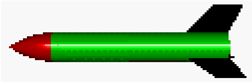
Physics 221, January 26

Key Concepts:

- Newton's 1st law
- Newton's 2nd law
- Weight
- Newton's 3rd law

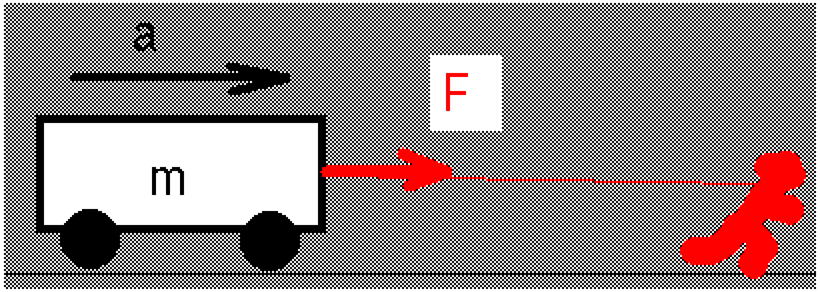
Please find a seat.

Keep all walkways free for safety reasons and to comply with the fire code.



Newton's first law, also called **the law of inertia**, defines a special class of reference frames, called **inertial frames**. It states that, when viewed in an inertial reference frame, an object at rest remains at rest, and an object in motion continues in motion with constant velocity, unless it is acted on by an **external net force**.

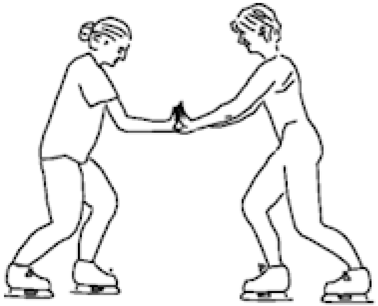
Note: Newton's second and third laws are valid in all inertial reference frames.



Newton's second law states that the acceleration of an object is directly proportional to the **net force** acting on it, and inversely proportional to its mass, $\mathbf{F}_{net} = m\mathbf{a}$.

Note: This is a vector equation.

$F_x = ma_x$, $F_y = ma_y$, $F_z = ma_z$.

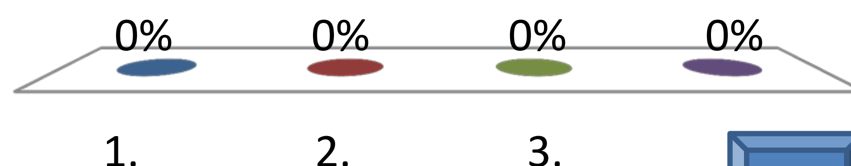


Newton's third law states that for every force that an object exerts on a second object, there is a force equal in magnitude but opposite in direction exerted by the second object on the first object.

Newton's third law is also called **the law of action and reaction**.

As I apply the brakes in my car, books on the passenger seat suddenly fly forward. That is most likely because

1. the decelerating car is not an inertial reference frame.
2. the seat supplies a forward push to make the books accelerate.
3. there is a strong gravitational field generated by the brakes.
4. there is a strong magnetic field generated by the brakes.



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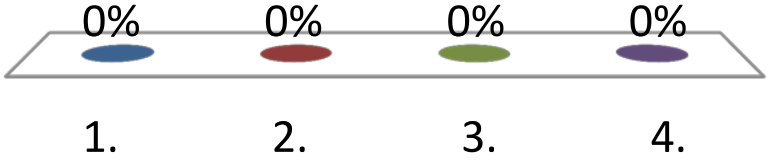
A 50 N force and a 100 N force both act on the same object. What is the net force (total force) acting on the object?

Hint: Force is a vector.

1. 50 N
2. 100 N
3. 150 N
4. Not enough information is given.



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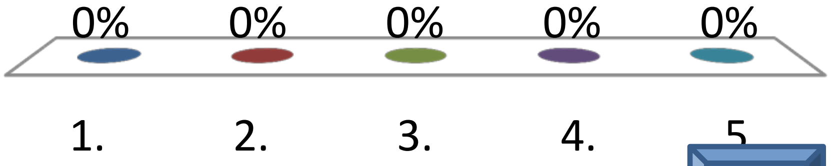
Two objects each accelerate at 2.0 m/s^2. The first object's mass is 10.0 kg and the second object's mass is 5.0 kg. What is the magnitude of the force on each object?

