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.

Question:

1. What is a *force*? How can forces be described?
2. What types of forces exist?
3. Provide some examples from your experience and observations that describe situations in which forces act.

Answer:

1. **A force can be defined in simple terms as a push or pull. It can be defined more precisely as the interaction between objects. Force is the mechanism by which objects interact.**
2. **Types of force can be organized along the following categories:**
   a) **Everyday Forces**
   b) **Fundamental Forces of Nature**
   c) **Free-Body Diagram Forces**
3. **Student provided examples…**

Question:

Consider the following questions:

I. **What is an "everyday" force"?**
II. **What is a "fundamental force"?**
III. **What is the nature of force itself?.**

Answer:

I. **Everyday forces include: Weight (Gravity), Normal, Friction, Applied**
These are also the forces which should be considered when constructing a free-body diagram.
II. **Fundamental forces include: Strong Nuclear, Weak Nuclear, Electromagnetic, Gravity.**
III. **Force is the mechanism of interaction between objects.**

Question:

Which Fundamental force of nature is the strongest?

a. **Gravitational**
b. **Electromagnetic**
c. **Strong Nuclear**
d. **Weak Nuclear**
e. **They are have the same strength**

Answer:

c.

Question:

Which of the following statements concerning forces is correct?

- **I. A force is an action exerted on an object that can change the object's state of motion.**
- **II. A force cannot act on an object unless direct contact occurs.**
- **III. The weakest *fundamental* force in nature is the *Weak Force*.**

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

Answer:

a.

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.

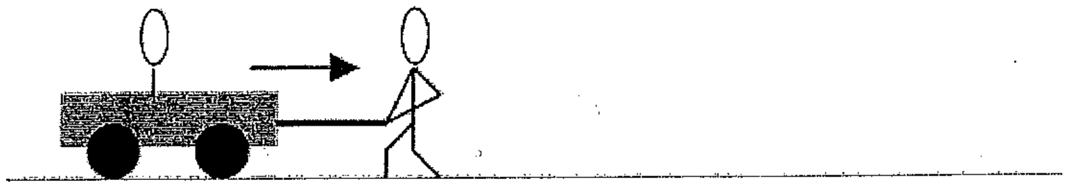
a. I only
b. II only
c. III only
d. I and II only
e. I, II and III

Answer:

d.

Question:

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.

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:

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

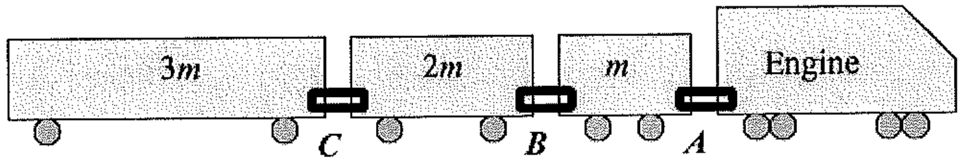
$$\mathbf{F}_g = W = m\mathbf{g}$$

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:



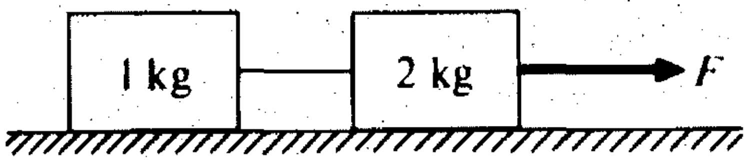
A locomotive engine of unknown mass pulls a series of railroad cars of varying mass: the first car has mass m, the second car has mass $2m$, and the last car has mass $3m$. The cars are connected by links A, B, and C, as shown. Which link experiences the greatest force as the train accelerates to the right?

a. A
b. B
c. C
d. Which link depends on the mass of the engine.
e. A, B, and C all experience the same force.

Answer:

The correct answer is *a*. Link A is responsible for pulling the entire mass of the train ($m + 2m + 3m = 6m$ total) to the right. Link B only needs to pull $5m$, and Link C only $3m$.

Question:



When the frictionless system shown above is accelerated by an applied force of magnitude the tension in the string between the blocks is

(A) 2F (B) F (C) 2/3 F (D) ½ F (E) 1/3 F

Answer:

E

Question:

An object moves in a straight line according to the equation $x = 2t^3 - 3t^2 - 6t$, where x is in meters and t is in seconds. At what time is the net Force acting on the object = 0?

a. $t = 0.5$s
b. $t = 1.0$s
c. $t = 2.0$s
d. $t = 2.5$s
e. $t = 3.0$s

Answer:

The correct answer is ***a***. The net Force acting on the object will be 0 when the object has zero acceleration, so this question is really asking, "when is the acceleration of this object 0?"

