Question:

Which of the following statements is correct?

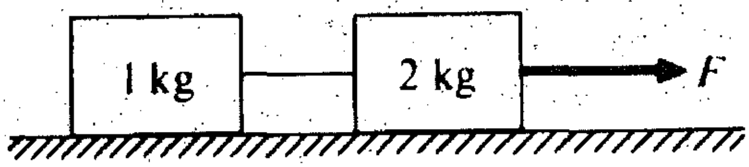
For a balance force system in a state of *equilibrium*,

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:



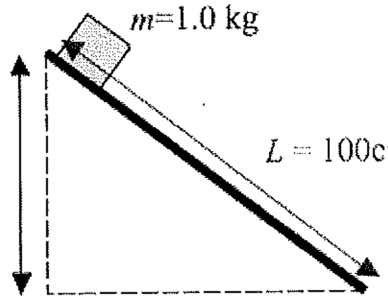
When the frictionless system shown above is accelerated by an applied force of magnitude the tension in the string between the blocks is

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

Answer:

E

Question:



To determine the coefficient of friction between a block of mass 1.0kg and a 100cm long surface, an experimenter places the block on the surface and begins lifting one end. The block just begins to slip when the end of the surface has been lifted 60cm above the horizontal. The static coefficient of friction between the block and the surface is most nearly

a. 0.60
b. 0.75
c. 0.90
d. 1.05
e. 1.20

Answer:

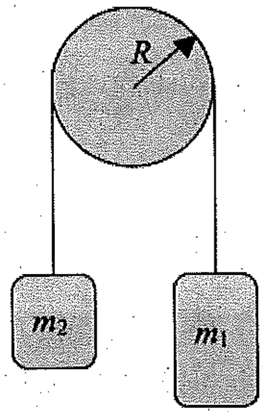
The correct answer is ***b***. The ramp can be thought of as the hypotenuse of a 3-4-5 right triangle, with a corresponding 3-4-5 right triangle as part of the free-body diagram for the block.

The force of friction when the block just begins to slip equal the force $F_{parallel}$, and the normal force F_{Normal} equals the force $F_{perpendicular}$. The coefficient of friction, then, can be calculated:

$$\mu = \frac{F_{friction}}{F_{Normal}}$$

$$\mu = \frac{6.0N}{8.0N} = 0.75$$

Question:



Two masses are hung are connected by a light cord and hung from a frictionless pulley of negligible mass as shown. Mass m_1 = 3.00kg, and mass m_2 = 2.00kg. When the two masses are released from rest, the resulting acceleration of the two masses is approximately:

a. 1 m/s^2
b. 2 m/s^2
c. 4 m/s^2
d. 6 m/s^2
e. 8 m/s^2

Answer:

The correct answer is *b*. This is a Newton's Second Law problem, using $F_{net} = ma$, where F_{net} = the net force acting on the pulley, and *m* refers to the total mass of the system.

$$F_{net} = ma$$

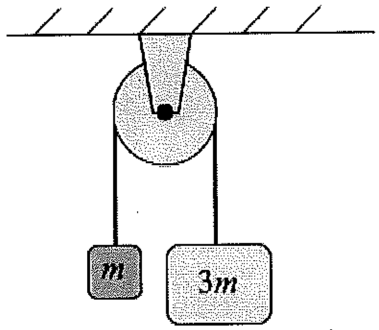
$$a = \frac{F_{net}}{m}$$

$$a = \frac{F_3 - F_2}{m}$$

$$a = \frac{3kg(g) - 2kg(g)}{(2kg + 3kg)}$$

$$a = \frac{1}{5}g \approx 2m/s^2$$

Question:



Two objects, one of mass m and the other of mass $3m$, are connected by a light string and hung over a frictionless pulley of negligible mass as shown. When the blocks are released from rest, what is the tension in the string connected to the mass m?

a. $3m\mathbf{g}$

b. $\frac{5}{2}m\mathbf{g}$

c. $2m\mathbf{g}$

d. $\frac{3}{2}m\mathbf{g}$

e. $\frac{5}{4}m\mathbf{g}$

Answer:

The correct answer is *d*. The acceleration of the system can be determined by using Newton's Second Law, $\mathbf{F}_{net}=m\mathbf{a}$:

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

Taking down on the right to be in the positive direction:

$$-\mathbf{F}_m + \mathbf{F}_{3m} = (m + 3m)\mathbf{a}$$

$$-m\mathbf{g} + 3m\mathbf{g} = 4m\mathbf{a}$$

$$2m\mathbf{g} = 4m\mathbf{a}$$

$$\mathbf{a} = \frac{\mathbf{g}}{2}$$

Now use a free-body analysis of mass m to determine the tension in the string:

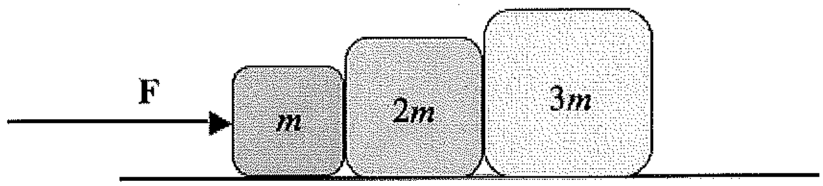
$$\mathbf{F}_{net} = m\mathbf{a}$$

$$T - mg = ma$$

$$T = m\mathbf{a} + m\mathbf{g}$$

$$T = m\left(\frac{\mathbf{g}}{2}\right) + m\mathbf{g} = \frac{3}{2}m\mathbf{g}$$

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:

$$F_{net} = ma$$

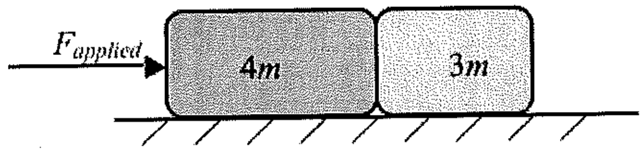
$$a = \frac{F_{net}}{m_{total}} = \frac{F}{6m}$$

