This print-out should have 17 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

Conceptual 04 Q08
001 10.0 points

In order to slide a heavy desk across the floor at constant speed in a straight line, you have to exert a horizontal force of 800 Newtons.

Compare the 800-Newton horizontal pushing force F to the frictional force f between the desk and the ground.

1. $F = f$ from Newton's first law. **correct**

2. $F = f$ from Newton's third law.

3. $F > f$; the frictional force is always less than any other force acting on the object.

4. $F < f$; the frictional force is greater than the pushing force since it is such a heavy desk.

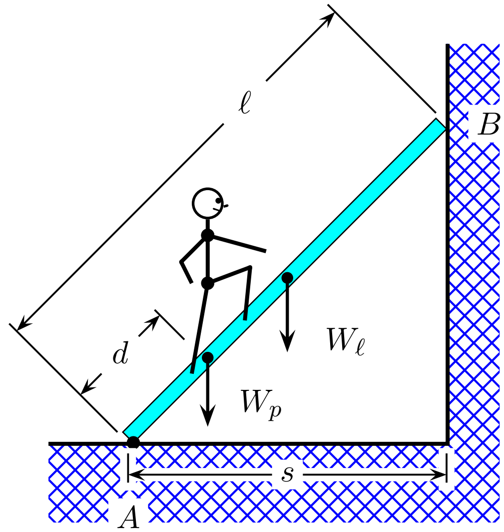
5. It depends on the direction the desk moves.

Explanation:

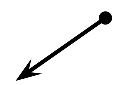
Since the desk moves at constant speed in a straight line, Newton's first law tells us the two forces must balance.

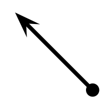
Conceptual forces 05
002 (part 1 of 4) 10.0 points

A ladder leans against a wall while someone climbs up, as shown in the figure below.



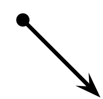
Which way does the normal force point at position A?

1. 

2. 

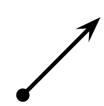
3. 

4. None of these

5. 

6.  **correct**

7. 

8. 

9. 

Explanation:

The normal force points upward so that it doesn't fall through the floor.

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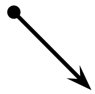
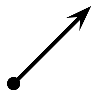
003 (part 2 of 4) 10.0 points

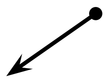
Which way does the normal force point at position B?

1. 

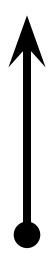
2.  **correct**

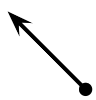
3. 

4. 

5. 

6. 

7. 

8. 

9. None of these

Explanation:

The wall has to push the ladder out so that it doesn't fall through the wall.

The normal force thus points to the left.

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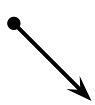
004 (part 3 of 4) 10.0 points

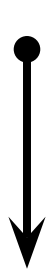
Consider the case where both the wall and the floor are rough.

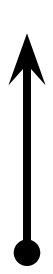
Which way does the force due to friction point at position A?

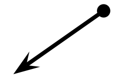
1. 

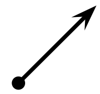
2. None of these

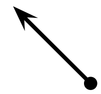
3.  **correct**

4. 

5. 

6. 

7. 

8. 

9. 

Explanation:

If both the floor and the wall were frictionless, the base of the ladder would slide to the left.

The force due to static friction points towards the right, opposing the ladder's tendency to move to the left.

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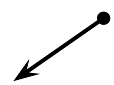
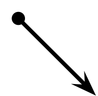
005 (part 4 of 4) 10.0 points

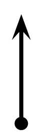
Which way does the force due to friction point at position B?

1. 

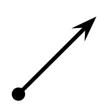
2. None of these graphs are correct.

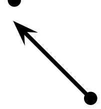
3. 

4. 

5.  **correct**

6. 

7. 

8. 

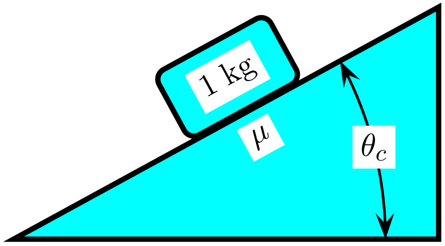
9. 

