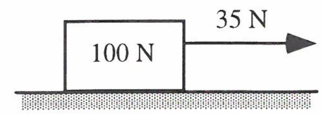
#1

B3-SCT86: Box Pulled on Rough, Horizontal Surface—Frictional Force on Box

A 100 N box is initially at rest on a rough, horizontal surface. The coefficient of static friction is 0.6, and the coefficient of kinetic friction is 0.4. A constant 35 N horizontal force to the right is applied to the box. Four students are discussing the frictional force exerted on the box by the rough surface 1 second after the force is first applied:



Al: *"The frictional force is 60 N since the box will not be moving and the* coefficient of static friction is 0.6 with a normal force of 100 N."

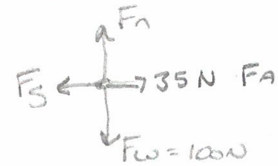
Brianna: "The frictional force is 40 N since the coefficient of kinetic friction is 0.4 and there is a normal force of 100 N."

Carlos: "The frictional force is 35 N since the box will not be moving and the frictional force will cancel out the applied force of 35 N."

David: "It is 40 N for the kinetic frictional force and 60 N for the static frictional force. The normal force is 100 N and the coefficient of kinetic friction is 0.4, giving 40 N for the kinetic friction. Similarly, for the static frictional force it is 60 N since it has a coefficient of static friction of 0.6."

With which, if any, of these students do you agree?

Al _____ Brianna __✓__ Carlos _____ David _____ None of them _____



Explain your reasoning.

Answr: Carlos is correct.
The applied force is less than 60 N, the amount needed to get the box moving, so it is still at rest. The static frictional force remains at 35 N and opposes the applied force of 35 N.

$\Sigma F_x = F_A - F_S = ma$ (a = 0) $\Sigma F_y = F_N - F_W = ma$ (a = 0)

$F_S = F_A$ ∴ No movement, it will ↑ till $F_{S max}$

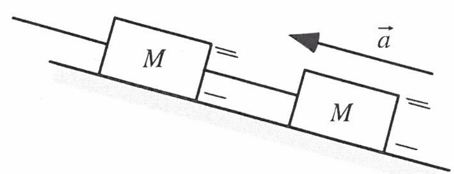
$F_A = F_S$
$F_S = \mu F_N$
$= .60(100N)$
$F_S = 60N$

$F_N = F_W$
$= 100N$

#2.

B3-SCT83: Blocks on a Smooth Incline—Tension

Two blocks are tied together with a rope and are pulled so that they accelerate up a smooth (frictionless) incline. Three students are comparing the tension in the rope between the blocks to the magnitude of the force that the lower block exerts on that rope:



Alberto: "I think the tension has to be larger because it is causing the lower block to accelerate up the incline. If it was the same, then the block wouldn't accelerate."

Benifacio: "I disagree. Force equals mass times acceleration, and the accelerations of the rope and the lower block are the same. The rope hardly weighs anything compared to the block, so it can't exert as much force. The force the block exerts has to be greater."

Connie: "I agree that the rope and the block have exactly the same acceleration since they are moving together. But I think that means that the force has to be the same."

With which, if any, of these students do you agree?

Alberto____ Benifacio _____ Connie _____ None of them__✓__

Explain your reasoning.

$F_{2,1}$ $F_{1,2}$ 3rd LAW

Answer: None of these students is correct.
Connie is correct that the forces being compared are equal in magnitude, but her reasoning is incorrect. The force that the lower block exerts on the rope and the tension force that the rope exerts on the block are a Newton's Third Law pair, and so they must have equal magnitudes.

