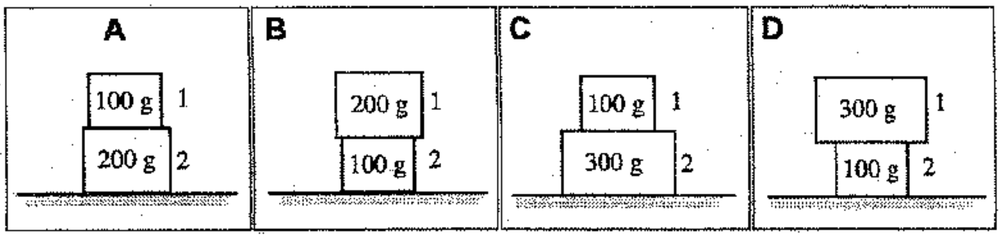
Key

B3-RT07: Two Stacked Blocks at Rest—Net Force on the Bottom Block

Two wooden blocks with different masses are at rest, stacked on a table. The top block is labeled **1,** and the bottom block is labeled **2.**



Rank the magnitude of the net force on the bottom block (2).

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

Explain your reasoning.

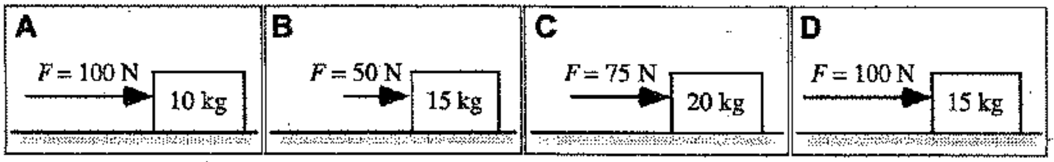
Answer: All Zero.

The net force on each block must be zero due to Newton's 1st Law since they are not accelerating.

At rest ∴ $\vec{a} = 0$ ∴ $\Sigma \vec{F} = \vec{F}_{net} = m \cdot \vec{a} = 0$

B3-RT08: Force Pushing Box—Acceleration

Various similar boxes are being pushed for 10 m across a floor by a net horizontal force as shown below. The mass of the boxes and the net horizontal force for each case are given in the indicated figures. All boxes have the same initial velocity of 10 m/s to the right.



Rank the acceleration of the boxes.

A	D	C	B	OR			
1 Greatest	2	3	4 Least		All the same	All zero	Cannot determine

Explain your reasoning.

Answer: A > D > C > B

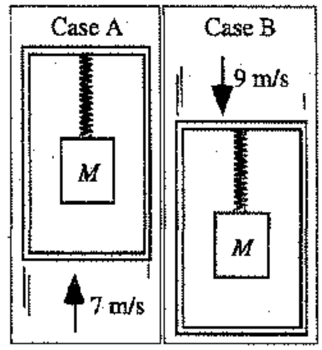
The acceleration equals the net force on each box divided by the mass of the block or a= Fnet/m using Newton's 2nd Law. For A, a = Fnet /m = 100 N/ 10 kg = 10 m/s² ; for B, a = Fnet /m = 50 N/ 15 kg = 3.33 m/s² ; for C, a = Fnet /m = 75 N/ 20 kg = 3.75 m/s²; and for D, a = Fnet /m = 100 N/ 15 kg = 6.67 m/s²

$$\vec{a} = \frac{\Sigma \vec{F}}{m}$$

A	B	C	D
$\vec{a} = \frac{100\,N}{10\,kg} = 10\,m/s^2$	$\frac{50\,N}{15\,kg} = 3.\bar{3}\,m/s^2$	$\frac{75\,N}{20\,kg} = 3.75\,\frac{m}{s^2}$	$\frac{100\,N}{15\,kg} = 6.67\,m/s^2$

B3-CT09: BLOCKS IN MOVING ELEVATORS—STRETCH OF SPRING

A spring is attached to the ceiling of an elevator, and a block of mass M is suspended from the spring. The cases are identical except that in Case A the elevator is moving upward with a constant speed of 7 m/s, while in Case B the elevator is moving downward with a constant speed of 9 m/s.