Explanation:

If both the wall and the floor were frictionless, the top of the ladder would slide down. The force due to static friction points upward, opposing the ladder's tendency to move downward.

Friction on an Incline 01
006 (part 1 of 3) 10.0 points

Consider a block on an incline plane. The coefficients of static and kinetic friction between the block and the incline are $\mu_s = 0.546$ and $\mu_k = 0.43$.



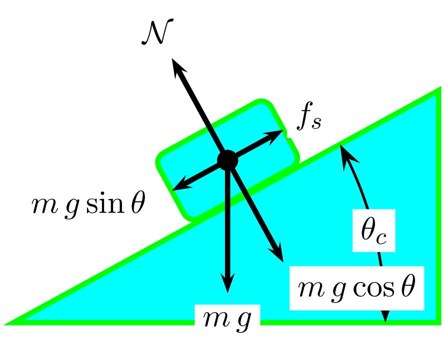
Calculate the critical angle θ_c, where the block just begins to slide.

Correct answer: 28.6346°.

Explanation:

Basic Concepts: Friction: $f_s \le \mu_s \mathcal{N}$, $f_k = \mu_k \mathcal{N}$

$$\begin{aligned} \text{Let}: \quad m &= 1 \text{ kg}, \\ \mu_k &= 0.43, \\ \mu_s &= 0.546, \quad \text{and} \\ v_f &= \text{final speed}. \end{aligned}$$



Solution: The frictional force, f_s, of a body at rest has to be less than $\mu_s N = \mu_s m\,g\cos\theta$. At $\theta = \theta_c$, $f_s = \mu_s N$. Since there is no acceleration along the plane of the incline, $f_s - m\,g\sin\theta = 0$. Thus,

$$f_s = \mu_s m\,g\cos\theta_c = m\,g\sin\theta_c$$

$$\begin{aligned} \Rightarrow \mu_s &= \tan\theta_c \\ \Rightarrow \theta_c &= \tan^{-1}\mu_s \\ &= \tan^{-1}(0.546) \\ &= 28.6346^\circ. \end{aligned}$$

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007 (part 2 of 3) 10.0 points

Determine the magnitude of the frictional force f when $\theta < \theta_{critical}$.

1. $|f| = m\,g\cot\theta$
2. $|f| = \mu_k\,m\,g\cos\theta$
3. $|f| = m\,g\cos\theta$
4. $|f| = \mu_s\,m\,g\sin\theta$
5. $|f| = m\,g\sin\theta$ **correct**
6. $|f| = \mu_s\,m\,g\cos\theta$
7. $|f| = \mu_k\,m\,g\sin\theta$

Explanation:

Below the critical angle the frictional force is exactly equal in magnitude and opposite in direction to the gravitational force parallel to the incline. From the force diagram we have

$$|f| = m\,g_{\|} = m\,g\sin\theta.$$

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008 (part 3 of 3) 10.0 points

Determine the magnitude of the frictional force f when $\theta > \theta_{critical}$.

1. $|f| = \mu_s\,m\,g\sin\theta$
2. $|f| = m\,g\cot\theta$
3. $|f| = m\,g\tan\theta$
4. $|f| = m\,g\cos\theta$
5. $|f| = \mu_s\,m\,g\cos\theta$
6. $|f| = \mu_k\,m\,g\sin\theta$
7. $|f| = \mu_k\,m\,g\cos\theta$ **correct**

Explanation:

When the block is sliding the frictional force is equal to the coefficient of sliding friction times the normal force.

$$|f| = \mu_k F_N = \mu_k m g_\perp = \mu_k m g \cos\theta\,.$$

Sliding occurs when $\theta > \theta_{critical}$.

Hitting the Brakes

009 (part 1 of 3) 10.0 points

You are driving at the speed of 27.9 m/s (62.4239 mph) when suddenly the car in front of you (previously traveling at the same speed) brakes. Considering an average human reaction, you press your brakes 0.56 s later. Assume that the brakes on both cars are fully engaged and that the coefficient of friction is 0.886 between both cars and the road.

The acceleration of gravity is 9.8 m/s^2 .

Calculate the acceleration of the car in front of you when it brakes.

Correct answer: -8.6828 m/s^2.