Tipper #2 - Unit 2 - KEY

#3

B3-WBT82: Newton's Second Law Equation—Physical Situation

The equation below results from the application of Newton's Laws to an object:

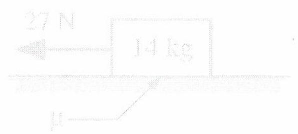
FA − u m g = No acceleration

$$27\ \text{N} - (\mu)(14\ \text{kg})(9.8\ \text{m/s}^2) = 0$$

14 x 9.8 = 137 N

Draw a physical situation that would result in this equation, and explain how your drawing is consistent with the equation.

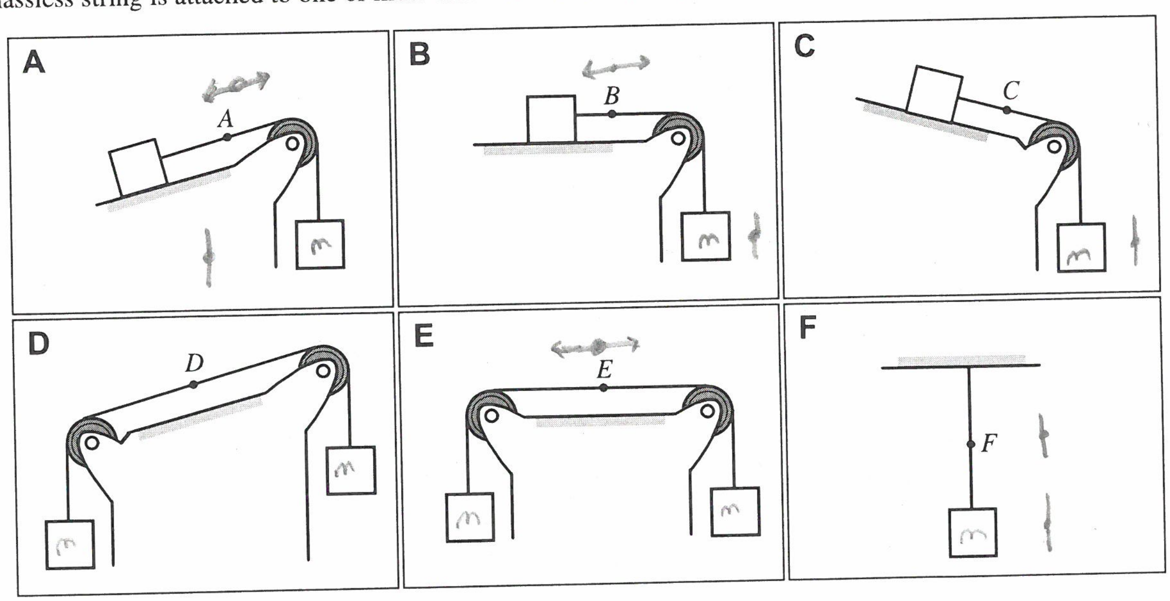
Answer: One possibility is a 14 kg object sitting at rest on a horizontal surface with friction. There also is a 27 N force on the object that is applied parallel to the surface which is less than the maximum static friction force.



#4

B3-RT81: Hanging Mass—String Tension

A massless string is attached to one or more identical blocks at rest. All the pulleys are frictionless and massless.



Rank the tension in the strings at the labeled points.

						OR	☒	☐	☐
1 Greatest	2	3	4	5	6 Least		All the same	All zero	Cannot determine

Explain your reasoning.