Hint: Use Newton's second law.

1. 20 N, 20 N
2. 10 N, 10 N
3. 10 N, 5 N
4. 2 N, 2 N
5. 20 N, 10 N



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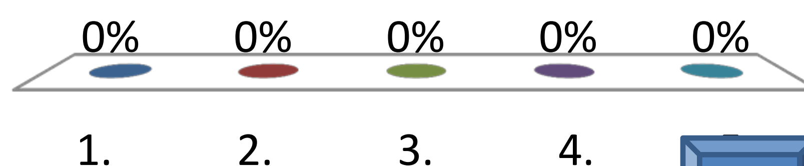
A car has a maximum acceleration of 6 m/s². What would be its maximum acceleration while towing a second car twice its mass?

Hint: $F_{max} = ma_{max}$
What is the total mass now?

1. 2.25 m/s²
2. 2 m/s²
3. 1.5 m/s²
4. 1 m/s²
5. 0.5 m/s²



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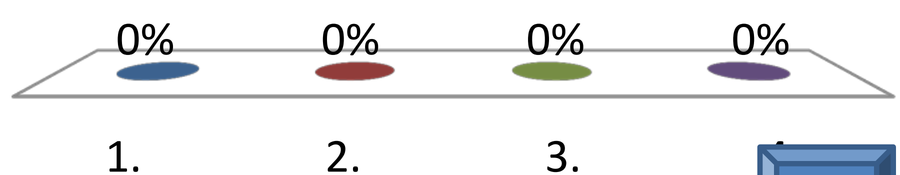
A force of 20 N in the positive x-direction accelerates an object with acceleration $a = 2\ m/s^2$. When the object is moving with velocity $v = 10\ m/s$, an additional force of 10 N in the negative x-direction is applied. Which statement is true?

Hint:
What is the net force now?

1. The object now accelerates with acceleration $a = -1\ m/s^2$ in the negative x-direction.
2. The object now accelerates with acceleration $a = 1\ m/s^2$ in the positive x-direction.
3. The object now moves with constant velocity.
4. The objects slows down and comes to a stop.



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Weight

The force of gravity , $\mathbf{F}_g$, acting on an object is called its weight.

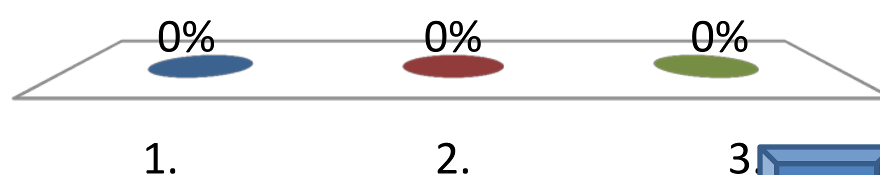
Near the surface of Earth $\mathbf{F}_g$ = m**g, pointing downward.**

g = 9.8m/s^2 pointing downward is the gravitational acceleration.

Spring scales measure the force they exert on a object.

A rock is thrown from the roof of a tall building. While it is falling towards the ground, the force of gravity acting on it is

1. less than its weight
2. more than its weight.
3. equal to its weight.



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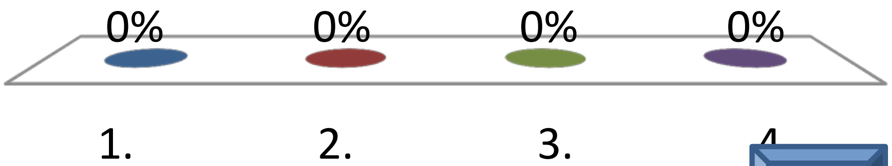
Suppose you are standing on a bathroom scale when you are flying in a jet airplane. For a moment the scale reads more than your actual weight. During that moment, the scale is exerting an upward force on you that is

1. greater than your weight.
2. equal than your weight.
3. less than your weight.
4. zero.



