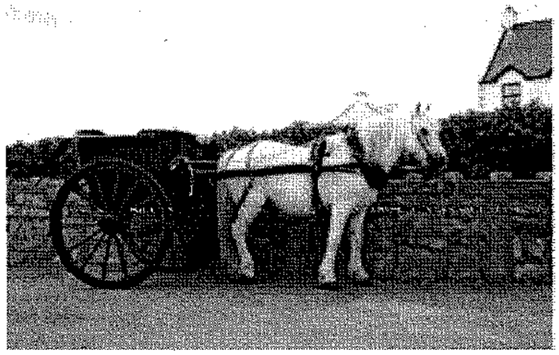
A heavy hammer is used to pound a small nail down into a piece of wood. Which of the following statements is *false*?

a. The hammer exerts a force down onto the nail, and causes it to accelerate downward into the wood.
b. The wood exerts a force of friction upward on the nail, resisting its motion.
c. The nail exerts an upward force on the hammer, causing it to accelerate upward.
d. The hammer exerts an upward force on the earth.
e. The force of the hammer on the nail is greater than the force of the nail on the hammer.

Answer:

The correct answer is *e*. When the hammer and the nail are in contact with each other, they exert forces on each other that are equal in magnitude, and in opposite directions. This relationship is described by Newton's Third Law of Motion, sometimes call the Law of Force Pairs.

Question:

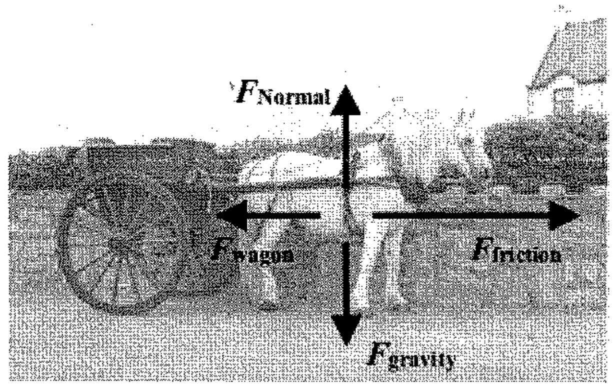


In the classic "horse and cart" problem, a horse is attached to a cart that can roll along on a set of wheels. Which of the following statements is true?

a. The horse pulls on the cart with a force, and the cart pulls back on the horse with an equal force—this is why the horse and cart cannot move forward.
b. The horse pulls on the cart with a force greater than the force that the cart pulls back on the horse—this is why the horse and cart can move forward.
c. The horse pulls the cart forward, but only if the horse has a mass greater than the mass of the cart.
d. The horse pulls the cart forward because of a time delay between the action and reaction forces.
e. The horse pulls the cart forward because the force of friction forward is greater than the force of the wagon backward.

Answer:
The correct answer is *e*. It's true that there are equal forces between the horse and the cart, acting in opposite direction. But that doesn't keep the horse and/or the cart from being able to move forward.

The thing that determines whether or not an object like the horse is able to accelerate is the *net Force* acting on that object. In this case, there are two horizontal forces acting on the horse: the wagon pulling backwards on him, and the force of friction between his hooves and the ground that allows him to be propelled forward. As long as the force forward on the hooves is greater than the force backward from the wagon, the horse will be able to move forward.



To help understand why this is so, it helps to draw a free-body diagram of the forces in the problem.

Question:

The force of earth's gravity pulling on an object, $\mathbf{F}_g$, is called its ***weight***, and also sometimes indicated with the symbol *W*. Which of the following statements is true?

a. ***Weight*** and ***mass*** are essentially the same thing, really.
b. An object's ***mass*** depends on how much it weighs.
c. *Mass* and ***weight*** are directly proportional–when one quantity increases, the value of the other quantity increases by the same factor.
d. In the absence of gravity, an object has no mass.
e. An object's ***weight*** varies depending on how far away it is from the source of gravity.

Answer:

The correct answer is *e*. The Weight of an object *W* is simply a special name given for the force of earth's gravity acting on an object, for which we can also use the symbol $\mathbf{F}_g$. This weight can be calculated using the formula

$$\mathbf{F}_g = W = m\mathbf{g}$$

and if asked about the direction of this force, you probably know that it's directed ***down***, towards the center of the earth.