Recall that $a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$, so we need to get the second derivative of the x equation:

$$v = \frac{dx}{dt} = \frac{d}{dt}\left(2t^3 - 3t^2 - 6t\right) = 6t^2 - 6t - 6$$

$$a = \frac{dv}{dt} = \frac{d}{dt}\left(6t^2 - 6t - 6\right) = 12t - 6$$

$$a = 0 = 12t - 6$$

$$t = 0.5s$$

Question:

A 0.50-kg object moves along the *x*-axis according to the function $x = 4t^3 + 2t - 1$, where *x* is in meters and *t* is in seconds. What is the magnitude of the net force acting on the object at time $t = 2.0$s?

a. 50 N
b. 25 N
c. 46 N
d. 48 N
e. 24 N

Answer:

The correct answer is *e*. The acceleration of the object is determined by using $a = \frac{d^2x}{dt^2}$, as follows:

$$v = \frac{dx}{dt}$$

$$v = \frac{d}{dt}(4t^3 + 2t - 1) = 12t^2 + 2$$

$$a = \frac{dv}{dt}$$

$$a = \frac{d}{dt}(12t^2 + 2) = 24t$$

Substitute in $t = 2.0$s to get $\mathbf{a} = 48\text{m/s}^2$. Use $\mathbf{F}_{net} = m\mathbf{a}$ to get $\mathbf{F}_{net} = 24$ N.

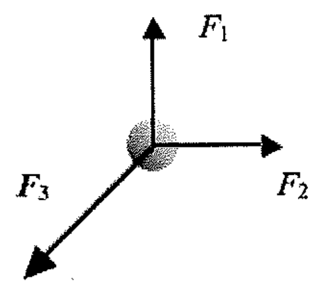
Question:

A mass *m* in three-dimensional space is subjected to three forces: F_1, F_2, and F_3. F_1 and F_2 have the same magnitude, with F_1 in the positive-*x* direction, and F_2 in the positive-*y* direction. If the mass has an acceleration of 0, which of the following statements is *false*?

a. The magnitude of F_3 is the same as that of F_1.
b. The object is in equilibrium, and could be stationary.
c. F_3 lies in the *x*-*y* plane.
d. The object is in equilibrium, and could be moving.
e. The object experiences a net force of 0.

Answer:

The correct answer is ***a***. By definition, the object is in equilibrium, either static (unmoving) or dynamic (moving with a constant velocity). If the object has acceleration $a = 0$, the net force acting on the mass must be 0 as well:



$$F_{net} = ma$$

$$F_{net} = m(0) = 0$$

With forces F_1 and F_2 in the *x*-*y* plane, the force that will counteract them must lie in the *x*-*y* plane as well, as shown. The magnitude of that force F_3 is equal to the vector sum of F_1 and F_2, and can be calculated as follows:

$$\sum F_x = 0 = \vec{F}_2 - \vec{F}_{3-x}$$

$$\sum F_y = 0 = \vec{F}_1 - \vec{F}_{3-y}$$

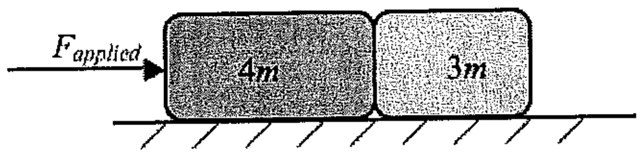
$$|F_3| = \sqrt{F_{3-x}^{\ 2} + F_{3-y}^{\ 2}}$$

$$= \sqrt{F_1^2 + F_2^{\ 2}}$$

$$= F_1\sqrt{2}$$

Both graphically and analytically, we can see that the magnitude of F_3 is not the same as that of F_1.

Question:



A Force $F_{applied}$ is exerted on a pair of unconnected objects of mass $4m$ and $3m$, resting on a frictionless horizontal surfce as shown above. What is the magnitude of the force between the two masses?

a. $F_{applied}$

b. $2F_{applied}$

c. $\frac{3}{4}F_{applied}$

d. $\frac{3}{7}F_{applied}$

e. $\frac{4}{7}F_{applied}$

Answer:

The correct answer is *d*. The problem can be solved by drawing two separate free-body diagrams and solving $F_{net} = ma$ for each body, then substituting and solving to get the required force. It's probably easier and faster, however, to solve $F_{net} = ma$ for the system as a whole to find acceleration...

$$F_{net} = ma$$

$$F_{applied} = (4m + 3m)a$$

$$a = \frac{F_{applied}}{7m}$$

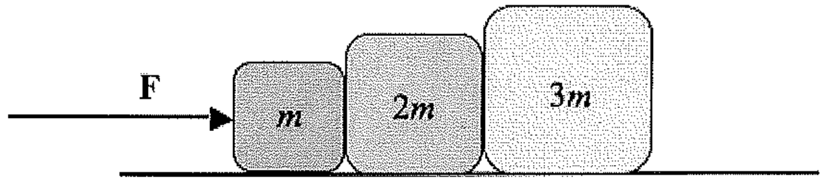
...and then use this acceleration with the mass $3m$ to get the force acting between the masses:

$$F_{net} = ma$$

$$F_{on\ 3m\ from\ 4m} = (3m)\left(\frac{F_{applied}}{7m}\right)$$

$$F = \frac{3}{7}F_{applied}$$

Question:



Three blocks of mass *m*, 2*m* and 3*m*, are placed adjacent to each other on a frictionless, horizontal surface as shown above. A constant force of magnitude **F** is applied to the right. Which of the following statements is true?

a. The acceleration of the blocks will vary according to their mass.
b. The acceleration of each block will be the same: **F**/*m*.
c. The net force acting on each block is the same.
d. The magnitude of the force on block 3*m* from 2*m* is greater than the magnitude of the force back on 2*m* from 3*m*.
e. The net force acting on block 3*m* is three times greater than the net force acting on *m*.

Answer:

The correct answer is *e*. The blocks all experience the same acceleration, calculated with Newton's Second Law of Motion as follows:

$$F_{net} = ma$$

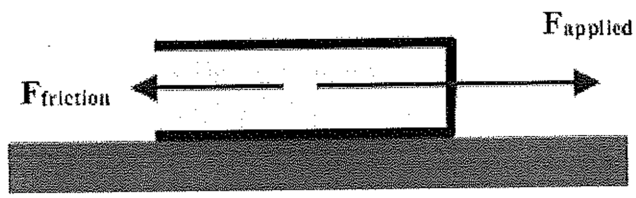
$$a = \frac{F_{net}}{m_{total}} = \frac{F}{6m}$$

By analyzing each block using a free-body diagram and $F_{net} = ma$, we can determine the net force acting on each block.

$$F_{net} = ma$$

$$F_{net-block1} = m\left(\frac{F}{6m}\right) = \frac{F}{6}; \quad F_{net-block2} = 2m\left(\frac{F}{6m}\right) = \frac{F}{3}; \quad F_{net-block3} = 3m\left(\frac{F}{6m}\right) = \frac{F}{2}$$

Question:



A large 2.0 kg book rests on the surface of a rough table, and a horizontal force of 50 Newtons (to the right in the sketch above) is applied to it. If a friction force of 30 Newtons opposes the motion of the book

a. The book will accelerate to the left at 25 m/s^2.
b. The book will accelerate to the right at 25 m/s^2.
c. The book will move at constant velocity to the right.
d. The book will accelerate at 10 m/s^2 to the right.
e. The book will remain at rest.

Answer:

The correct answer is *d*. The net force acting on the book is to the right, which causes the mass of the book to accelerate according to Newton's Second Law of Motion:

$$F_{net} = ma$$

$$F_{applied} - F_{friction} = ma$$

$$50N - 30N = (2.0kg)(a)$$

$$a = \frac{20N}{2kg} = 10m/s^2$$

Question:

The __________ force is the one force added to an unbalanced force system that places the force system into a state of equilibrium.

- **a.** *net*
- **b.** *resultant*
- **c.** *everyday*
- **d.** *fundamental*
- **e.** *equilibrant*

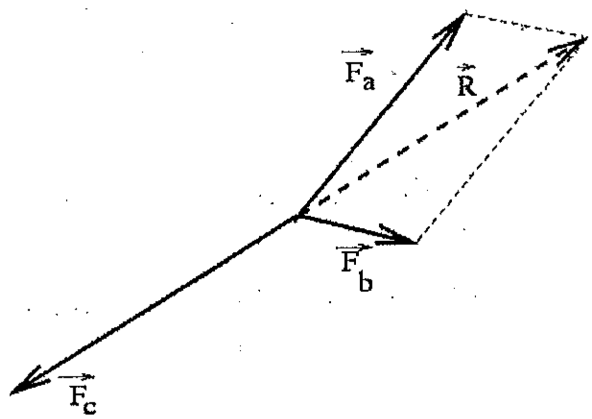
Answer:

e.

c

Question:

A force system is shown in the figure below. Which force causes the resultant net force on the system to be equal to zero?



a. $\mathbf{F_A}$
b. $\mathbf{F_B}$
c. $\mathbf{F_C}$
d. **R**
e. None of the above

Answer:

c. This system is in a condition of *equilibrium* and the force $\mathbf{F_C}$ is called the *equilibrant*.

Question:

When two or more forces act on an object such that the *net* or *resultant* force is zero, causing the object to remain at rest or move with uniform velocity, the object is in a state of ________.

Answer:

equilibrium

Question:

Which of the following statements concerning force systems is correct?

I. In a force system the equilibrant force is always equal to the system's resultant in both magnitude and direction.

II. The resultant of a system of forces acting on an object in equilibrium is always zero.

III. In a state of equilibrium, the forces acting on an object will cause the object to either be in a state of rest or be moving with uniform velocity.

