Bite 6: Newton's Third Law

Newton's three laws of motion predict the motion of virtually all objects on Earth and in space. You are about to know all of them. **Newton's 1st law: an object at rest tends to stay at rest and an object in motion tends to stay in motion. Newton's 2nd Law: Force equals mass times acceleration. Now this lesson, Newton's 3rd Law: Every action has an equal and opposite reaction.** After this lesson, you guys will have the full set of Newton's Laws of Motion. Congratulations! Newton's Laws are all they used to launch space craft to the moon and soon you will understand them all. Pretty powerful stuff huh!?

Are you ready for **Newton's Third and final law of motion? Here it is, every action has an equal and opposite reaction.** Taaa Daaa! Even though this is the most well known of Newton's Three, it seems to me to be the hardest to fully comprehend. Again, it is a tribute to Newton that he was able to "see" this law. For every action, every force, the same action/force happens in the opposite direction. As you sit on your chair reading this, gravity is pulling down with a certain force (the force of your weight and the weigh of the chair). The floor is pushing up with the same force. Quick quiz – what would happen if the floor pushed up with more force then force of the chair pushing down? There would be an upward force which would cause an acceleration of the chair causing your mass to lift upwards! (That's Newton's Second Law, right?) Because the force up and the force down is equal, the net force is zero and there is no motion.

This law helps you walk. As you walk, you push backwards against the ground. The ground gives an equal and opposite push to you so you move forward. Try to imagine someone walking in a canoe. (I don't recommend trying this, unless you know how to swim and are willing to get wet!) As the person steps forward, the canoe moves backward. The equal and opposite force of the walking moves the person forward just as far as it moves the canoe backward.

"But Jim…how come as I walk on my floor, my house doesn't move backwards like the canoe?" Ahhh, good, I'm glad you're paying attention. Let's go back to Newton's Second Law again. Force equals mass times acceleration. What is the mass of you compared to your house? Pretty small right? So the force you create to move your mass forward, is nowhere near the force that is required to move the house backward (especially since your

house is anchored to the earth.) You do push backward on your house but due to the immense inertia of the house it doesn't move. Let's try the next few experiments and see if we can really get this concept.

Experiment 2
Rocket Bus

(A movie of this is available at www.handsonlinelearning.com/bitesmovies.htm.)

This experiment will pop a cork out of a wine bottle and make it go 20 to 30 feet, while the bus moves in the other direction! This is an outdoor experiment. **Be careful with this. The cork comes out with a good amount of force. Don't point it at anyone or anything. Don't point it at yourself.**

What you need:
Wine bottle
Cork (be careful that the corkscrew didn't go all the way through it)
Baking Soda
Vinegar
Paper towel
Fairly large Toy Car, Truck or Bus
Duct Tape
Flat Sidewalk or Driveway

1. Strap the wine bottle to the top of the toy bus with the duct tape. You want the opening of the bottle to be at the back of the bus.

2. Put about one inch of vinegar into the bottle.

3. Shove a wad of paper towel as far into the neck of the bottle as you can. Make sure the wad is not too tight. It needs to stick into the neck of the bottle but not too tightly.

4. Pour baking soda into the neck of the bottle. Fill the bottle from the wad of paper all the way to the top of the bottle.
5. Now put the cork into the bottle fairly tightly.

6. Now tap the whole contraption hard on the ground outside to force the wad of paper and the baking soda into the bottle.

7. Give the bottle a bit of a shake.

8. Set it down and watch. Do not stand behind the bus where the cork will shoot.

9. In 20 seconds or less, the cork should come popping off of the bottle.

What you should see is the cork firing off the bottle and going some 10 or 20 feet. The bus should also move forward a foot or two. This is Newton's Third law in action. One force fired the cork in one direction. Another force, equal and opposite, moved the bus in the other direction. Why did the bus not go as far as the cork? The main reason is the bus is far heavier then the cork. F=ma. The same force could accelerate the light cork a lot more than the heavier bus. Now try this:

Experiment 3
Do the Twist

You need:
A chair that can spin

1. Sit in the chair and put your arms out.

2. Lift your feet off the floor

3. Now twist your torso quickly in one direction.

4. Pretty simple huh?

As you moved your torso, the chair twisted in the opposite direction of your moving arms. Why did the chair move in one direction while your arms moved in the other direction? If you said, "because Newton said so." you're right! Every action has an equal and opposite reaction. The action of your body moving one way has an opposite action of the chair moving the other way.