Weight depends in part upon the mass *m* of an object–the more massive the object is, the greater the force of gravity acting on it–but it also depends on the value **g**, the "acceleration due to gravity." The value of **g** is 9.8 m/s^2 at the surface of the earth, but that value changes as one changes one's location. Most importantly, that value decreases as one moves away from the surface of the earth, and drops to essentially zero once one gets farther away. (At about 35,000 miles above the surface of the earth, the force of gravity drops to 1% of what it is at the surface.)

The mass of the object hasn't changed at these greater distances–the matter that makes up the object is still there, and it still requires a Force to make it move in space–but the force of earth's gravity acting on the object–its Weight–is effectively zero. The object is ***weightless*** in space.

Question:

A 0.150 kilogram hockey puck is at rest on the icy surface of a frozen lake. When the puck is hit by a 300 Newton force from a hockey stick, it begins to accelerate horizontally on the frictionless ice. The acceleration of the puck during the hit is

a. 300 m/s^2
b. 2000 m/s
c. 300 m/s
d. 2000 m/s^2
e. 45 m/s^2

Answer:

The correct answer is ***d***. We can calculate the acceleration of the puck by using Newton's Second Law of Motion:

$$F_{net} = ma$$

$$F_{hockey\ stick\ on\ puck} = (0.150kg)(a)$$

$$300N = (0.150kg)(a)$$

$$a = \frac{300N}{0.150} = 2000m/s^2$$

FOLLOW-UP QUESTION: If the stick hit the puck for 0.01 seconds, what is the final velocity of the puck as it slides across the lake after being hit?

FOLLOW-UP ANSWER:

$$a = 2000m/s^2$$

$$v_f = v_i + at$$

$$v_f = 0 + (2000m/s^2)(0.01s)$$

$$v_f = 20m/s$$

Question:

A small 1.0 kilogram rock and a large 2.0 kilogram rock are held at the top of a high cliff, and then simultaneously dropped over the edge. They accelerate downwards with negligible air friction. Which statement is correct?

a. The 2.0 kg rock has twice as much inertia as the 1.0 kg rock because it has a greater mass.
b. The 2.0 kg rock has twice as much inertia as the 1.0 kg rock because it has a greater volume.
c. The two rocks have the same inertia because they have the same velocity.
d. The two rocks have the same inertia because they have the same acceleration.
e. Just before the rocks were dropped, their inertia was 0.

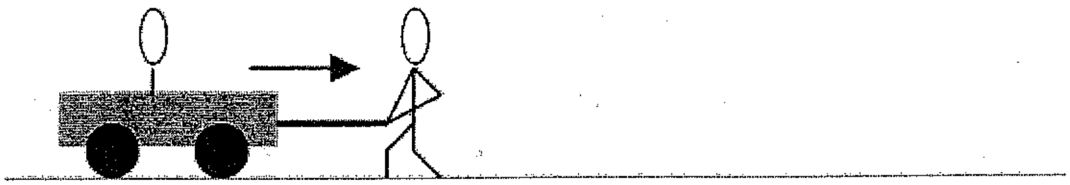
Answer:

The correct answer is ***a***. ***Inertia*** is a measure of how difficult it is to change an object's state of motion, and the quantity we usually use for that is ***mass***. A more massive rock has more inertia, by definition.

Inertia doesn't have anything to do with velocity, so the fact that the rocks are moving, or not, is not a factor in determining inertia.

Question:

Girl pulls wagon to the right



A boy sits in a wagon that rolls with essentially no friction, and a girl applies a horizontal force to the right as shown. Which statement is *false*?

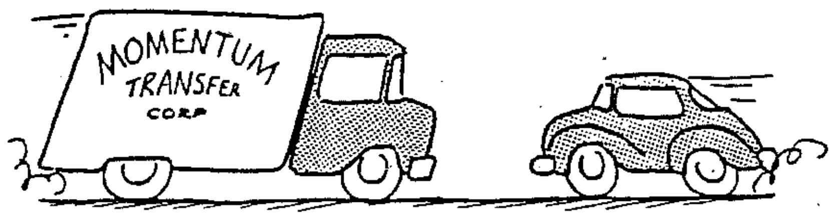
a. The force applied by the girl causes the wagon to accelerate.
b. After the wagon starts to move, if the girl stops applying a force, the wagon will stop.
c. If the girl wants the wagon to *continue* accelerating, she has to *continue* applying a force to it.
d. There is no net force acting in the vertical direction on the wagon.
e. The girl pulls on the wagon to the right, and the wagon pulls back on the girl to the left.

Answer:
The correct answer is ***b***. If the girl stops applying a force to the moving wagon, it will continue to move in straight-line motion according to the Newton's First Law of Motion, the Law of Inertia.