Explanation:

The only force on the car horizontally when braking is the force of friction, F_f. Thus

$$F_{net} = ma = -F_f = -\mu\mathcal{N} = -\mu mg$$

since the braking force is a deceleration. Thus

$$ma = -\mu mg$$

$$a = -\mu g = (0.886)(9.8\,\text{m/s}^2) = -8.6828\,\text{m/s}^2\,.$$

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010 (part 2 of 3) 10.0 points

Calculate the braking distance for the car in front of you.

Correct answer: 44.8248 m.

Explanation:

For constant acceleration a,

$$v^2 - v_0^2 = 2a\,(x - x_0) \quad .$$

The final velocity $v_f = 0$, and for $d_{br} = x - x_0$,

$$-v_0^2 = 2\,a\,d_{br}$$

$$d_{br} = -\frac{v_0^2}{2a} = \frac{(27.9\text{ m/s})^2}{2(-8.6828\text{ m/s}^2)} = 44.8248\text{ m}$$

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011 (part 3 of 3) 10.0 points

Find the minimum safe distance at which you can follow the car in front of you and avoid hitting it (in the case of emergency braking described here).

Correct answer: 15.624 m.

Explanation:

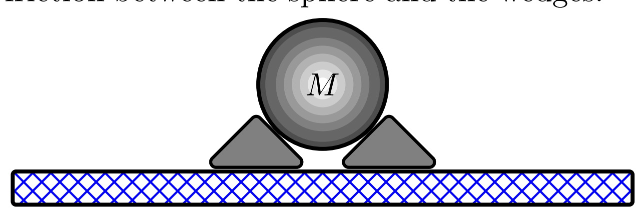
The car in front of you moves a total distance of d_{br}, which also is the distance you travel while braking. You also traveled a distance $d_{react} = v_0\Delta t$ because of your reaction time Δt. Thus the minimum safe distance is the distance you travel during your reaction time:

$$d_{safe} = v_0\Delta t = (27.9\,\text{m/s})(0.56\,\text{s}) = 15.624\,\text{m}$$

Conceptual forces 06 short

012 10.0 points

A spherical mass rests upon two wedges, as seen in the figure below. The sphere and the wedges are at rest and stay at rest. There is no friction between the sphere and the wedges.

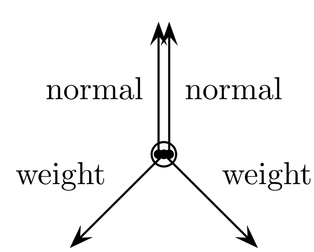


The following figures show several attempts at drawing free-body diagrams for the sphere.

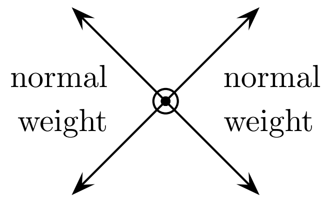
Which figure has the correct directions for each force?

Note: The magnitude of the forces are not necessarily drawn to scale.

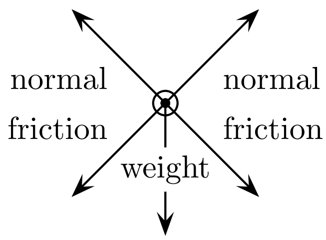
1.



2.

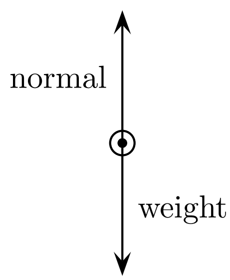


3.

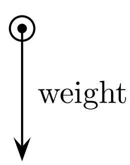


4. Since the sphere is not moving, no forces act on it.

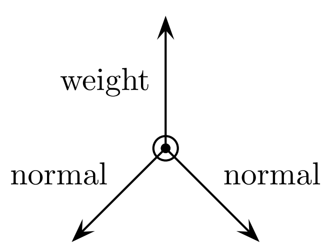
5.



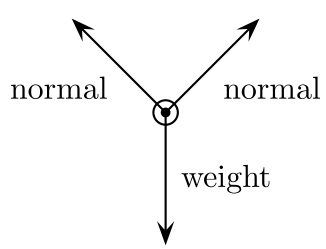
6.



7.

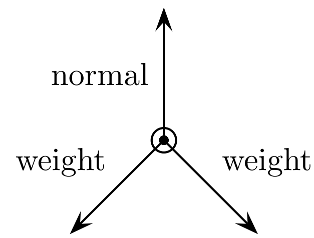


8.



correct

9.