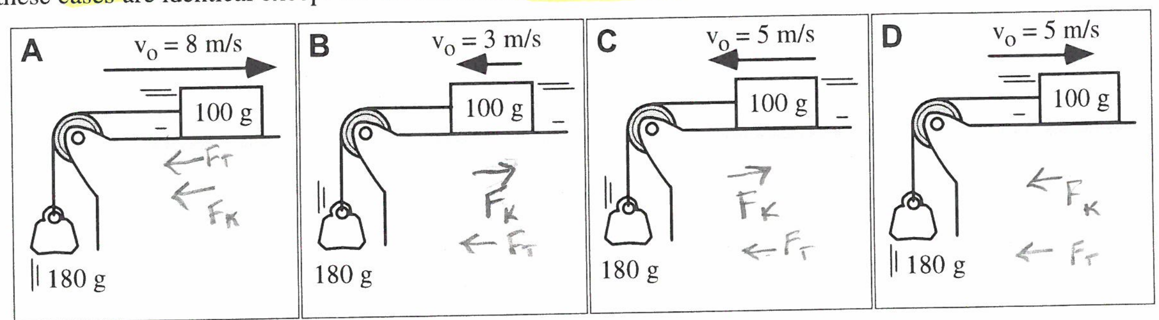
Answer: The tensions at all of the labeled points are the same.
For a massless string, the tension is the same at all points along the string. A free-body diagram of any hanging block will have a tension force upward and a 10-N weight downward, so the tension in all strings is 10 Newtons.

Tipper #2 - Unit 2 - KEY

#5

B3-RT74: Hanging Stone Connected to Box on Rough Surface—Acceleration

In each case shown below, a box is sliding along a horizontal surface. There is friction between the box and the horizontal surface. The box is tied to a hanging stone by a massless rope running over a massless, frictionless pulley. All these cases are identical except for the different initial velocities of the boxes.



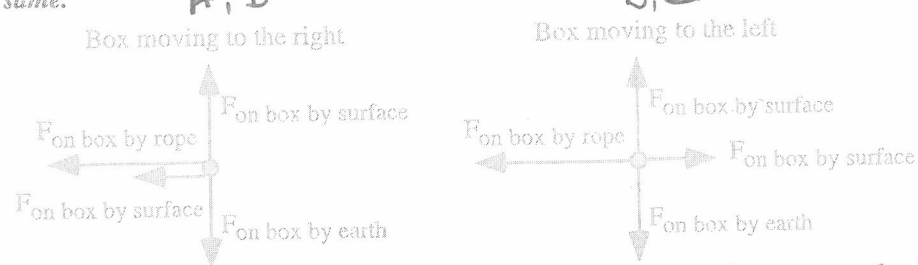
Rank the magnitudes of the accelerations of the boxes at the instant shown.

F=ma

1 Greatest	2	3	4 Least	OR	All the same	All zero	Cannot determine

Explain your reasoning.

Answer: A = D > B = C.
Since the surfaces are identical and the blocks all have the same mass, the magnitude of the friction force is the same in all cases. However, when the box is moving to the left the frictional force is to the right (opposite the direction of the tension force on the box) and when the box is moving to the right the frictional force is to the left, in the same direction as the tension. The friction force doesn't depend on the velocity. The acceleration is the same for all boxes that are moving in the same direction, since the free-body diagrams for these boxes will be the same.



F_f doesn't care about v

No velocity in Eqn

$\Sigma F_x = -F_T - u_k F_f = ma$

$a = \frac{-F_T - u_k F_f}{m}$ >

$\Sigma F_x = -F_T + u_k F_f = ma$

$a = \frac{u_k F_f - F_T}{m}$

Tipper #2-Unit 2 -KEY

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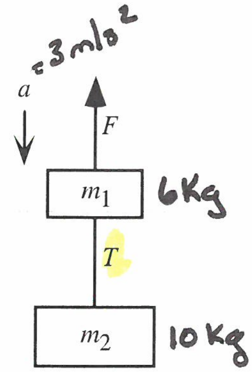
#6

B3-LMCT85: Two Connected Objects Accelerating Downward—Tension in String



Two objects with masses of m_1 = 6 kg and m_2 = 10 kg are connected by a massless string. They are pulled upward by an applied force *F*. Since this force is smaller than the total weight of the objects, there is a constant downward acceleration of 3 m/s². The tension in the string connecting the objects is labeled *T*.

Identify from choices (i)–(iv) how each change described below will affect the tension (*T*) in the string between the objects.