All the other statements are true. The force applied by the girl causes the wagon to accelerate according to Newton's Second Law of Motion, $\mathbf{F}_{net} = m\mathbf{a}$. To continue the acceleration, she has to continue to apply a net force, which will require her to continue running faster and faster ahead of the wagon. Although there are forces acting in the vertical direction–the Normal force and the force of gravity–they should balance out to be zero (except under some interesting circumstances that don't appear to be part of this situation). Finally, the girl pulls on the wagon, and the wagon pulls back on the girl; these are the "force pairs" between two objects that are described by Newton's Third Law of Motion.

conceptual **PHYSICS**

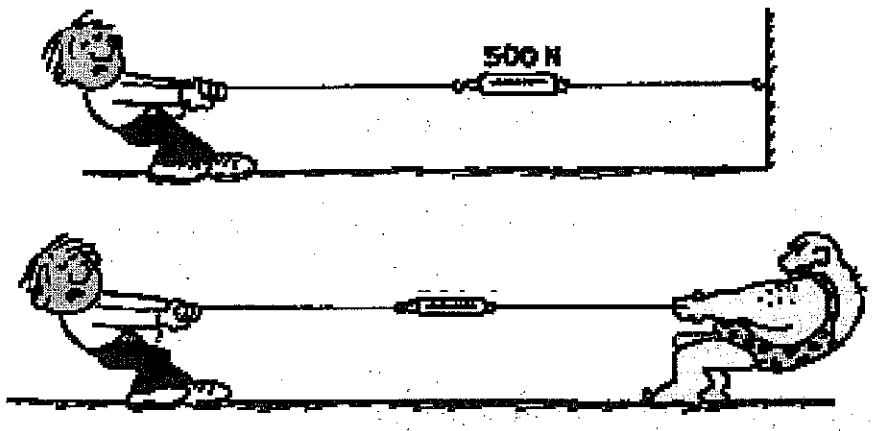
IF A MACK TRUCK AND A VOLKSWAGEN HAVE A HEAD-ON COLLISION, WHICH VEHICLE WILL EXPERIENCE THE GREATER IMPACT FORCE?



a) THE MACK TRUCK
b) THE VOLKSWAGEN
✓ c) BOTH THE SAME
d) ... IT DEPENDS ON OTHER FACTORS

Question:

Apply Newton's laws to determine the scale reading for the case shown in the second figure.

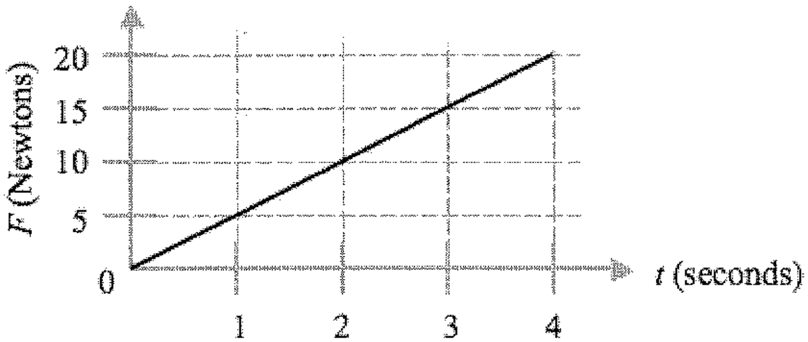


a. 0 N
b. 250 N
c. 500 N
d. 1000 N
e. None of the above

Answer:

c.

Question:



A block is pushed along a horizontal, frictionless surface, with a horizontal Force that varies as a function of time as shown in the graph here. At time $t = 3$ seconds, the acceleration of the block is 5.0 m/s^2. The mass of the block is

a. 1 kg
b. 2 kg
c. 3 kg
d. 5 kg
e. 15 kg

Answer:

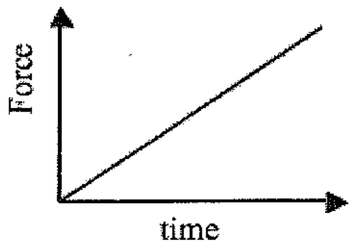
The correct answer is *c*. The relationship between the force acting on the block, its mass, and acceleration is described by F=*m*a.