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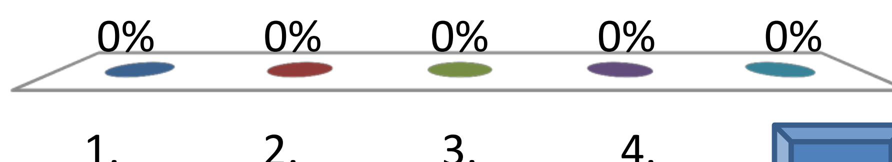
Suppose you are standing on a bathroom scale while riding in an elevator. For a moment the scale reads 160 lb = 712 N while your actual weight is 180 lb = 800 N. What is your (and the elevator's) acceleration? (Let $g = 10\ m/s^2$.)

1. $-1.1\ m/s^2$
2. $-1.39\ m/s^2$
3. $-10\ m/s^2$
4. $-7.1\ m/s^2$
5. $-88\ m/s^2$

Hint:
Let the upward direction be the positive direction.
What is your mass?
What is the net force $F_{floor} - mg$ acting on you?
What is your acceleration $a = F_{net}/m$?



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Solution:

Magnitude of your actual weight: 800 N
Your mass: 80 kg

Let the upward direction be the positive direction.

Net force acting on you: $F_{floor} - mg = 712\text{ N} - 800\text{ N} = -88\text{ N}$

$a = F_{net}/m = -88\text{ N}/80\text{ kg} = -1.1\text{ m/s}^2$

Remember!

constant velocity

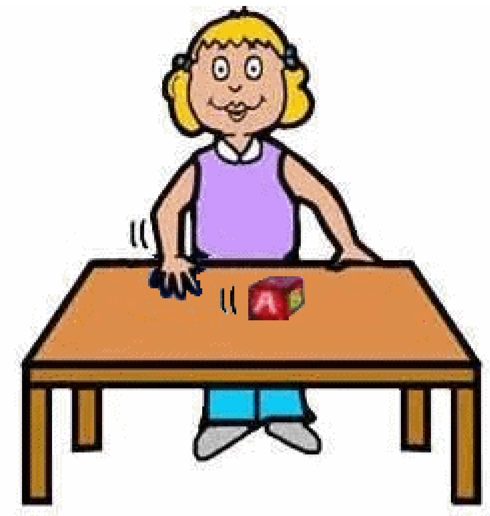
$\leftrightarrow$

no acceleration

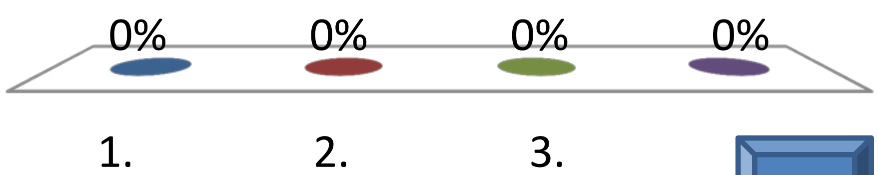
$\leftrightarrow$

no net force

A child playing with very smooth blocks on a very smooth, horizontal table pushes one of the blocks across the table. After the push, when the child's hand is no longer touching the block, the block continues to move with constant velocity because



1. the force of gravity pushes on the block.
2. the force of the child's push continuously acts on the block.
3. both the force of gravity and the force of the child's push continuously act on the block.
4. there is no net force acting on the block.



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Newton’s third law

Newton's third law is also called the **law of action and reaction**.

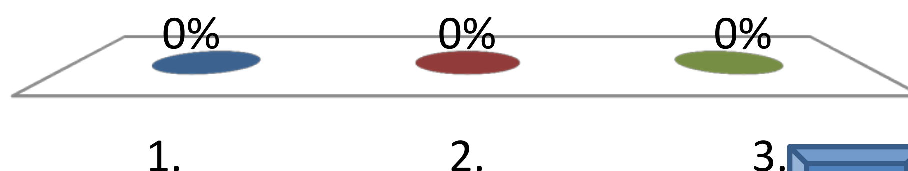
For every action force, there exists a reaction force, equal in magnitude and opposite in direction.