Will the spring be stretched (i) *more* in Case A, (ii) *more* in Case B, or (iii) *the same* in both cases? _____

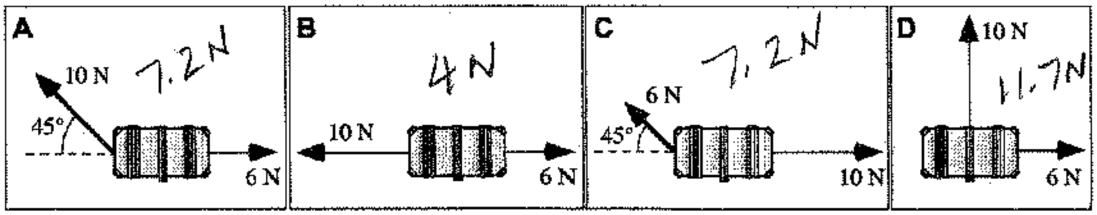
Explain your reasoning. iii = the same

Answer: The same in both cases.
In both cases the block is moving with a constant velocity, so the net force on the block is zero. Since the only forces acting on the block are the weight of the block and the force from the spring, these forces must be equal in magnitude and opposite in direction to give zero net force. Since the weight of the block is the same in case A as in case B, the force by the spring must be the same also, and therefore the springs are stretched the same amount.

$\vec{a} = 0 \quad \therefore \sum \vec{F} = \vec{F}_{net} = m \cdot \vec{a} = 0$

B3-RT10: TWO-DIMENSIONAL FORCES ON A TREASURE CHEST—FINAL SPEED

Identical treasure chests (shown from above) each have two forces acting on them. All chests start at rest.



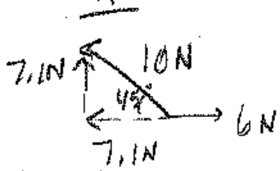
Rank the speed of the treasure chest after 2 seconds.

1 Greatest	2	3	4 Least	OR	All the same	All zero	Cannot determine
D	A = C		B				

Explain your reasoning.

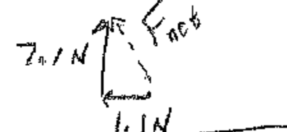
Answer: D > C = A > B.
We need to find the accelerations of the chests. Since they are all starting from rest and accelerating for the same time, the final speed will be proportional to the acceleration. The acceleration will be proportional to the net force, i.e., the vector sum of the two forces acting on each chest.

A



$\Sigma F_x = 7.1N + (-6N) = m \cdot \vec{a}$

$\Sigma F_x = 1.1N = m \cdot a$



$\Sigma F = \sqrt{(1.1)^2 + (7.1)^2}$

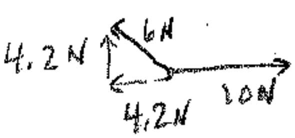
$\Sigma F = 7.2N$

B

$\Sigma F_x = 10N + (-6N) = m \cdot \vec{a}$

$\Sigma F_x = 4N = m \cdot \vec{a}$

C



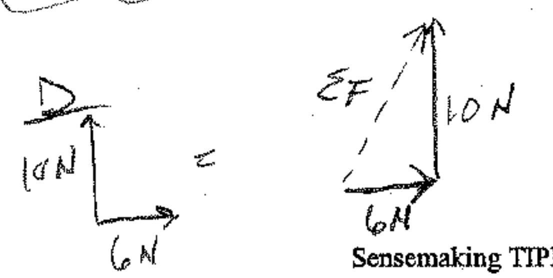
$\Sigma F_x = 10N - 4.2N = m \cdot \vec{a}$