$$F_{net} = ma$$

$$15N = m(5m/s^2)$$

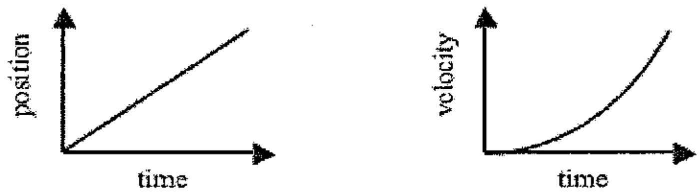
$$m = 3kg$$

Question:

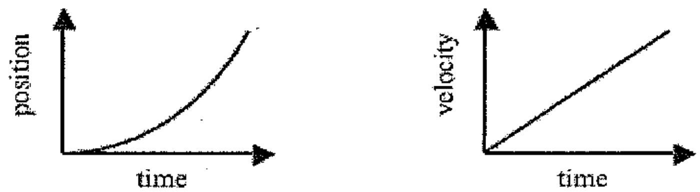


The graph above shows the Force applied to an object as a function of time t. Which of the following pairs of graphs represent possible position-time and velocity-time graphs for this object?

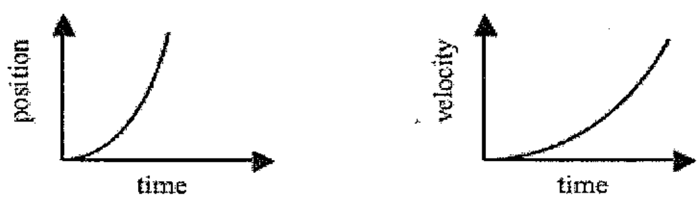
a.



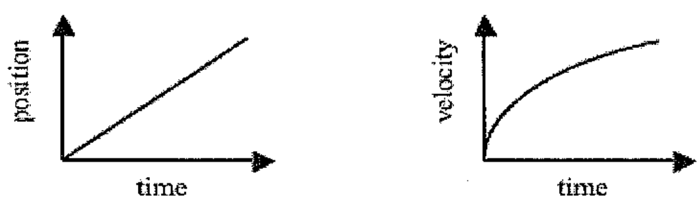
b.



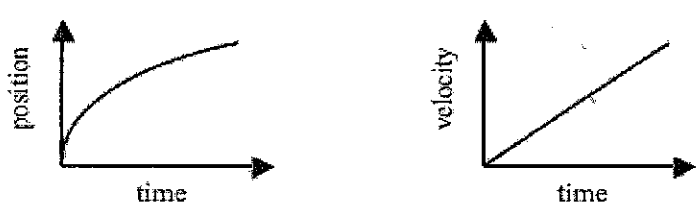
c.



d.



e.

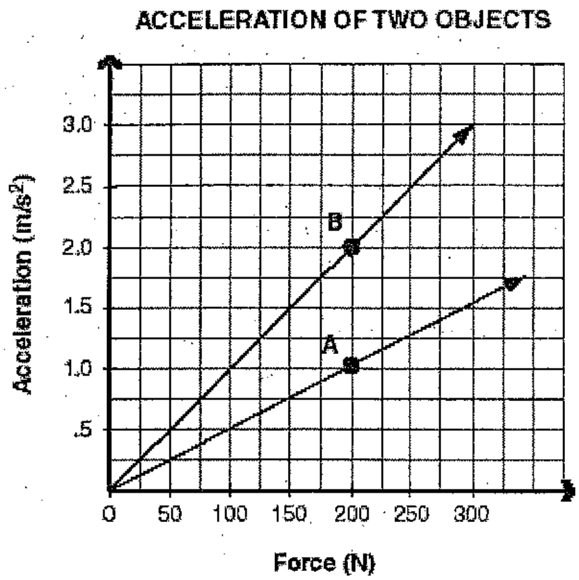


Answer:

The correct answer is *c*. As Force increases linearly with time, acceleration will need to increase linearly as well. $a = {}^{dv}/_{dt}$, so we'd expect that the slope of the velocity-graph will be increasing over time. Likewise, with $v = {}^{dx}/_{dt}$, the slope of the position-time graph will be increasing.

Question:

Forces are applied to two objects of different mass **A** and **B** and the resulting accelerations are measured. The results are shown in the graph below. According to Newton's laws, which of the objects has the greater mass?



Answer:

A

This graph plots acceleration vs force.

For this arrangement, Newton's 2nd law would be written as follows:

$$a = 1/m\ F$$

This means that the slope of the curves is 1/m, so the greatest mass would correspond to the curve with the smallest slope. This makes sense in accordance with the fact that a smaller mass requires less force to accelerate by the same amount compared to a larger mass.