Compared to the case above, this change will:

(i) ***increase*** the tension in the string.
(ii) ***decrease*** the tension in the string but not to zero.
(iii) ***decrease*** the tension in the string **to zero.**
(iv) *have* ***no effect*** on the tension in the string.
(v) *have an* ***indeterminate*** effect on the tension in the string.

All of these modifications are the only changes to the initial situation shown in the diagram.

(a) The mass of m_1 is decreased to 5 kg and the mass of m_2 is increased to 11 kg. _____
Explain your reasoning.

Answer (i). Altering m_1 has no effect on the tension. Increasing m_2 will require a larger tension for the same acceleration with an increased weight. T goes from 68 N to 74.8 N.

1st m_2 = 10 2nd mg = 11 kg
Fw ↑ ∴ FT ↑
↑ FT ↓ FW

(b) The mass of m_1 is increased to 7 kg and the mass of m_2 is decreased to 9 kg. _____
Explain your reasoning.

Answer (ii). Altering m_1 has no effect on the tension. Decreasing m_2 will require a smaller tension for the same acceleration & decreased weight. T goes from 68 N to 61.2 N.

1st m_2 = 10 kg 2nd mg = 9 kg
Fw↓ ∴ FT↓

(c) The applied force *F* is increased and the acceleration is 2 m/s² downward. _____
Explain your reasoning.

Answer (i). The tension T is the weight of m_2 minus the net force—m_2 times the acceleration due to gravity—as required by Newton's second law. T goes from 68 N to 78 N.

↑ FT ↓ FW

$\Sigma F_{y1} = F_T - F_W = ma$
$F_T = F_W + ma$
$= (10 kg)(9.8 m/s^2) + (10 kg)(-3 m/s^2)$
$F_T = 98 - 30 = 68 N$

$\Sigma F_{y2} = F_T = F_W + ma$
$= 98 N - (10 kg)(-2 m/s^2)$
$= 98 N - 20 N$
$F_T = 78 N$

(d) The applied force *F* is increased and the acceleration is 4 m/s² upward. _____
Explain your reasoning.

Answer (i). The increase in the acceleration due to the increase in the applied force will require that the tension increase. In this case, T goes from 68 N to 138 N.

$F_{T_1} = 68 N$

$F_{T2} = 98 N + 10 kg(+4 m/s^2)$
$= 98 + 40 N$
$F_{T2} = 138 N$

(e) The applied force *F* is decreased and the acceleration is 4 m/s² downward. _____
Explain your reasoning. -4 m/s²

Answer (ii). The increase in the acceleration due to the decrease in the applied force will require that the tension decrease. In this case, T goes from 68 N to 58 N.

$F_{T_1} = 68 N$

$F_{T_2} = 98 N + (10 kg)(-4 m/s^2)$
$= 98 N - 40 kg$
$F_{T2} = 58 N$

Tipper #2 - Unit 2 - KEY

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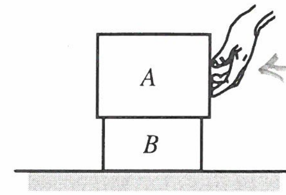
#7

B3-QRT91: Stacked Blocks Slowing Down—Friction Forces

A student pushes two blocks across a desk. At the instant shown, the blocks are *slowing down.* The force exerted on block A by the student is directed horizontally to the left. The mass of block A is greater than the mass of block B.



(a) The magnitude of the friction force exerted on block A by block B

(i) is *greater than* the magnitude of the friction force exerted on block B by block A.
(ii) is *less than* the magnitude of the friction force exerted on block B by block A.
(iii) is *equal to* the magnitude of the friction force exerted on block B by block A.
(iv) cannot be compared to the magnitude of the friction force exerted on block B by block A based on the information given.

Explain your reasoning.

(iii) The friction force on block B by block A must be equal to the friction force on block A by block B by Newton's Third Law.