$\Sigma F_x = 5.8N = m \cdot \vec{a}$

$\Sigma F = \sqrt{(5.8)^2 + (4.2)^2}$

$\Sigma F = 7.2N$

D

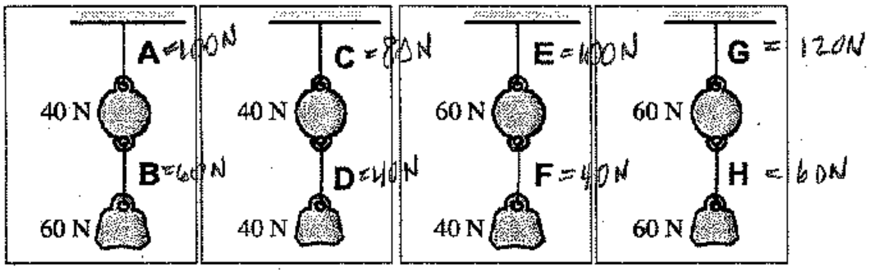


$\Sigma F = \sqrt{(10N)^2 + (6N)^2}$

$\Sigma F = 11.7N$

B3-RT17: Hanging Weights—Rope Tension

Two weights are hung by ropes from a ceiling as shown. All of these systems are at rest.



Rank the tensions in the ropes.

1 Greatest	2	3	4	5	6	7	8 Least	OR All the same	Cannot determine
G	A = E		C	B = H		D = F			

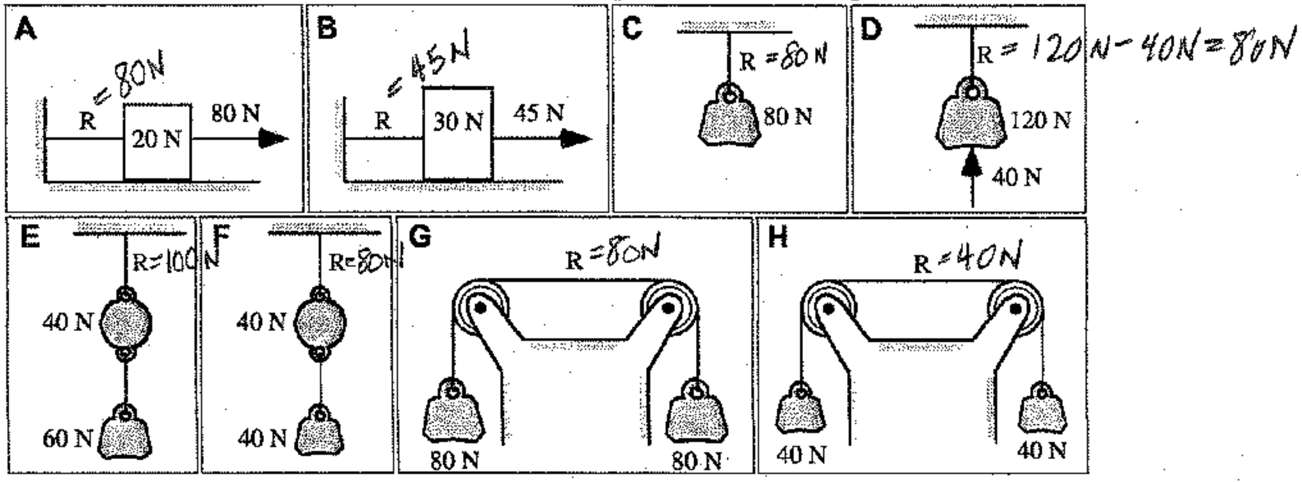
Explain your reasoning.

Answer: G > A = E > C > B = H > D = F.

Since the systems are at rest the vector sum of the forces on each block has to be zero. Working up from the bottom the lower tensions must be equal to the weights of the lower blocks, and the tensions in the upper ropes must be equal to the sum of the two weights.

B3-RT18: Blocks and Weights at Rest—Tension

In all of the cases shown, the systems are at rest. In Cases A and B, there is a force to the right acting on the block, which is on a frictionless surface, and in Case D there is a 40 N upward force on the weight.