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 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...

$$F_{net} = ma$$

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

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

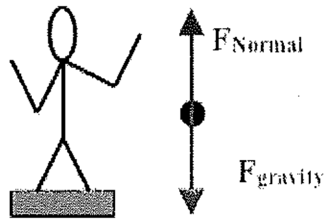
...and then use this acceleration with the mass $3m$ to get the force acting between the masses:

$$F_{net} = ma$$

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

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

Question:



A person standing on a stationary bathroom scale sees a measurement indicated on the scale. This number represents all of the following *except*:

a. the effect of gravity pulling down on the person
b. the Weight of the person
c. the force of the scale pushing up on the person
d. the force exerted by earth's gravity field on the person
e. the density of the person

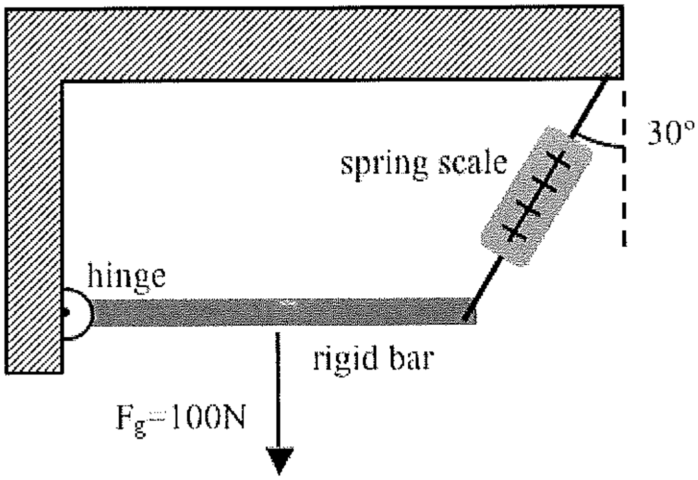
Answer:
The correct answer is *e*. This answer is incorrect because we'd need to know the person's mass and volume to be able to calculate their density.

The person on the scale is attracted by the force of earth's gravity, and this force is often called Weight. The scale also measures how hard the earth pushes up on the person, a force that is called by scientists "the Normal Force." These two forces, the Force of gravity pulling down and the Normal Force pushing up, are equal to each other in most cases, and reveal that the person standing on the bathroom scale isn't accelerating up or down.

$$F_{net} = ma$$

$$a = \frac{F_{net}}{m} = \frac{F_{Normal} - F_{gravity}}{m} = \frac{0}{m} = 0 m/s^2$$

Question:



A rigid bar with a weight of 100 Newtons is free to rotate about a frictionless hinge at a wall, and supported in a horizontal position by a spring scale attached to the ceiling at an angle of 30° to the vertical, as shown. What force of tension is indicated by the spring scale?

a. $100\ N$
b. $100\sqrt{3}\ N$
c. $100/\sqrt{3}\ N$
d. $50/\sqrt{3}\ N$
e. $50\ N$

Answer:
The correct answer is *c*. The problem can be solved in two ways. The bar is being held in static equlibrium, so the sum of the torques acting on the bar has to be zero. Taking the hinge to be $x = 0$, one can add up the torque due to the force of gravity down (acting at the center of mass) and the torque due to the spring scale up.
More simply, the sum of the forces in the vertical direction has to be 0. Therefore:

$$\sum F_y = ma = 0$$

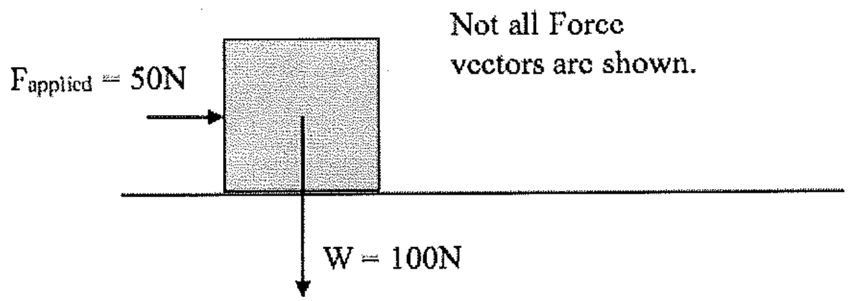
$$F_{hinge} - F_{gravity} + F_{y-springscale} = 0$$

Hinge and spring scale are equidistant from the center of mass, so each supports 50N.

$$F_{y-springscale} = 50N = F_{springscale}\cos 30$$

$$F_{springscale} = \frac{50}{\sqrt{3}/2} = \frac{100}{\sqrt{3}}N$$

Question:



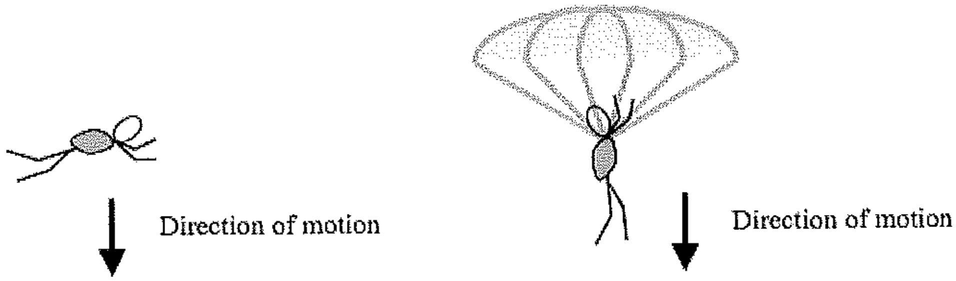
A large box has a mass of 10 kg, and thus a weight of about 100 Newtons, and is resting on a rough surface. A horizontal force of 50 Newtons is applied sideways to the box, but this doesn't cause the box to move. Which one of the following statements about this situation is true?

a. The force of friction opposing the box's motion at this point is less than 100 N.
b. The force of friction opposing the box's motion at this point is exactly 50 N.
c. The force of friction opposing the box's motion at this point is 50 N or greater.
d. The force of friction opposing the box's motion at this point is greater than 50 N.
e. The force of the surface up on the box is greater than 100 N.