(b) The magnitude of the friction force exerted on block B by the desk

(i) is *greater than* the magnitude of the friction force exerted on block B by block A.
(ii) is *less than* the magnitude of the friction force exerted on block B by block A.
(iii) is *equal to* the magnitude of the friction force exerted on block B by block A.
(iv) cannot be compared to the magnitude of the friction force exerted on block B by block A based on the information given.

Explain your reasoning.

(i) Since block B is slowing down, the net horizontal force acting on it must be directed to the right, so the friction force on B by the desk must be greater in magnitude and opposite in direction to the friction force on B by A.

(c) The magnitude of the friction force exerted on block A by block B

(i) is *greater than* the magnitude of the force exerted on block A by the hand.
(ii) is *less than* the magnitude of the force exerted on block A by the hand.
(iii) is *equal to* the magnitude of the force exerted on block A by the hand.
(iv) cannot be compared to the magnitude of the force exerted on block A by the hand based on the information given.

Explain your reasoning.

(i) Since block A is slowing down, the net horizontal force acting on it must be directed to the right, so the friction force on A by B must be greater in magnitude and opposite in direction to the force on A by the hand.

Tipper #2 - Unit 2 - KEY

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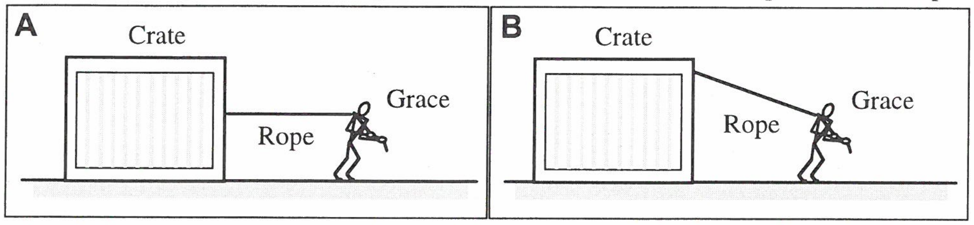
#8

B3-CT73: Pulling a Crate Across Floor—Applied Force

In both cases below, Grace pulls the same large crate across a floor at a constant speed of 1.48 m per second.



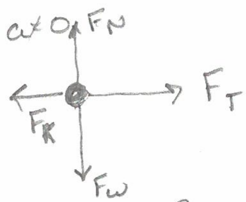
Is the magnitude of the force exerted by Grace on the rope (i) *greater* in Case A, (ii) *greater* in Case B, or (iii) *the same* in both cases? _____

Explain your reasoning.

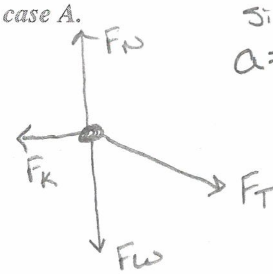
Answr: Greater in case B.
Since the force that the rope exerts on the crate in case B has a downward vertical component, and the net vertical force is zero (the crate has a constant velocity), the normal force on the crate by the floor is larger than the weight of the crate in case B. In case A, however, the normal force on the crate by the floor is equal to the weight. Since the normal force on the crate by the floor is greater in case B than in case A, the friction force is also greater in case B than in case A. So it must be true that the horizontal component of the tension is greater in case B than in case A, since the net horizontal force is zero (the crate has a constant velocity). The tension in case B is greater than its horizontal component, and the horizontal component of this tension is greater than the tension in case A, so the tension in case B is greater than the tension in case A.