Rank the tension in the rope labeled R.

1 Greatest	2	3	4	5	6	7	8 Least	OR All the same	Cannot determine
E	A =	C =	D =	F =	G	B	H		

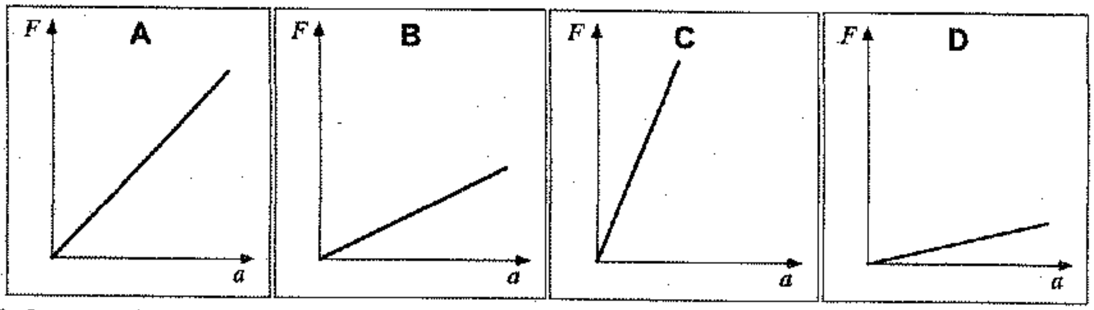
Explain your reasoning.

Answer: E > A = C = D = F = G > B > H.

Since in all of these cases the systems are at rest the net forces acting on the systems are zero. So for cases A, B, C, E, and F the tension is balancing the applied force. For case D the tension plus the 40 N applied force must balance the 120 N weight. For cases G and H the tension is equal to the weight of the hanging blocks.

B3-RT20: NET FORCE-ACCELERATION GRAPHS—MASS

These graphs are of net force versus acceleration for different objects. All graphs have the same scale for each respective axis.



Rank the mass of the objects.

C	A	B	D	OR			
1 Greatest	2	3	4 Least		All the same	All zero	Cannot determine

Explain your reasoning.

Answer: C > A > B > D.
The slopes of these graphs—given by the force divided by the acceleration—is the mass of the object involved.

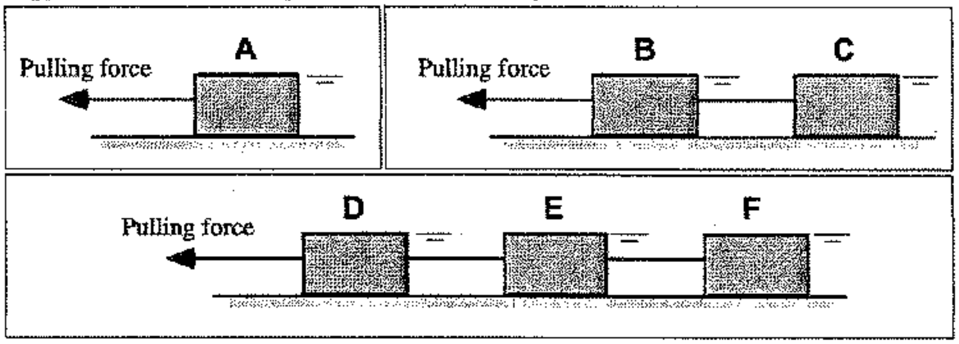
$$\Sigma \vec{F} = m \cdot \vec{a}$$

$$\text{Slope} = \frac{\text{Rise}}{\text{Run}} = \frac{F}{a} = m$$

Steeper Slope = greater mass

B3-RT21: Ropes Pulling Boxes—Acceleration

Boxes are pulled by ropes along frictionless surfaces, accelerating toward the left. All of the boxes are identical. The pulling force applied to the left-most rope is the same in each figure.



Rank the accelerations of the blocks.