Answer:
The correct answer is *b*. If the box isn't moving then the forces on it must be balanced, so there must be a Normal force from the surface of 100 N upwards, and there must be a friction force of 50 N acting to the left.

Note that the ***maximum*** friction force that the surface applies to the box is 50 N or greater, but we won't be able to determine that maximum friction force until we apply a greater force and observe the box start to accelerate. At this point in time, though, the Force of friction is exactly 50 N.

Question:

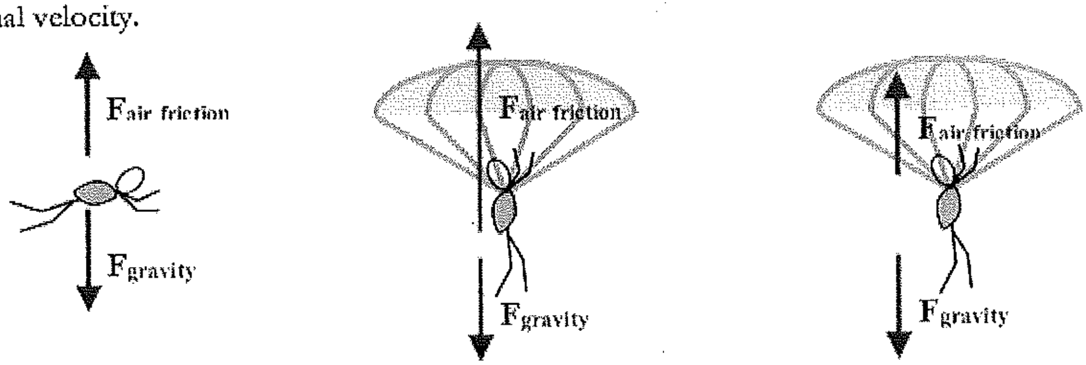


A skydiver with an unopened parachute is falling at his *terminal velocity*. When he opens the parachute, which statement is true?

a. As the parachute opens, the net force on the skydiver is still in the downward direction.
b. As the parachute opens, there is an increased force of air friction, but it's less than the force of gravity.
c. As the parachute opens, the skydiver will begin to move upwards.
d. After the skydiver reaches a new terminal velocity, the net force on him is downward.
e. none of the above statements are true.

Answer:

The correct answer is *e*. The opening of the parachute momentarily increases the force of air friction upwards, causing the skydiver to *decelerate* (accelerate in the upward direction) even as he continues to travel downwards–thus, the skydiver is slowing down to a new, smaller, terminal velocity.



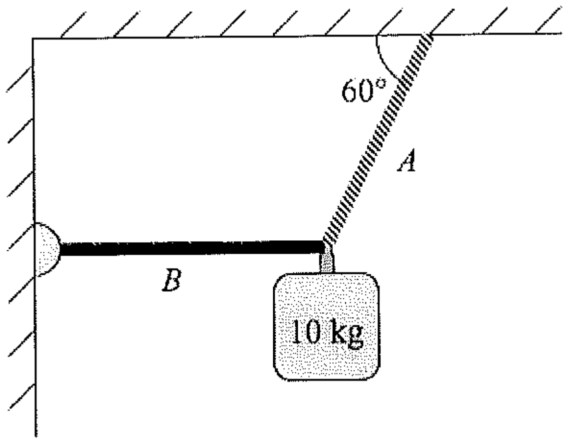
At terminal velocity, the net Force is zero.

As parachute opens at high terminal velocity, Force of air friction is momentarily greater than Force of gravity.

Once skydiver as decelerated, Force of air friction and Force of gravity are again the same.

At these terminal velocities, the net Force is always zero, so the object isn't accelerating downwards–it's *moving* downwards at constant velocity.

Question:



A mass of 10 kg is suspended from a cable *A* and a rigid horizontal bar *B* that is free to rotate, as shown. What is the approximate tension, in Newtons, in cable *A*?

a. $\frac{100}{\sqrt{3}}$

b. $100\sqrt{3}$

c. $\frac{200}{\sqrt{2}}$

d. $200\sqrt{3}$

e. $\frac{200}{\sqrt{3}}$

Answer:

The correct answer is *e*. The weight of the mass, approximately 100N, must be entirely supported by the vertical component of the tension in the cable, F_y. Therefore:

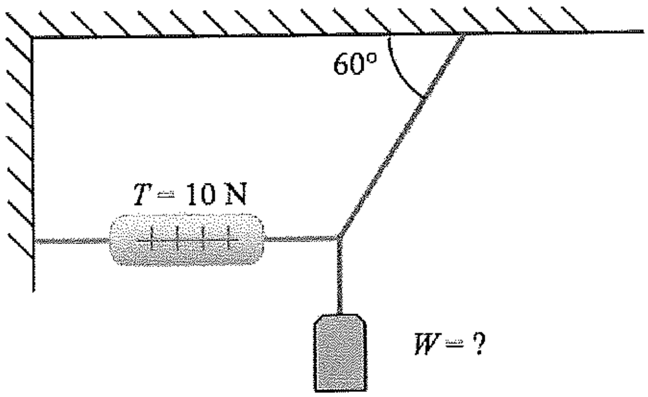
$$\sum F_y = ma$$

$$F_y - F_g = 0$$

$$F_y = F_{Tension}\sin 60 = (10kg)(\sim 10m/s^2)$$

$$F_{Tension} = \frac{100N}{\sqrt{3}/2} = 200/\sqrt{3}$$

Question:

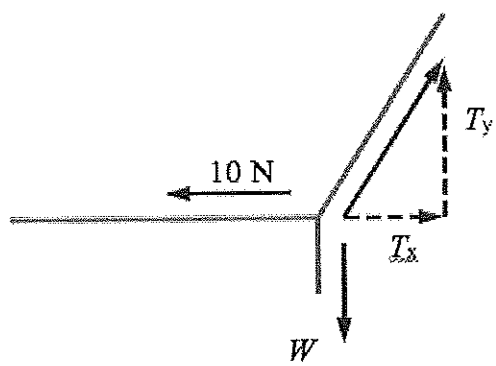


A mass with unknown weight W is suspended from cords as shown above. When the system is in static equilibrium, the tension in the horizontal cord is 10N. The weight W of the mass is:

a. $20\ N$
b. $10\ N$
c. $10\sqrt{3}\ N$
d. $5\sqrt{3}\ N$
e. $20\sqrt{3}\ N$

Answer:

The correct answer is *c*. The horizontal tension of 10N is matched by the horizontal component of tension in the diagonal cord, while the vertical component of tension in the diagonal cord is equal to the unknown weight of the mass, W. A free-body diagram is useful in analyzing the forces.



Analyzing the Forces along the x-axis:

$$\sum F_x = ma_x = 0$$

$$T_x - 10N = 0 \rightarrow T_x = 10N$$

$$\frac{T_x}{T} = \sin 30 \rightarrow T = \frac{T_x}{\sin 30} = 20N$$

Moving to an analysis of the y-axis:

$$\sum F_y = ma_y = 0$$

$$T_y - W = 0$$

$$W = T\cos 30 = T\frac{\sqrt{3}}{2} = 20\frac{\sqrt{3}}{2} = 10\sqrt{3}N$$

a

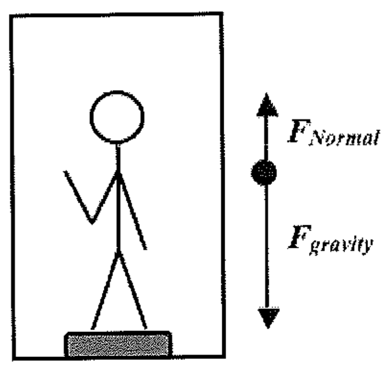
Question:

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.

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

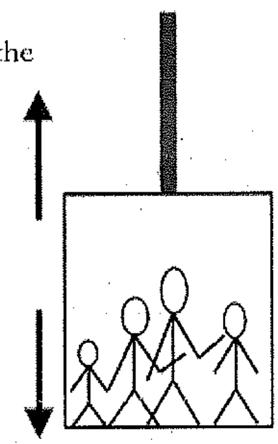
Answer:

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:

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

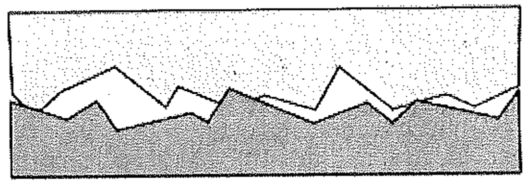
- **a.** *net*
- **b.** *resultant*
- **c.** *everyday*
- **d.** *fundamental*
- **e.** *equilibrant*

Answer:

e.

Question:

Microscopic view of two "smooth" surfaces in contact and sliding against each other.



When two solid objects have surfaces that slide against each other, there is usually a *friction force* between the objects. Which statement is *false* ?

a. The friction force depends on the type of surfaces in contact.
b. The friction force opposes the motion of the objects.
c. The friction force depends in part on how fast the objects are sliding against each other.
d. The friction force does *not* depend on the surface area of the objects.
e. The friction force results from small irregularities in the two surfaces .

Answer:
The correct answer is *c*. The sliding friction force does *not* typically depend on how fast the objects are sliding against each other.

All the other statements are true. Friction force does depend on the type of surfaces: tire rubber on pavements has a much greater friction force than an icy hockey puck on the surface of an ice rink. Friction forces *do* oppose the sliding of the objects. The force of sliding friction does *not* depend on surface area. And the force of sliding friction *is* due to microscopic irregularities in the two surfaces, which cause the "nooks and crannies" of the two surfaces to bump across each other as the objects slide.

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:

A large object is raised to a height above the earth's surface and released so that it falls, and experiences air friction during its descent. Which of the following statements is correct?

a. Air friction is at a maximum when the ball is first released.
b. Air friction doesn't depend on the shape of the object.
c. An object of the same size and greater mass will experience less air friction.
d. Air friction increases as the object's speed increases.
e. The acceleration of the object is greatest just before it hits the ground.

Answer:

The correct answer is *d*. The drag force of air friction varies according to the velocity of the object through the air, the cross-sectional area exposed to the air, the density of the substance through which it's falling, and its shape, as expressed by a *drag coefficient*. The net force acting on the object (and therefore its acceleration) is greatest when the ball is first released, before air friction has an effect.