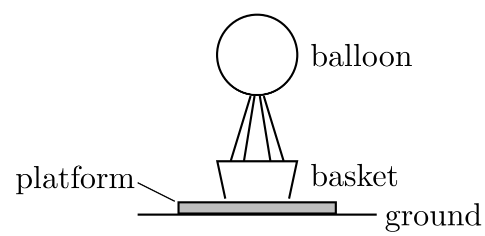


Explanation:

Weight – the force of gravity – pulls the sphere down. The normal force of the left wedge upon the sphere acts perpendicular to (*normal to*) their surfaces at the point of contact; *i.e.*, diagonally upward and rightward. Likewise, the normal force of the right wedge upon the sphere acts diagonally upward and leftward.

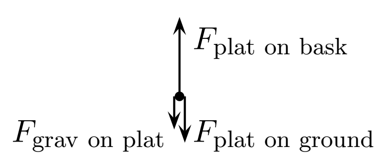
Free Body Diagram of Balloon
013 (part 1 of 2) 10.0 points

A balloon is waiting to take off. As seen in the figure below, the balloon's basket sits on a platform which rests on the ground. The balloon is pulling up on the basket, but not hard enough to lift it off the platform.

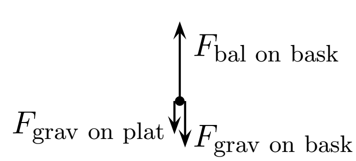


What is the free-body diagram for the platform? Some parallel vectors are offset horizontally for clarity.

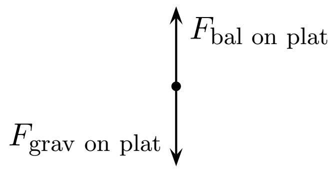
1.



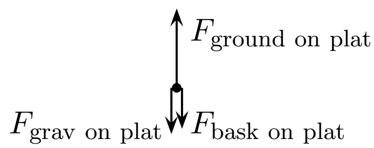
2.



3.

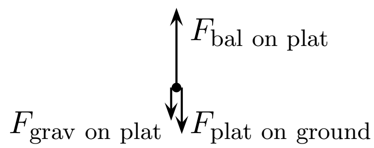


4.



correct

5.



Explanation:

All forces acting on the platform must be represented. No forces acting on other objects should be represented.

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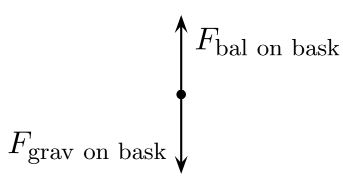
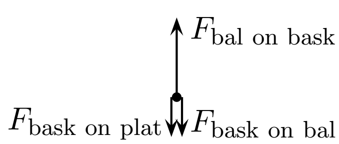
014 (part 2 of 2) 10.0 points

What is the free body diagram for the basket? Again some parallel vectors are offset horizontally for clarity.

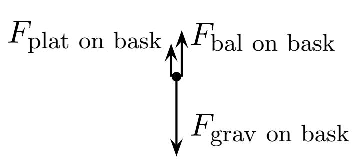
1.



2.

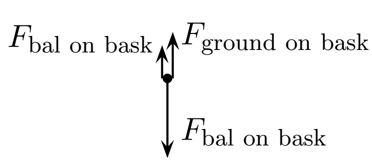


3.

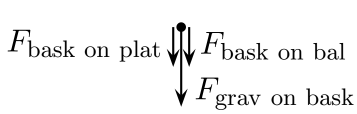


correct

4.



5.

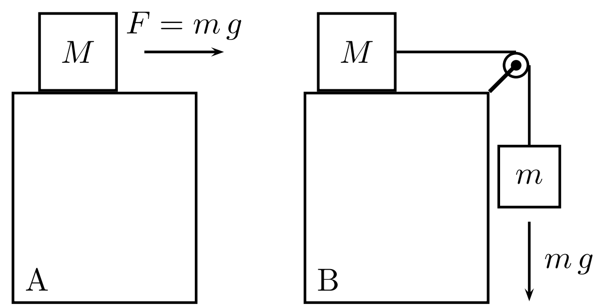


Explanation:

All forces acting on the basket must be represented. No forces acting on other objects should be represented.