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

Answer:

d.

Question:

Which of the following statements concerning ***equilibrium*** is correct?

- **I. An object's acceleration must always be zero when it is in a state of *equilibrium*.**
- **II. When in a state of *equilibrium*, an object cannot be in motion.**
- **III. The *equilibrant* force on an object in *equilibrium* must always be equal to zero.**

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

Answer:

a.

Question:

Which of the following statements is correct?

For a balance force system in a state of *equilibrium,*

- **a.** the *equilibrant* is greater than the *resultant* and oriented in the same direction as the *resultant.*
- **b.** the *resultant* is greater than the *equilibrant* and oriented in the opposite direction as the *equilibrant.*
- **c.** the *resultant* and *equilibrant* have equal magnitudes and are oriented in the same direction.
- **d.** the *resultant* and *equilibrant* have equal magnitudes and are oriented in opposite directions.
- **e.** None of the above

Answer:

d.

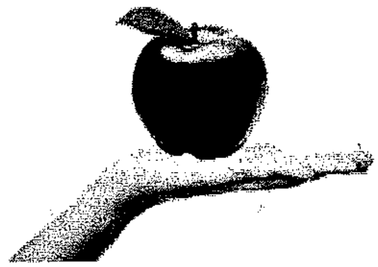
Question:

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:



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.

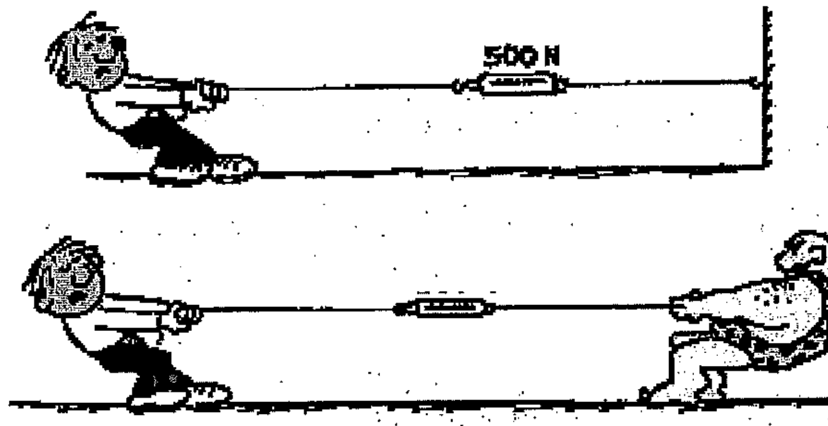
If you thought that the answer was *b*, well, it is sometimes the case that the force upwards from the hand is equal to the force down from gravity. But those are two different forces acting on a single object, which will allow us to determine its acceleration–*those two forces are not the "equal and 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:

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 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 cardboard box sliding across a rough floor slows down and eventually comes to a stop. Which of the following statements is true?

a. The box has no inertia when it is at rest.
b. The box has no inertia when it is moving.
c. The box's motion isn't consistent with Newton's First Law of Motion because the box doesn't stay in motion.
d. The box's motion isn't consistent with Newton's Third Law of Motion because there is an unbalanced force acting on the box.
e. None of the statements above is true.

Answer:

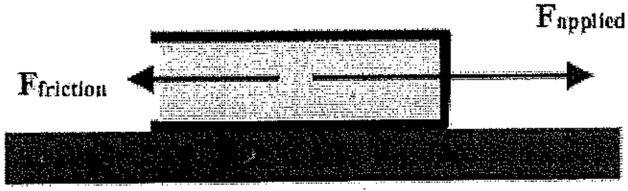
The correct answer is *e*. Statements *a* – *b* are all false.

Inertia is the tendency of an object to maintain its state of motion, either at rest, or moving with constant speed in a straight line. We use the quantity *mass* as a measure of an object's inertia; the more *mass* an object has, the more it tends to maintain its motion, and the harder it is to change that object's motion.

Here, the box has mass, and therefore inertia, whether it's moving or not, so statements *a* and *b* are both false. Choice *c* above is a false statement, because Newton's First Law states that an object tends to maintain its motion *unless a net external force acts on the object*. In other words, Newton's First Law makes allowances for the fact that the box may not continue its state of motion under certain circumstances. And choice *d* is also incorrect, because although there is a net force acting on the box (via friction) to slow it down, that friction force is also experienced in the opposite direction by the floor underneath the box.

The sliding box follows all three of Newton's Laws of Motion. In fact, in classical mechanics, Newton's Laws of Motion are *always* true for *all* masses—that's what makes them natural Laws! Please note that under some circumstances beyond the scope of this introductory course, quantities like *mass* and relationships like $\mathbf{F} = m\mathbf{a}$ require modification or further clarification. If you continue your study of physics, you will eventually learn about these other circumstances.