A	B=	C	D=	E=	F	OR	☐	☐	☐
1 Greatest	2	3	4	5	6 Least		All the same	All zero	Cannot determine

Explain your reasoning.

Answer: A > B = C > D = E = F.

Since the same net force is acting on all three systems the accelerations will depend on the masses of the systems and all masses in a system will have the same acceleration.

$$\vec{a} = \frac{\Sigma F}{m}$$

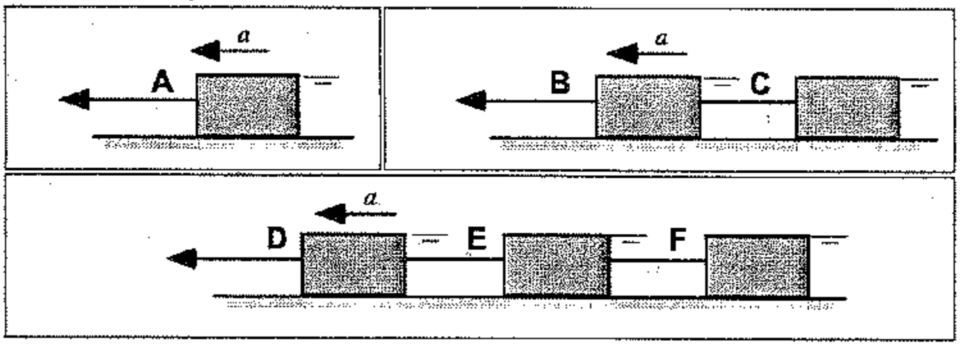
A: $\vec{a} = \frac{\Sigma F}{m}$

B=C: $\vec{a} = \frac{\Sigma F}{m}$

D=E=F: $\vec{a} = \frac{\Sigma F}{M}$

B3-RT22: Ropes Pulling Boxes—Rope Tension

Boxes are pulled by ropes along frictionless surfaces, accelerating toward the left. All of the boxes are identical, and the accelerations of all three systems are the same.



Rank the tensions in the ropes.

D	B ≠ E		A ≠ C ≠ F			OR			
1 Greatest	2	3	4	5	6 Least		All the same	All zero	Cannot determine

Explain your reasoning.

Answer: D > B = E > A = C = F.

Since the boxes all have the same mass (m) and all of the accelerations are the same, the tensions will be determined by how many boxes the rope is accelerating. The only horizontal force on the rightmost blocks in each case is the tension in the rope to the left of that block (A, C, and F), and this tension must therefore be the mass of that block times the acceleration, ma. The tension in ropes B and E are the net forces on the systems of the two blocks to their right, so the tensions in these ropes must be 2ma. For the system of all 3 blocks in the last case the net force is the tension in rope D, 3ma.

$$\Sigma \vec{F} = m \cdot \vec{a} \Rightarrow \vec{a} = \frac{\Sigma F}{m}$$

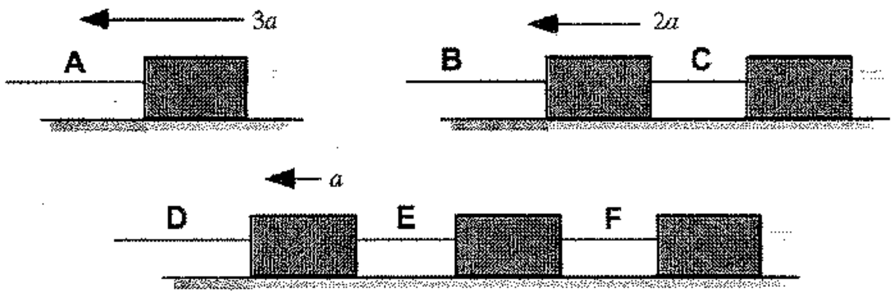
D: $\vec{a} = \frac{\Sigma F}{m}$

B = E: $\vec{a} = \frac{\Sigma F}{m}$

A = C = F: $\vec{a} = \frac{\Sigma F}{m}$

B3-RT27: Ropes Pulling Identical Boxes—Rope Tension

Boxes are pulled by ropes along frictionless surfaces, accelerating toward the left. All of the boxes are identical, and the accelerations of the boxes are indicated.