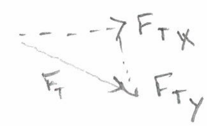
Since V = constant
$a = \emptyset$

A $a \neq 0$



B





$\Sigma F_x = F_T - F_K = m a^0$

$F_K = \mu_K F_N$

$\Sigma F_y = F_N - F_W = m a^0$

$F_N = F_W$

$F_T = \mu_K F_W$

$\Sigma F_x = F_{Tx} - F_K = ma$

$\Sigma F_y = -F_{Ty} + F_N - F_W = ma^0$

$F_N = F_{Ty} + F_W$

$F_{Tx} = F_K$

$F_{Tx} = \mu_K F_N$

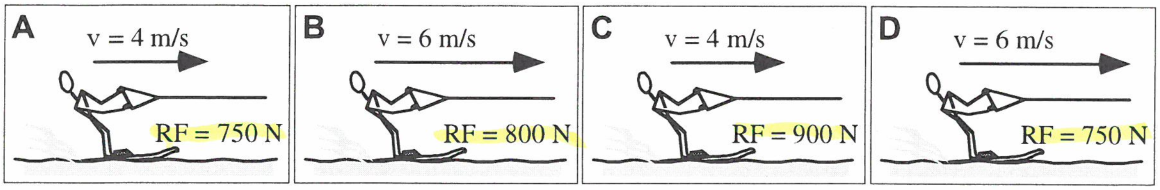
$F_{Tx} = \mu_K (F_{Ty} + F_N)$

greater T

#9

B3-RT71: Water Skiers—Tension

Water skiers are pulled at a constant speed by a towrope attached to a speedboat. Because the weight of the skiers and the type of skis they are using varies, they experience different resistive forces from the water. Values for this resistive force (RF) and for the speed of the skiers are given.



Rank the tension in the towrope.

				OR	☐	☐	☐
1 Greatest	2	3	4 Least		All the same	All zero	Cannot determine

Constant speed ∴ $a = 0$

$\Sigma F_x = F_T - RF = m a^0$

$F_T = RF$

Velocity doesn't matter

Explain your reasoning.

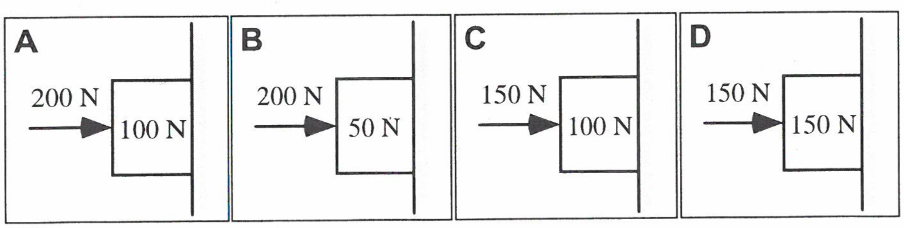
Answer: C > B > A = D.
The net force on each skier must be zero because they are not accelerating. The only horizontal forces are the tension in the ski rope and the resistive force. These must be equal and opposite to each other to give zero net force. So the ranking of the tension is the same as the ranking of the resistive force.

$C_{900} > B_{800} > A_{750} = D_{750}$

#10

B3-RT89: Boxes Held Against Vertical Surfaces—Frictional Forces on the Wall

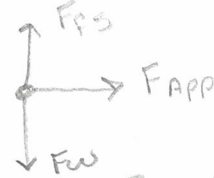
A box is held at rest against a rough, vertical surface by a force pushing horizontally as shown. Values for the applied force and the weight of the boxes are given. The boxes are all made of the same material and the walls are identical.



Rest ∴ No a

Rank the magnitude of the frictional force exerted on the wall by these boxes.

				OR	☐	☐	☐
1 Greatest	2	3	4 Least		All the same	All zero	Cannot determine



Explain your reasoning.

$\Sigma F_y = F_{fs} - F_w = m a^0$

$F_{f_s} = F_w$

Answer: D > A = C > B.
The frictional force on the box by the wall is equal to the weight of each box since they are at rest. The net force must be zero on each box, and the friction force must have the same magnitude as the weight and be in the opposite direction. The friction force on the wall by the box is the Newton's Third Law pair to the friction force on the box by the wall, and has the same magnitude, so the friction force on the wall by the box has the same magnitude as the weight of the box.

3rd Law Action - Reaction
Box - Wall Action / Reaction Pair ∴ Forces = Equal