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.

c

Question:

Two masses, $M > m$, are connected by a light string hanging over a pulley of negligible mass. When the masses are released from rest, the magnitude of the acceleration of the masses is:

a. $\left(\dfrac{M+m}{M-m}\right)g$

b. $\left(\dfrac{M-m}{M+m}\right)g$

c. $\left(\dfrac{M}{M+m}\right)g$

d. $\left(\dfrac{m}{M+m}\right)g$

e. $\left(\dfrac{M-m}{M}\right)g$

Answer:

The correct answer is *b*. We can analyze this situation by drawing a picture and doing a free-body diagram for each of the two masses, as shown here. Because the pulley has negligible mass, the force of Tension between the two masses is equal (by Newton's 3rd Law), and we can use Newton's 2nd Law to determine the acceleration of the system:

M: $\quad F_{net} = ma = Ma$

$\quad Mg - F_{Tension} = Ma$ (where "down" is positive)

m: $\quad F_{net} = ma$

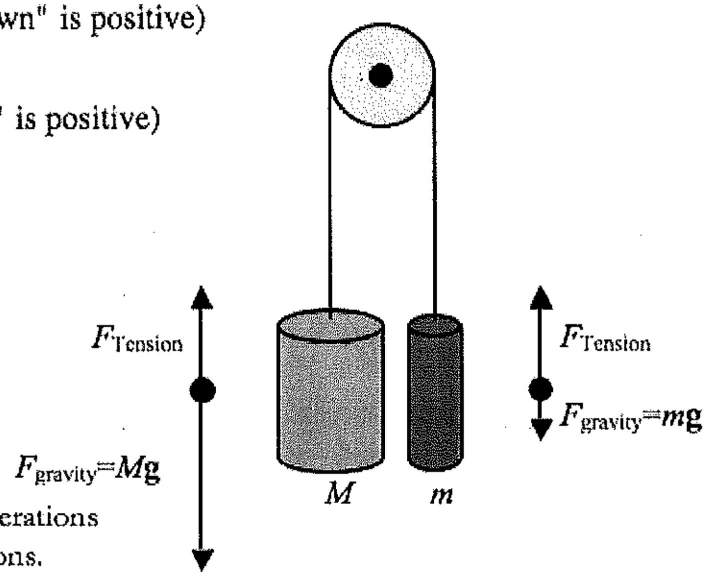
$\quad F_{Tension} - mg = ma$ (where "up" is positive)

Combine equations and solve:

$$Mg - (ma + mg) = Ma$$

$$(M - m)g = (M + m)a$$

$$a = \left(\frac{M-m}{M+m}\right)g$$

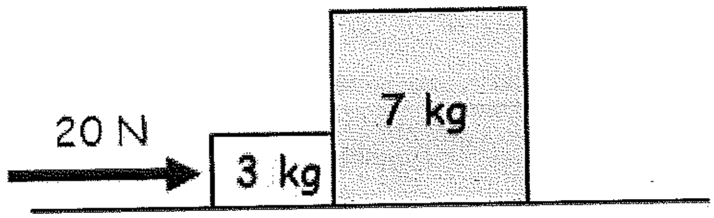


Notice that we have selected different frames of reference for the two masses (for *m*, "up" is positive; for *M*, "down" is positive) so that the accelerations of the masses will have identical directions.

If we don't adjust our analysis to take the different directions into account, we'll get an incorrect result when we combine the two equations.

A horizontal force of 20N is applied as shown to two wooden blocks of masses 3 kg and 7 kg.

The blocks are in contact with each other on a frictionless surface.



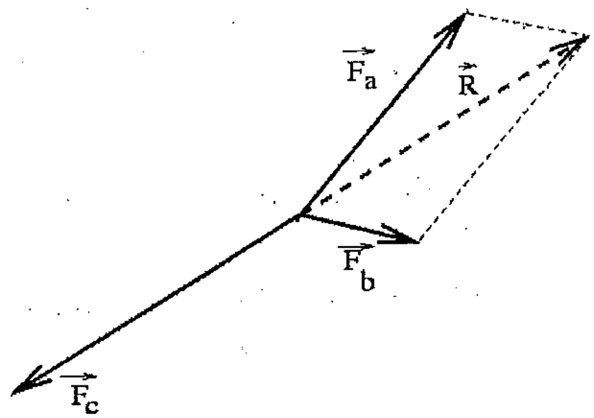
What is the size of the horizontal force acting on the 7 kg block?

Answer: 14 N

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?

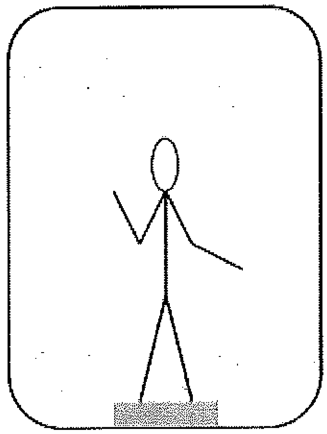


a. $\mathbf{F_A}$
b. $\mathbf{F_B}$
c. $\mathbf{F_C}$
d. **R**
e. **None of the above**

Answer:

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

Question:



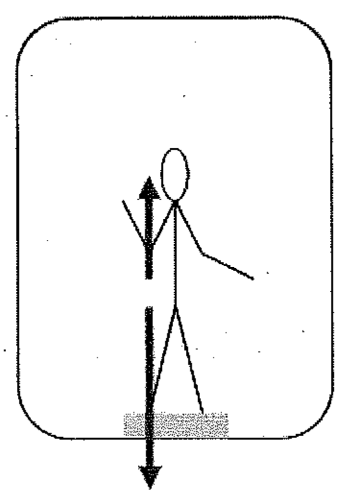
A student with a mass of 50 kg performs an experiment by taking a scale into an elevator, setting it on the floor, and standing on it. At first the scale indicates a weight of about 500 Newtons, but then the elevator starts to accelerate downwards at 4 m/s^2. The weight indicated on the scale during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

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

Answer:

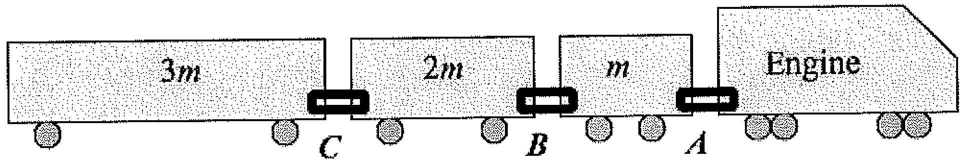
The correct answer is *c*. Although the student's weight hasn't changed, her ***apparent weight*** has changed, as indicated by the spring scale. When the elevator begins to accelerate downwards, you can imagine that the scale, because it too is starting to accelerate downwards, pushes up *less* on the 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.



$$F_{net} = ma$$
$$F_{Normal} - F_{gravity} = ma$$
$$F_{Normal} - mg = ma$$
$$F_{Normal} = ma + mg$$
$$F_{Normal} = (50kg)(-4m/s^2) + (50kg)(\sim 10m/s^2)$$
$$F_{Normal} = -200 + 500 = 300N$$

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 $3m$.