The action and reaction force always act on **different objects**. The objects interact.

A car traveling at 100 km/hr strikes an unfortunate bug and splatters it.

The magnitude of the force of impact is

1. greater on the bug.
2. greater on the car.
3. the same for both.



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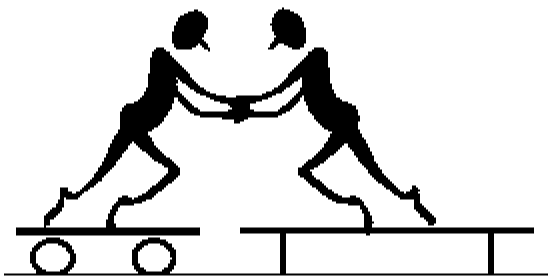
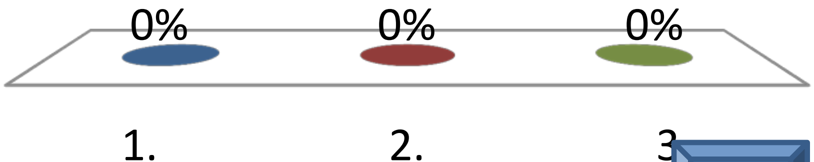
If you push on a friend and he is accelerating away from you, how will the force you exert on your friend compare to the force your friend exerts on you?



1. You push harder, since the friend is moving away from you.
2. Your friend pushes harder, he has to push himself off.
3. The forces are equal in magnitude.



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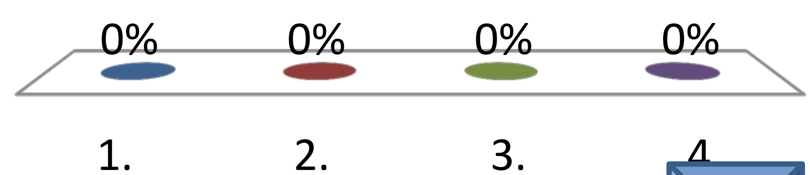
Consider a car at rest. We can conclude that the downward gravitational force Earth exerts on the car and the upward contact force the surface of Earth exerts on the car are equal in magnitude and opposite in direction because

1. the two forces form an action-reaction (interaction) pair.
2. the net force on the car is zero.
3. both of the above.
4. neither of the above.



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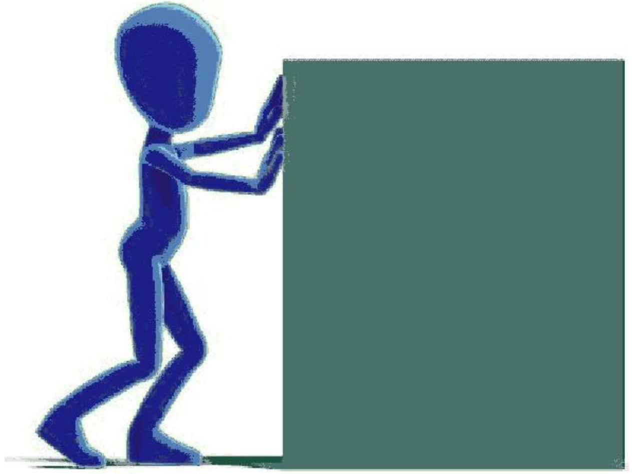
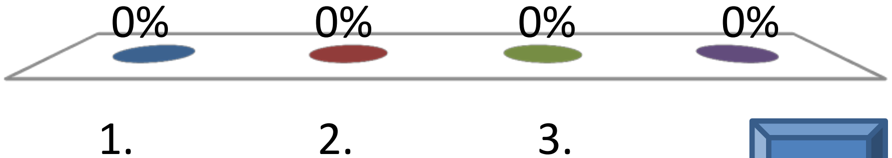
Your hands push on a heavy box to slide it across the floor.
The other force of the action/reaction pair is



1. friction pushing backward on the floor.
2. gravity pulling downward on the box.
3. the box pushing downward against the floor.
4. the box pushing backward against your hands.



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