Accel Comparison
015 10.0 points

Consider two different situations. In situation A, a box of mass M on a frictionless tabletop is being pulled by a constant horizontal force $F = m\,g$. In situation B, a box of mass M is on a frictionless tabletop and a string of negligible mass runs over a peg of negligible friction, to a hanging mass m which is allowed to fall.



In which situation would the acceleration a of the box of mass M be the largest?

1. The acceleration is the same in situations A and B, since the same force $m\,g$ acts.

2. Not enough information is provided.

3. Initially, the acceleration is largest in situation A, but as the mass m begins to fall faster, it will become largest in situation B.

4. In situation B

5. Initially, the acceleration is largest in situation B, but as the mass m begins to fall faster, it will become largest in situation A.

6. In situation A **correct**

Explanation:

In case A, a net force $F = m\,g$ is applied to mass M, so by Newton's second law,

$$M\,a_A = m\,g$$

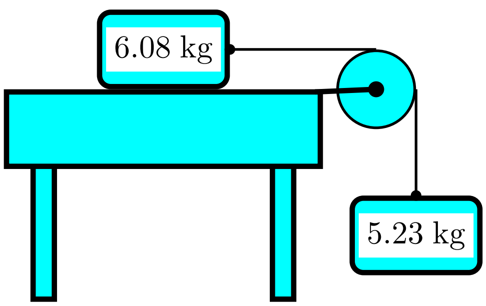
$$a_A = \frac{m}{M}\, g\,.$$

In case B, however, a net external force of $m\,g$ is applied to a system of two masses, so Newton's second law gives

$$(m + M)\, a_B = m\, g$$
$$a_B = \frac{m}{m + M}\, g < a_A\,.$$

Accelerated System 01
016 (part 1 of 2) 10.0 points

A block of mass 6.08 kg lies on a frictionless horizontal surface. The block is connected by a cord passing over a pulley to another block of mass 5.23 kg which hangs in the air, as shown. Assume the cord to be light (massless and weightless) and unstretchable and the pulley to have no friction and no rotational inertia.

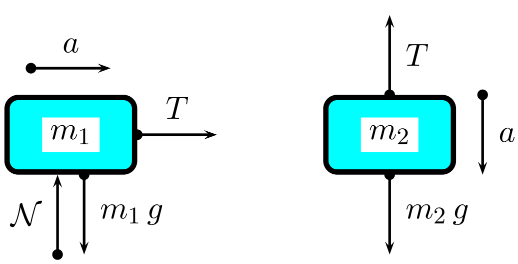


Calculate the acceleration of the first block. The acceleration of gravity is 9.8 m/s^2 .

Correct answer: 4.53174 m/s^2.

Explanation:

$$\text{Let :}\quad m_1 = 6.08\text{ kg}\quad\text{and}$$
$$m_2 = 5.23\text{ kg}\,.$$



Since the cord is unstretchable, the first block accelerates to the right at exactly the same rate a as the second (hanging) block accelerates downward. Also, the cord's tension pulls the first block to the right with exactly the same tension T as it pulls the second block upward.

The only horizontal force acting on the first block is the cord's tension T,so by Newton's Second Law

$$m_1\, a = F_1^{\text{net}\rightarrow} = T\,.$$

The second block feels two vertical forces: The cord's tension T (upward) and the block's own weight $W_2 = m_2\, g$ (downward). Consequently,

$$m_2\, a = F_2^{\text{net}\downarrow} = m_2\, g - T\,.$$

Adding,

$$(m_1 + m_2)\, a = m_2\, g$$
$$a = \frac{m_2}{m_1 + m_2}\, g$$
$$= \frac{5.23\text{ kg}}{6.08\text{ kg} + 5.23\text{ kg}}\,(9.8\text{ m/s}^2)$$
$$= \boxed{4.53174\text{ m/s}^2}\,.$$

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017 (part 2 of 2) 10.0 points

Calculate the tension in the cord.

Correct answer: 27.553 N.

Explanation:

$$T = m_1\, a = (6.08\text{ kg})\,(4.53174\text{ m/s}^2)$$
$$= \boxed{27.553\text{ N}}\,.$$