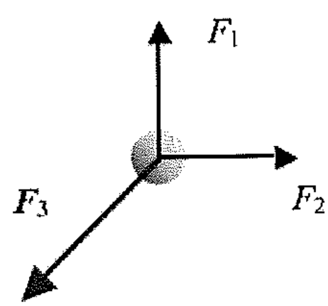
Question:

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:

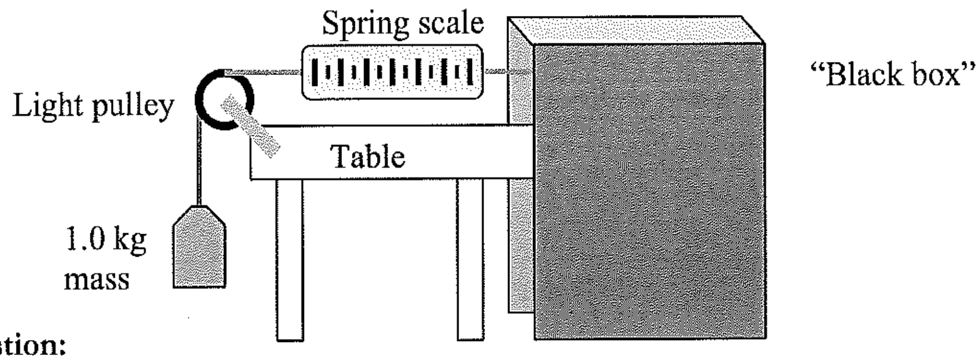


$$F_{net} = ma$$
$$F_{net} = m(0) = 0$$

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 photograph of an old experiment is represented in the diagram shown above, in which a 1.0-kilogram mass is attached to a thin, light, cord, which runs over a pulley and is attached to a spring scale. A similar piece of cord is attached to the other side of the spring scale, after which the cord runs into a large "black box" which prevents observing the right side of the experiment. In the photograph, the spring scale indicates a force of about 10 Newtons.

Three hypotheses are proposed for what was happening in the experiment at the moment the photo was taken:

I. The mass is stationary, and the cord attached to the right side of the spring scale is attached to a similar, second pulley and mass on the right side of the table.

II. The mass is accelerating in freefall, and cord attached to the right side of the spring scale is not being held by anything.

III. The mass is stationary, and the cord attached to the right side of the spring scale is tied to an anchor in the wall.

Which of these hypotheses is/are possible under the conditions given?

a. I only is possible
b. I and II only are possible
c. II and III only are possible
d. I and III only are possible
e. I, II, and III are all possible

Answer:

The correct answer is *d*. The downward force of gravity on the 1.0 kilogram mass—9.8 Newtons—is balanced by the force of tension in the cord, which holds the mass in *static equilibrium*. Because of the black box, we don't know what the other end of the cord is attached to: it could be a similar mass on the opposite side, it could be an anchor in the wall, it could be a student hiding in the box... Regardless of what the source is, the tension maintained in the rope is 9.8 Newtons, indicating a net Force of zero on the mass, which means the mass is not accelerating.

There is another possibility: the mass *could* be moving at constant velocity, if some resistive force in the black box were opposing the force of gravity. That was not one of the hypotheses proposed in this problem, however!

Question:

Which of the following sets of quantities affect the magnitude of the frictional force between an object and the surface it's in contact with when the object is on the verge of sliding or is actually sliding?

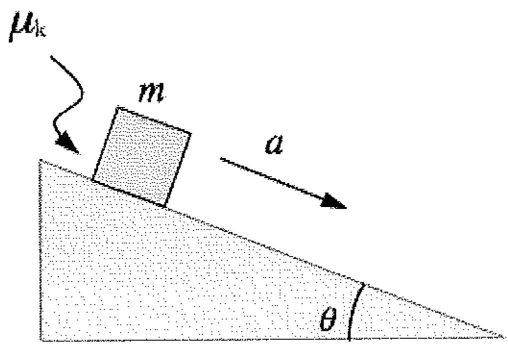
a. object's mass and the applied force acting on the object
b. μ of the contact materials and the object's mass
c. coefficient of friction of the contact materials and the applied force acting on the object
d. μ of the contact materials and the normal force acting on the object
e. coefficient of friction of the contact materials and the weight of the object

Answer:

d.

c

Question:

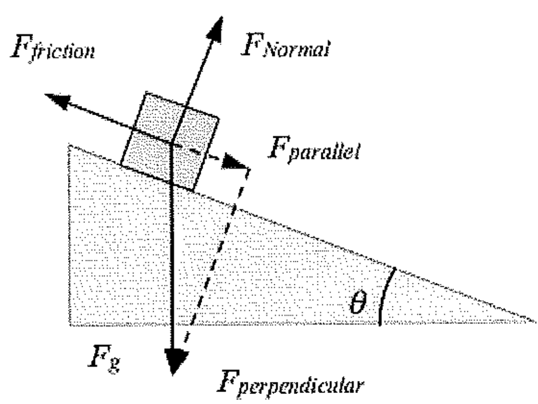


A block of mass m is placed on a plane inclined at an angle θ relative to the horizontal as shown. There is a coefficient of kinetic friction μ_k that acts as the block accelerates down the ramp. The acceleration of the mass m is

a. $mg\sin\theta - mg\cos\theta$
b. $mg\sin\theta - \mu mg\cos\theta$
c. $mg\sin\theta - \mu mg$
d. $g\sin\theta - g\cos\theta$
e. $g\sin\theta - \mu g\cos\theta$