Rank the tension in these ropes.

1 Greatest	2	3	4	5	6 Least	OR	All the same	All zero	Cannot determine
B	D =	A	C =	E	F				

Explain your reasoning.

Answer: B > D = A > C = E > F.

Since the surface is frictionless, the tension in all ropes is the net force on the system of all blocks to the right of that rope. So the tension is equal to the mass of all blocks to the right of that rope times the acceleration. For rope A, this is (m)(3a); for B it is (2m)(2a); for C it is (m)(2a); for D it is (3m)(a); for E it is (2m)(a); and for F it is (m)(a).

$\Sigma F = m \cdot a$

B

$(2m)(2a) = 4F$

D=A

$(3m)(a) = 3F$

$(1m)(3a) = 3F$

C=E

$(1m)(2a) = 2F$

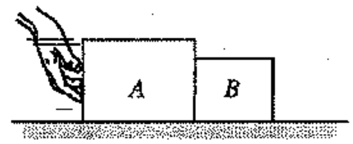
$(2m)(1a) = 2F$

F

$(1m)(1a) = 1F$

B3-QRT28: Student Pushing Two Blocks—Force

A student pushes horizontally on two blocks, which are moving to the right. Block A has more mass than block B. There is friction between the blocks and the table.



(a) For the situation where the blocks are moving at a constant speed, which of the following statements is true about the magnitude of the forces?

(i) The force that block A exerts on block B is *greater than* the force that block B exerts on block A.
(ii) The force that block A exerts on block B is *less than* the force that block B exerts on block A.
(iii) The force that block A exerts on block B is *equal to* the force that block B exerts on block A.
(iv) We cannot compare the forces unless we know how fast the blocks are slowing down.

Explain your reasoning.

Answer iii. These two forces are a Newton's Third Law pair.

(b) For the situation where the blocks are moving at a constant speed, which of the following statements is true about the net force?

(i) The net force on block A points *to the right* and is *equal to* the net force on block B.
(ii) The net force on block A points *to the left* and is *equal to* the net force on block B.
(iii) The net force on block A points *to the right* and is *greater than* the net force on block B.
(iv) The net force on block A points *to the left* and is *greater than* the net force on block B.
(v) The net force on block A points *to the right* and is *less than* the net force on block B.
(vi) The net force on block A points *to the left* and is *less than* the net force on block B.
(vii) None of these are correct.

$\vec{a} = 0 \therefore \Sigma F = F_{net} = m \cdot \vec{a} = 0$

Explain your reasoning.

Answer vii. The blocks are moving at a constant speed and so the net force on each block must be zero.

(c) For the situation where the blocks are slowing down, which of the following statements is true about the magnitude of the forces?

(i) The force that block A exerts on block B is *greater than* the force that block B exerts on block A.
(ii) The force that block A exerts on block B is *less than* the force that block B exerts on block A.
(iii) The force that block A exerts on block B is *equal to* the force that block B exerts on block A.
(iv) We cannot compare the forces unless we know how fast the blocks are slowing down.

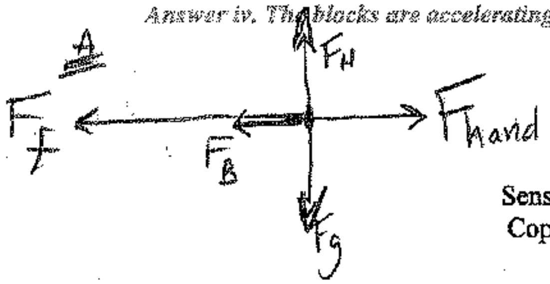
Explain your reasoning.