Question:



A large 2.0 kg book rests on the surface of a rough table, and a horizontal force of 50 Newtons (to the right in the sketch above) is applied to it. If a friction force of 30 Newtons opposes the motion of the book

a. The book will accelerate to the left at 25 m/s^2.
b. The book will accelerate to the right at 25 m/s^2.
c. The book will move at constant velocity to the right.
d. The book will accelerate at 10 m/s^2 to the right.
e. The book will remain at rest.

Answer:

The correct answer is *d*. The net force acting on the book is to the right, which causes the mass of the book to accelerate according to Newton's Second Law of Motion:

$$F_{net} = ma$$

$$F_{applied} - F_{friction} = ma$$

$$50N - 30N = (2.0kg)(a)$$

$$a = \frac{20N}{2kg} = 10m/s^2$$

C

Question:

A certain elevator with passengers loaded into has a total weight of 10,000 Newtons, or 10 kN, all of which is supported by a strong cable. If the elevator is able to slide up and down without friction, which of the following statements is true?

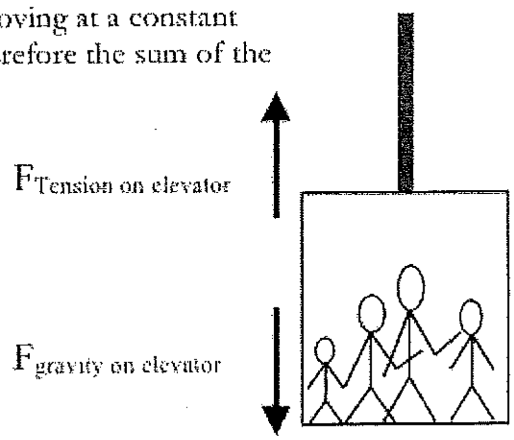
a. When lowering the elevator at a constant speed, the tension in the cable is less than 10 kN.
b. When lowering the elevator at a constant speed, the tension in the cable is greater than 10 kN.
c. When raising the elevator at a constant speed, the tension in the cable is greater than 10 kN.
d. When raising the elevator at a constant speed, the tension in the cable is less than 10 kN.
e. None of the above is true

Answer:

The correct answer is *e*. When the elevator is moving at a constant speed up or down, it is not accelerating, and therefore the sum of the forces acting on the elevator is zero.

$$F_{net} = ma = 0$$

We can calculate the force of tension in the cable, then, by adding its force to the others acting on the elevator:



$$F_{net} = ma$$

$$F_{cable} - F_{gravity} = ma = 0$$

$$F_{cable} = F_{gravity}$$

$$F_{cable} = 10kN$$

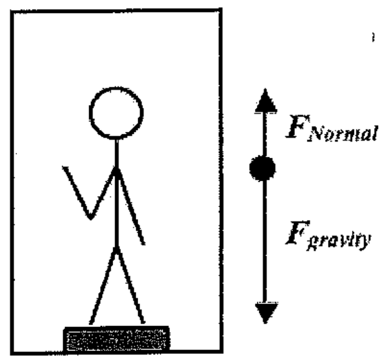
Note in the diagram that the forces are equal, *even when the elevator is moving at constant velocity*. It's true that an elevator initially at rest has to be accelerated to begin moving it upwards. At that point the tension in the cable *will* need to be greater than 10kN, but just during the acceleration—once it's moving at a constant velocity, the tension is back to 10kN.

Likewise, if the elevator is initially at rest and then *lowered*, it will be accelerating downwards for a moment and the tension in the cable will be less than 10kN during that time.

Question:
A person with a weight of 500 Newtons is standing on a spring scale in an elevator, which indicates a force of only 250 Newtons. Which description might explain this situation?

a. The elevator is moving upward at a constant velocity of 5 m/s.
b. The elevator is moving upward, and accelerating downward at 5 m/s^2.
c. The elevator is moving upward, and accelerating upward at 5 m/s^2.
d. The elevator is moving downward, and accelerating upwards at 5 m/s^2.
e. The elevator is moving downward at a constant velocity of 5 m/s.

Answer:
The correct answer is *b*. A free-body diagram of the forces acting on the person includes a weight of 500 N and a Normal force (as measured by the spring scale) of 250 N upwards. We can determine the person's mass as approximately 50 kg:



$$F_g = W = mg$$
$$500N = m(10)$$
$$m = 50kg$$

Then use Newton's Second Law to determine the acceleration.

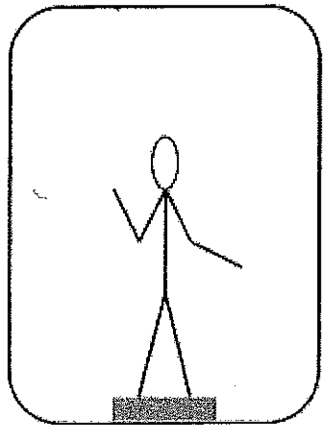
$$F_{net} = ma$$
$$F_{Normal} - F_g = ma$$
$$a = \frac{F_{Normal} - F_g}{m} = \frac{250N - 500N}{50kg} = -5m/s^2$$

Thus, the acceleration is 5 m/s^2 downwards. The only one of the possibilities given that fills this requirement is answer *b*.