Answer:

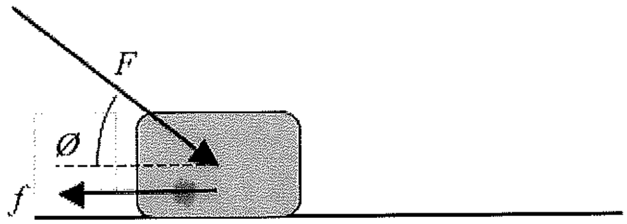
The correct answer is *e*. A free-body diagram of the forces acting on the block and an analysis using Newton's Second Law $F_{net} = ma$ yields the answer.



$$x-direction\ (down\ the\ ramp): F_{net} = ma$$
$$F_{parallel} - F_{friction} = ma$$
$$F_{friction} = \mu F_{Normal},\ and\ F_{Normal} = F_{perpendicular} = mg\cos\theta$$
$$mg\sin\theta - \mu mg\cos\theta = ma$$
$$a = g\sin\theta - \mu g\cos\theta$$

C

Question:



A block of mass *m* is pushed across a rough surface by an applied force *F*, directed at an angle Ø relative to the horizontal as shown above. The block experiences a friction force *f* in the opposite direction. What is the coefficient of friction between the block and the surface?

a. $\dfrac{mg}{F\sin\phi}$

b. $\dfrac{f}{F\sin\phi + mg}$

c. $\dfrac{f}{mg}$

d. $\dfrac{mg}{f}$

e. $\dfrac{f}{F\sin\phi - mg}$

Answer:
The correct answer is ***b***. The key to finding the coefficient of friction μ is in calculating the correct Normal force acting on the block.

$$\sum F_y = ma$$

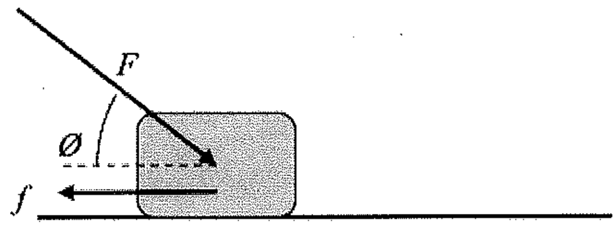
$$-F_{applied-y} - F_g + F_{Normal} = 0$$

$$F_{Normal} = F\sin\phi + mg$$

$$\mu = \frac{F_{friction}}{F_{Normal}} = \frac{f}{F\sin\phi + mg}$$

c

Question:



A block of mass *m* is pushed across a rough surface by an applied force *F*, directed at an angle Ø relative to the horizontal as shown above. The block experiences an acceleration *a* in the +*x* direction. What is the magnitude of the friction force *f* that opposes the block's motion?

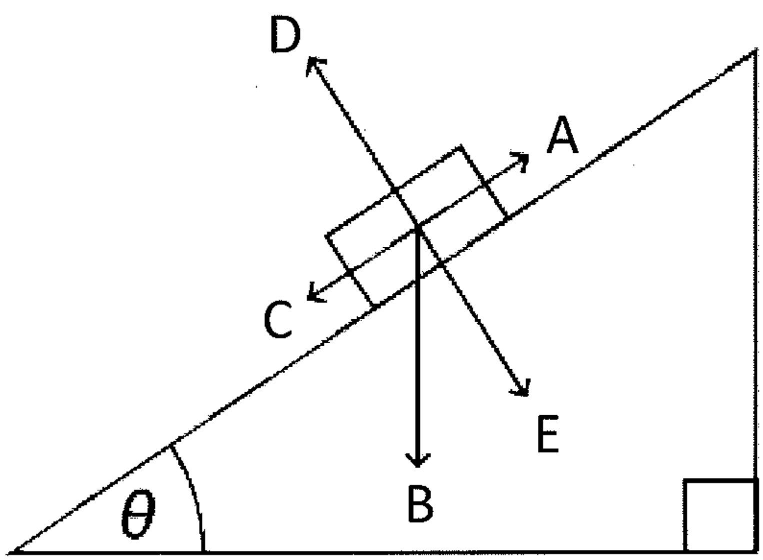
a. ma
b. $F\sin\phi + ma$
c. $F\sin\phi - ma$
d. $F\cos\phi + ma$
e. $F\cos\phi - ma$

Answer:
The correct answer is *e*. The friction force can be determined by applying Newton's Second Law $F_{net}=ma$ in the *x*-direction.

$$\sum F_x = ma$$
$$F_{applied-x} - f = ma$$
$$F\cos\phi - f = ma$$
$$f = F\cos\phi - ma$$

Question:

In the diagram below, an object is at rest on an incline tilted at a certain angle Θ. The free-body diagram of the object is included with the force vectors shown. Which letter sequence correctly represents the forces acting on the object in its state of rest on the incline?



a. A – mg sinΘ
B – mg cosΘ
C – mg
D – F_n
E – F_f

b. A – mg cosΘ
B – mg
C – F_f
D – F_n
E – mg sinΘ

c. A – F_f
B – mg
C – mg cosΘ
D – F_n
E – mg sinΘ

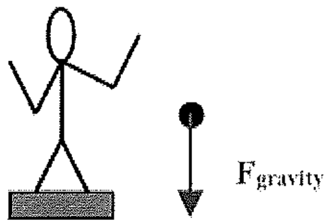
d. A – F_f
B – mg
C – mg sinΘ
D – F_n
E – mg cosΘ

e. none

Answer:

d.