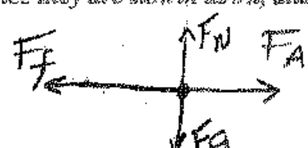
Answer iii. The force on B by A and the force on A by B form a Newton's Third Law pair, and are equal and opposite regardless of the state of motion of the blocks.

(d) For the situation where the blocks are slowing down, which of the following statements is true about the net force?

(i) The net force on block A points *to the right* and is *equal to* the net force on block B.
(ii) The net force on block A points *to the left* and is *equal to* the net force on block B.
(iii) The net force on block A points *to the right* and is *greater than* the net force on block B.
(iv) The net force on block A points *to the left* and is *greater than* the net force on block B.
(v) The net force on block A points *to the right* and is *less than* the net force on block B.
(vi) The net force on block A points *to the left* and is *less than* the net force on block B.
(vii) None of these are correct.

Answer iv. The blocks are accelerating to the left since they are slowin down, and A has the larger mass.

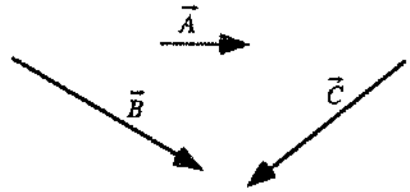




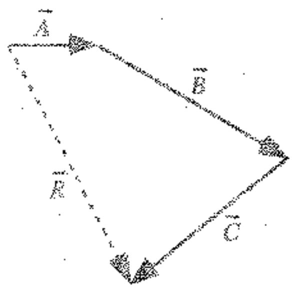
B3-QRT40: Three Vectors—Resultant

(a) In the space below, add the three vectors shown and label the resultant vector as $\vec{R}$. Be sure to clearly indicate the direction of the resultant.

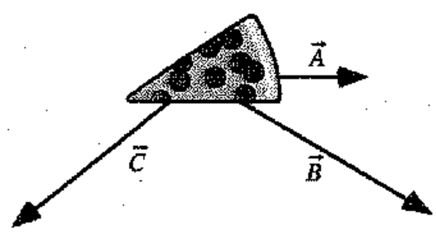
Explain your reasoning.



Answer:



Suppose the three vectors above represent forces exerted on a slice of pepperoni pizza by three people, Abel ($\vec{A}$), Beth ($\vec{B}$), and Celia ($\vec{C}$) as shown in the top view picture to the right. A fourth person, David, also pulls on the pizza. The pizza moves to the left at a constant speed. Assume there is no friction between the pizza slice and the greasy table.



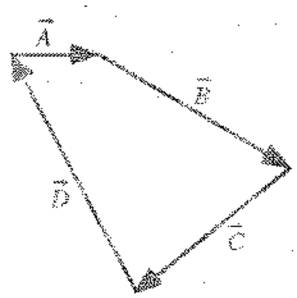
(b) In what direction is David pulling on the pizza?

Explain your reasoning.

Answer:

David must be exerting a force up and to the left, in the opposite direction to the resultant found in part A. Since the pizza slice is moving at a constant speed, the net force on it must be zero. So the vector representing the force that David exerts on the pizza slice must add to the other three to give a zero net force.

$$\sum \vec{F} = m \cdot \vec{a} = 0$$



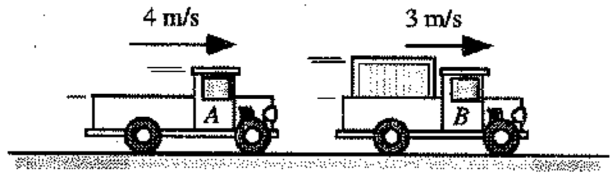
B3-CT53: Toy Truck Collisions—Force on Trucks

Two toy trucks traveling at different constant speeds are about to collide.

(a) The two identical trucks are traveling in the same direction, and truck B is carrying a heavy load.

During the collision, will the magnitude of the force exerted on truck A by truck B be (i) *greater than*, (ii) *less than*, or (iii) *equal to* the magnitude of the force exerted on truck B by truck A? ____ Equal

Explain your reasoning.