NOTE: Although answer *b* is the only possibility of the answers given that is correct, there are two other possible answers that weren't listed: the elevator could be moving downward and accelerating downward, and the elevator could be at rest (momentarily), but accelerating downward.

C

Question:

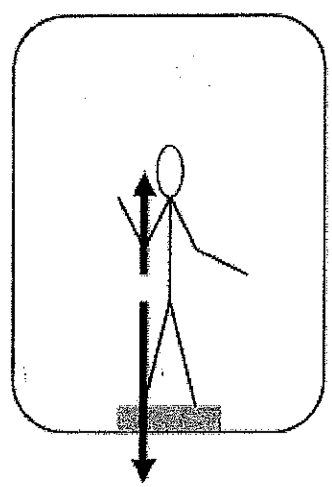


A student with a mass of 50 kg performs an experiment by taking a scale into an elevator, setting it on the floor, and standing on it. At first the scale indicates a weight of about 500 Newtons, but then the elevator starts to accelerate downwards at 4 m/s^2. The weight indicated on the scale during this period of acceleration is

a. still 500 Newtons
b. 200 Newtons
c. 300 Newtons
d. 700 Newtons
e. 400 Newtons

Answer:

The correct answer is *c*. Although the student's weight hasn't changed, her *apparent weight* has changed, as indicated by the spring scale. When the elevator begins to accelerate downwards, you can imagine that the scale, because it too is starting to accelerate downwards, pushes up *less* on the student. (You may also imagine that if the elevator were to be freely-falling, the scale couldn't push up on the student at all–in that case, the students apparent weight would be zero.)



To determine exactly what the scale reads, we need to figure out the force that it's pushing up on the student with (sometimes called the *Normal force*). We can anticipate that the net Force is downwards because the acceleration is downwards.

$$F_{net} = ma$$

$$F_{Normal} - F_{gravity} = ma$$

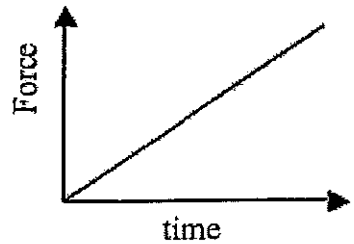
$$F_{Normal} - mg = ma$$

$$F_{Normal} = ma + mg$$

$$F_{Normal} = (50kg)(-4m/s^2) + (50kg)(-10m/s^2)$$

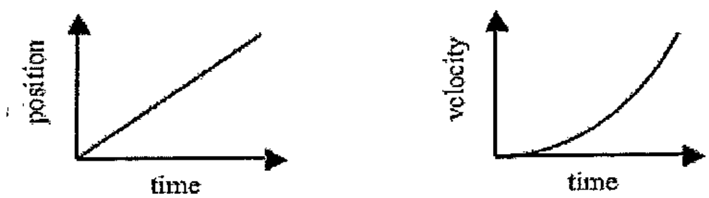
$$F_{Normal} = -200 + 500 = 300N$$

Question:

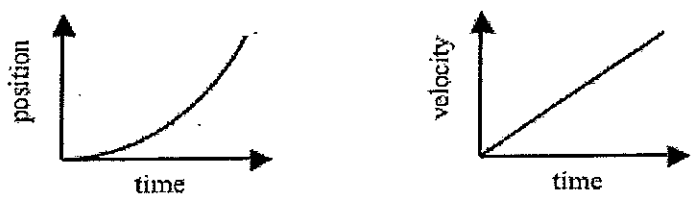


The graph above shows the Force applied to an object as a function of time *t*. Which of the following pairs of graphs represent possible position-time and velocity-time graphs for this object?

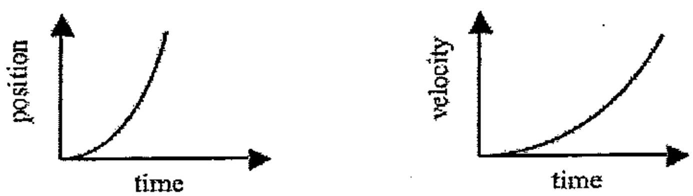
a.



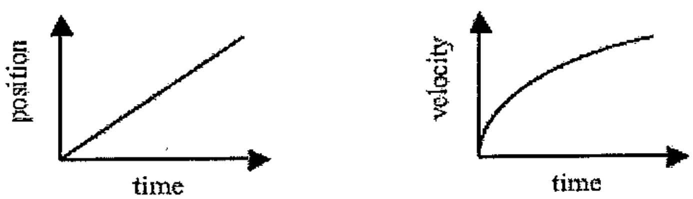
b.