Question:



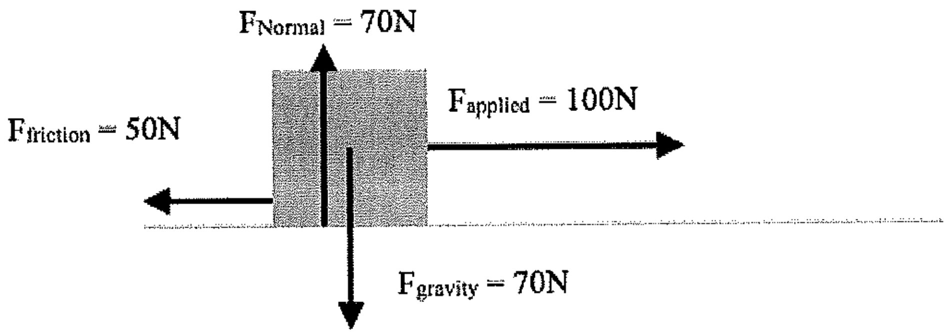
A person standing on a bathroom scale that is falling downwards, and accelerating at 9.8 m/s^2, sees a value of 0 indicated on the scale. This is because:

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 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.

Question:

Microscopic view of two "smooth" surfaces in contact and sliding against each other.

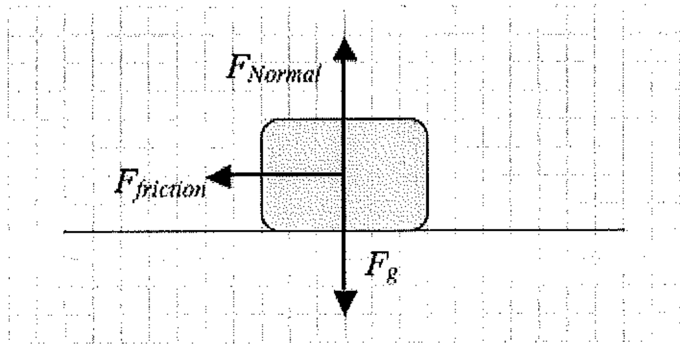
When two solid objects have surfaces that slide against each other, there is usually a *friction force* between the objects. Which statement is *false*?

a. The friction force depends on the type of surfaces in contact.
b. The friction force opposes the motion of the objects.
c. The friction force depends in part on how fast the objects are sliding against each other.
d. The friction force does *not* depend on the surface area of the objects.
e. The friction force results from small irregularities in the two surfaces .

Answer:
The correct answer is *c*. The sliding friction force does *not* typically depend on how fast the objects are sliding against each other.

All the other statements are true. Friction force does depend on the type of surfaces: tire rubber on pavements has a much greater friction force than an icy hockey puck on the surface of an ice rink. Friction forces *do* oppose the sliding of the objects. The force of sliding friction does *not* depend on surface area. And the force of sliding friction *is* due to microscopic irregularities in the two surfaces, which cause the "nooks and crannies" of the two surfaces to bump across each other as the objects slide.

Question:

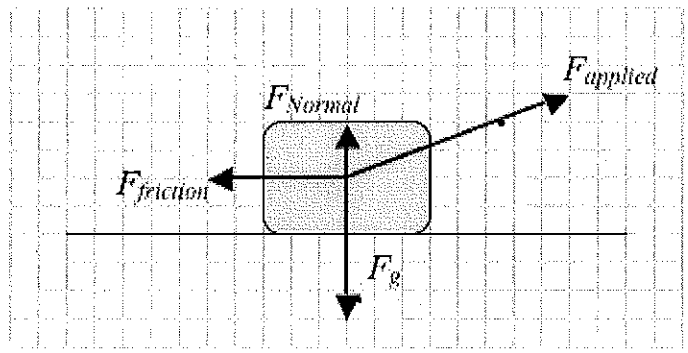


The free-body diagram shows all forces acting on a box supported by a horizontal surface, where the length of each force vector is proportional to its magnitude. Which statement below is correct?

a. The box must be moving to the left, due to the Force of friction acting in that direction.
b. The box must be accelerating to the right, as indicated by the Force of friction in the opposite direction.
c. The box must be moving to the right, as indicated by the Force of friction in the opposite direction.
d. The diagram is drawn incorrectly: there can be no Force of friction unless the box is moving.
e. None of these statements is correct.

Answer:
The correct answer is *c*. The diagram suggests that the box is currently moving to the right, and in the process of slowing down due to a force of friction that is causing it to accelerate in the opposite direction (slowing down the box).

Question:



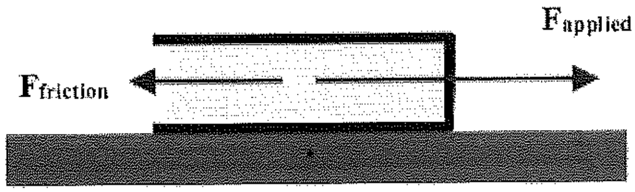
The free-body diagram shows forces acting on a box supported by a horizontal surface, where the length of each force vector is proportional to its magnitude. Which statement below is correct?

a. The box is accelerating downwards because the force of gravity is greater than the normal force.
b. The box is accelerating to the right, but not upwards.
c. The box is accelerating upwards, but not to the right.
d. The box is accelerating upwards *and* to the right.
e. None of the statements above is correct.

Answer:

The correct answer is *b*. The box has a net force in the positive-*x* direction, but the forces in the *y*-direction are balanced.

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:

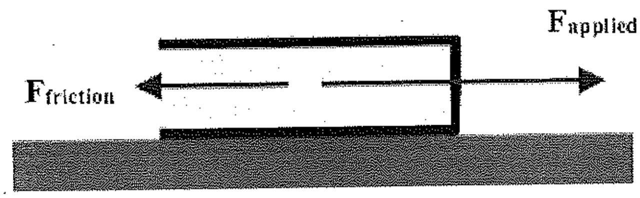
$$F_{net} = ma$$

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

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

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

Question:



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$$F_{net} = ma$$

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

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

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