Experiment 4
Backwards Ho

(A movie of this is available at www.handsonlinelearning.com/bitesmovies.htm.)

You need:

A skateboard or a wagon
The heaviest thing you can throw safely
Sidewalk or Driveway

1. **Sit in the wagon or on the skateboard (please do not stand up).**

2. **Throw the heavy thing as hard as you can. Please be careful not to hit anybody or anything.**

If this doesn't work don't worry about it. You need a fairly low friction skateboard or wagon to make this work. At this point, you should know what should happen, so what do you think? If you said that the throw forward would move you backward, you're right!

Experiment 5
Balloon Races

(A movie of this is available at www.handsonlinelearning.com/bitesmovies.htm.)

You need:

Balloon (the fat, long ones work well)
String
Straws
Chair

1. Blow up the balloon (don't tie it)

2. Let it go.

3. Wheeeee!

4. Tie one end of the string to a chair.

5. Blow up the balloon (don't tie it).

6. Tape a straw to it so that one end of the straw is at the front of the balloon and the other is at the nozzle of the balloon.

7. Thread the other end of the string through the straw and pull the string tight.

8. Let go. With a little bit of work (unless you got it the first time) you should be able to get the balloon to shoot about ten feet along the string.

Obviously this is a great demonstration of Newton's Third Law. It's also a good opportunity to bring up some science history. Many folks used to believe that it would be impossible for something to go to the moon because once something got into space there would be no air for the rocket engine to push against and so the rocket could not "push" itself forward. In other

words, those folks would have said that your balloon shoots along the string because the air coming out of the balloon pushes against the air in the room. The balloon gets pushed forward. You now know that that's hooey! What makes the balloon move forward is the mere action of the air moving backward. Every action has an equal and opposite reaction.

You now have a great grasp of Newton's three laws and with it you understand a good deal about the way matter moves about on Earth and in space. Take a look around. Everything that moves or is moved follows Newton's Laws.

Next lesson we will get into Newton's Third Law a little deeper when we discuss momentum and conservation of momentum.

In a Nutshell

Newton's Third Law states that every action has an equal and opposite reaction. (That's about it for this lesson. It's a one bite wonder!)

Did You Get it?

1. What's Newton's First Law?

2. What's Newton's Second Law?

3. What's Newton's Third Law?

4. What is force?

5. You are floating in space and your Super 3000 Space Jets short out on you. You are holding a wrench. How do you get back to the space ship?

6. I'm hammering a nail into a hard piece of wood. I'm using one of my son's light hammers and getting nowhere fast. Finally, I grab a hammer with a heavier head and it goes much easier. Which one of Newton's Laws did I finally remember?

7. David Letterman, a long time ago, had a race down a hallway with a fire extinguisher and a rolling office chair. As he shot the fire extinguisher one way, the chair zipped down the hallway. (Don't try this at home!!) Which of Newton's Laws was Dave delicately demonstrating?

8. I'm riding on my bike and I accidentally hit the front brakes instead of the back brakes. The bike stops and flips me right over the handle bars. As I'm falling, I realize that I am quite a comical example of which of Newton's Laws?

9. What two things on Earth cause Newton's First Law to appear to not be true?

10. What is acceleration?

Answers

Answers to Did You Get It

1. An object at rest tends to stay at rest, an object in motion tends to stay in motion.

2. F=ma or Force equals mass times acceleration.

3. Every action has an equal and opposite reaction.

4. Force is a push or a pull.

5. You can throw the wrench so that it goes in the opposite direction of the ship. The force of the throw will have an opposite force on you and you will zip to the ship. See how handy physics is?!

6. Newton's Second. The heavier head of the hammer has a larger mass. The larger mass with the same acceleration will hit with a greater force on the nail then the lighter hammer will. F=ma

7. Newton's Third Law. Every action has an equal and opposite reaction. The action of the fire extinguisher firing will have an equal and opposite reaction which zips Dave backwards down the hall.

8. Newton's First Law. An object in motion tends to stay in motion. An object at rest tends to stay at rest. Since I was moving, I continued moving even though the bike stopped. Luckily, my face broke my fall! (Helmets are a good idea!)

9. Gravity and Friction are two ever present forces on this planet that cause things to stop moving. If these forces did not exist, there would be nothing to stop objects from moving all over the place.

10. Acceleration is a change in velocity or in other words a change in speed or direction.