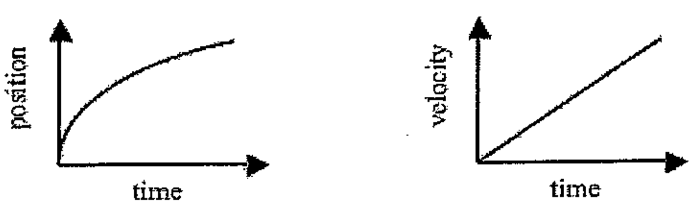
c.



d.



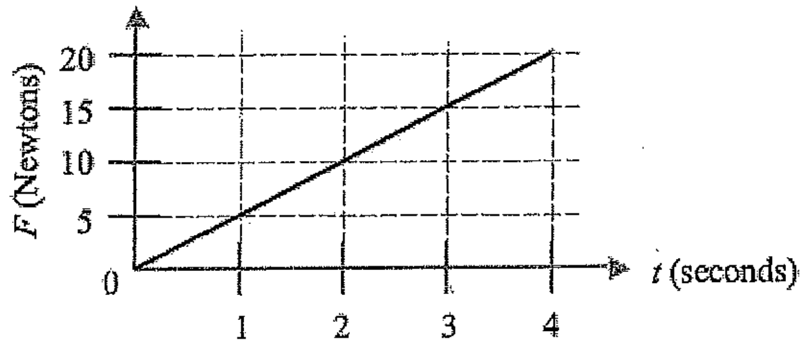
e.



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:



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

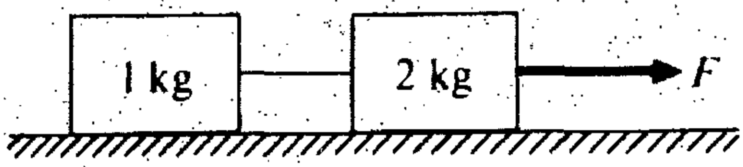
Answer:
The correct answer is *c*. The relationship between the force acting on the block, its mass, and acceleration is described by F=*m*a.

$$F_{net} = ma$$

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

$$m = 3kg$$

Question:



When the frictionless system shown above is accelerated by an applied force of magnitude the tension in the string between the blocks is

(A) 2F (B) F (C) 2/3 F (D) ½ F (E) 1/3 F

Answer:

E

Question:

A bat hits a 0.150 kilogram baseball so that a net force of 150 Newtons acts on the ball. Which statement is true?

a. The ball takes off at a speed of 1000 m/s.
b. The ball accelerates away, and the bat accelerates in the same direction.
c. The ball accelerates away, and the bat accelerates the same amount in the opposite direction.
d. The ball has a momentum of 22.5 kg•Newtons.
e. The ball accelerates at 1000 m/s^2.

Answer:

The correct answer is *e*. The relationship between the balls mass m, the net external force $\mathbf{F}$ applied to it, and its acceleration $\mathbf{a}$ is given by Newton's Second Law of Motion:

$$\mathbf{F}_{net} = m\mathbf{a}$$

It's important to remember that *acceleration* is a "change in velocity over time," and that can include things like changing speed ***and*** changing direction.

FOLLOW-UP QUESTION #1:

If the ball in the problem above was originally traveling at 50 m/s, what would be the final velocity of the ball after the bat accelerated it at 1000 m/s^2?

FOLLOW-UP ANSWER #1:

There's not enough information necessary to solve this problem!

FOLLOW-UP QUESTION #2: What additional measurement would we have to know in order to be able to figure out the final velocity of the ball?

FOLLOW-UP ANSWER #2: The *time the force was applied for*. Then we could use the acceleration, initial velocity, and time to figure out the final velocity of the ball after the hit.)

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/s²
b. 2000 m/s
c. 300 m/s
d. 2000 m/s²
e. 45 m/s²

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:

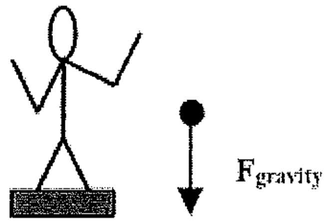
$$a = 2000m/s^2$$

$$v_f = v_i + at$$

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

$$v_f = 20m/s$$

Question:



A person standing on a bathroom scale that is falling downwards, and accelerating at 9.8 m/s^2, sees a value of 0 indicated on the scale. This is because:

a. the scale must be broken
b. there is no force of gravity acting on the person
c. there is no gravity field acting on the person
d. there is no Normal force acting on the person
e. the person no longer has any mass

Answer:
The correct answer is ***d***. While the Force of gravity continues to act on the person—and is responsible for his or her acceleration downwards—the scale is accelerating downwards too. A bathroom scale can be thought of as measuring the Normal force on the person, which is the force of the floor pushing up on someone in a normal, non-accelerating, bathroom. Here, the floor doesn't push up on the person at all, so it's reasonable to expect that the scale reads zero.