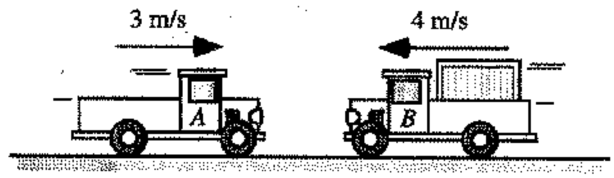


Answer: The forces will have the same magnitude due to Newton's Third Law.

(b) The two identical trucks are traveling in opposite directions, and truck B is carrying a heavy load.

During the collision, will the magnitude of the force exerted on truck *A* by truck B be (i) *greater than*, (ii) *less than*, or (iii) *equal to* the magnitude of the force exerted on truck B by truck A? ____ Equal

Explain your reasoning.

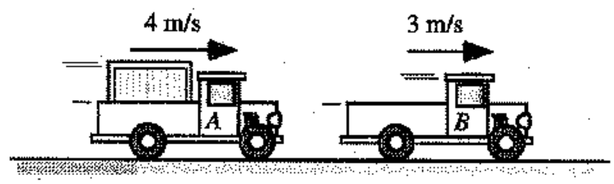


Answer: The forces will have the same magnitude due to Newton's Third Law.

(c) The two identical trucks are traveling in the same direction, and truck A is carrying a heavy load.

During the collision, will the magnitude of the force exerted on truck A by truck B be (i) *greater than*, (ii) *less than*, or (iii) *equal to* the magnitude of the force exerted on truck B by truck A? ____ Equal

Explain your reasoning.

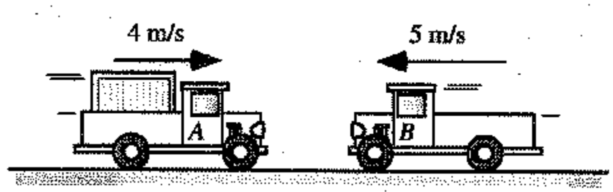


Answer: The forces will have the same magnitude due to Newton's Third Law.

(e) The two identical trucks are traveling in opposite directions, and truck A is carrying a heavy load.

During the collision, will the magnitude of the force exerted on truck A by truck B be (i) *greater than*, (ii) *less than*, or (iii) *equal to* the magnitude of the force exerted on truck B by truck A? ____ Equal

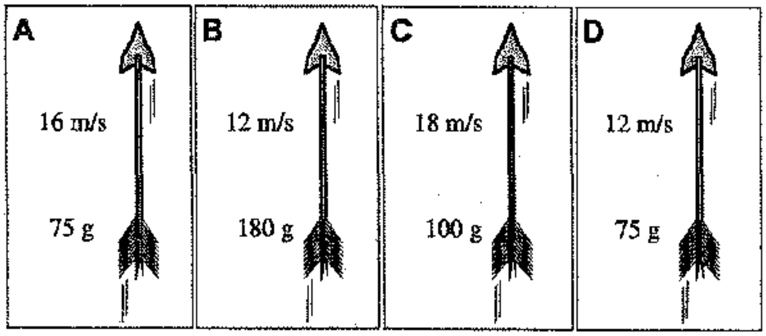
Explain your reasoning.



Answer: The forces will have the same magnitude due to Newton's Third Law.

B3-RT11: ARROWS—ACCELERATION

All of the arrows were shot straight up into the air from the same height, and all are the same size and shape. The arrows are made of different materials so they have different masses. The masses of the arrows and their speeds as they leave the bows are given.



Rank the magnitude of the acceleration of the arrows at the top of their flight.

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

Explain your reasoning.

Answer: All the same.
The only force acting on these arrows is the gravitational force the Earth exerts on them, so they all have the same acceleration of 9.8 m/s² throughout their motion.

$a_g = -9.8\ m/s^2$ for all