We sometimes refer to an object in this situation as "weightless," although that term certainly doesn't mean that the force of gravity is no longer acting on the object. Perhaps the best way of describing this is to say that the *apparent weight* of the object is zero. The value of such a term is especially useful in situation where the elevator is accelerating down at ½ **g**, or accelerating upwards at some rate. In these cases, the bathroom scale will again indicate some value that doesn't indicate the true Force of gravity (or "weight") of the person, but instead the *apparent weight*.

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?

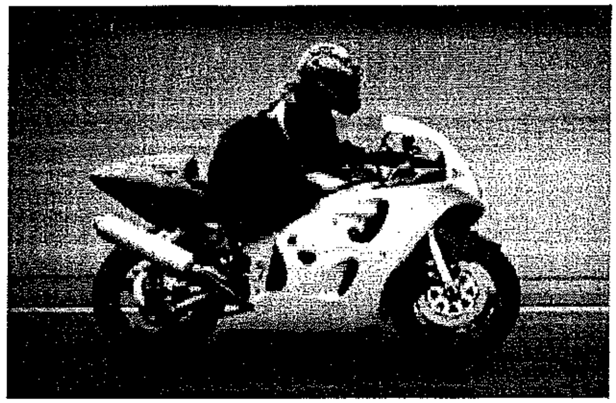
a. The 2.0 kg rock has twice as much inertia as the 1.0 kg rock because it has a greater mass.
b. The 2.0 kg rock has twice as much inertia as the 1.0 kg rock because it has a greater volume.
c. The two rocks have the same inertia because they have the same velocity.
d. The two rocks have the same inertia 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:

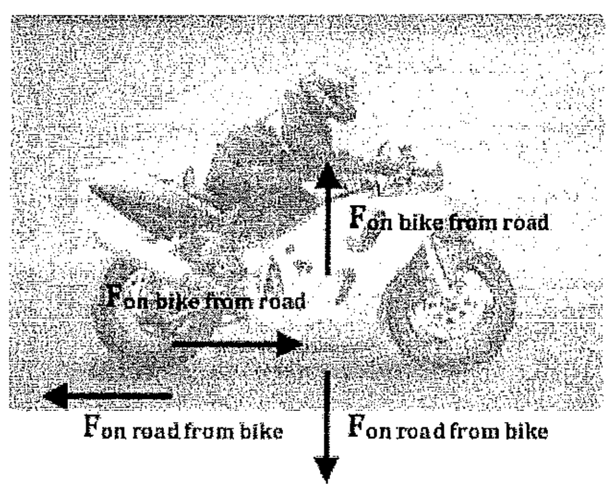


The motorcycle above is accelerating to the right. Which of the following statements is *false*?

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:

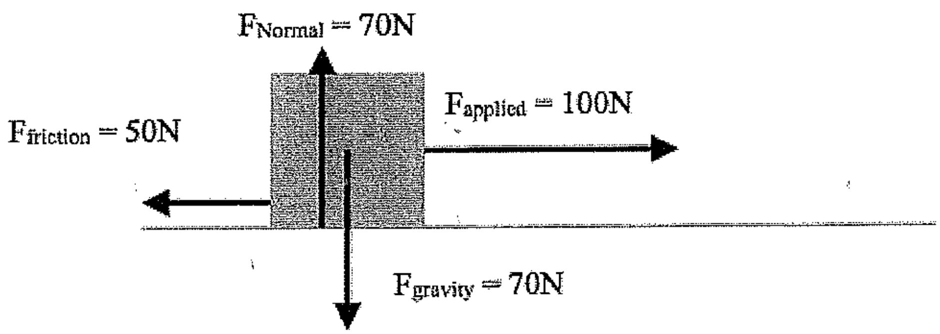
The correct answer is ***e***. This is a problem involving Newton's Third Law of Motion and the force pairs that exist between objects. A diagram of the force pairs acting between the motorcycle and the road is shown here.



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:



A box is dragged along a surface in the positive x-direction, with forces acting on the box as shown above. The *net force* acting on the box is

a. 50 N because that's the sum of the force vectors acting on the box
b. 0 N because the box is not accelerating up or down
c. 150 N because that's the sum of the forces in the x-direction
d. 290 N because that's the sum of all the forces
e. 100 N because that's the external force applied to the box

Answer:
The correct answer is *a*. The forces along the x-axis are +100 N – 50 N = 50 N. The forces along the y-axis cancel each other (+70 N – 70 N = 0), so the overall net force is simply 50 N to the right.

The "free-body diagram" that has been drawn shows the significant forces acting on the box, and allow us to determine what net force there is, and thus what acceleration the mass of the box will experience.