Name:_____

Group:_____

Newton's 3rd Law

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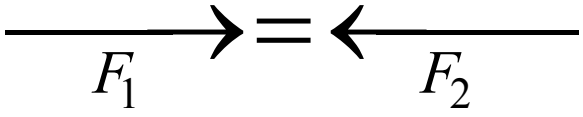
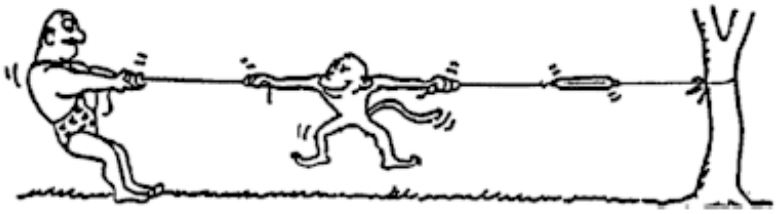
According to Newton, whenever objects A and B interact with each other, they exert forces upon each other. When you sit in your chair, your body exerts a downward force on the chair and the chair exerts an upward force on your body. There are two forces resulting from this interaction - a force on the chair and a force on your body. These two forces are called *action* and *reaction* forces and are the subject of Newton's third law of motion. Formally stated, Newton's third law is:

For every action, there is an equal and opposite reaction.



The statement means that in every interaction, there is a pair of forces acting on the two interacting objects. The size of the forces on the first object equals the size of the force on the second object. The direction of the force on the first object is opposite to the direction of the force on the second object. Forces always come in pairs - equal and opposite action-reaction force pairs.

Label at least 6 different Action-Reaction pairs in the diagram below.



When a rifle is fired, how does the size of the force of the rifle on the bullet compare to the force of the bullet on the rifle?

How do the accelerations of the rifle and bullet compare? Why?

Student Exploration: Free Fall Tower

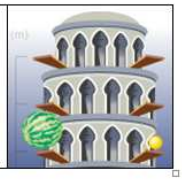
How to find the Simulator

1. Go to link http://www.explorelearning.com
2. At top right corner, click *Enroll In Class*
3. Enter in Class Code **XMNW2FMWPK**
4. Click *Login Now to Enroll*
5. Username: **columbia2013** Password: **columbia**
6. Click on the Gizmo Pictures and Follow Directions Below

Gizmo Warm-up

In the *Free Fall Tower* Gizmo™, drag a pair of objects (no parachutes) to the top of the tower, one to each platform. Check that **Air** is selected.

Click **Play** ( ). The objects are now in **free fall**, pulled to Earth by the force of **gravity**.

Activity A: **Free fall in a vacuum**	Get the Gizmo ready: • Click **Reset**. • Under **Choose atmosphere**, select **Vacuum (no air)**.	

Question: A vacuum is a region with no air or any other matter. How do different objects fall through a vacuum?

1. Form hypothesis: How do you think objects will fall when there is no air? _____
2. Experiment: Drop the different objects from the top of the tower. What do you notice? _____
3. Observe: Click **Reset**. Drop the watermelon and the ping pong ball from the top of the tower. Watch the speedometers. They show each object's speed in meters per second (m/s).
   A. What do you notice? _____
   B. What is the final speed of each object? _____

C. An object is **accelerating** if its speed is changing. What can you say about the acceleration of objects falling in a vacuum? _____

4. Interpret: Select the **Graph** tab. The graph shows the speeds of the objects over time.
   A. What do the lines on the graph look like? _____
   B. What does that tell you? _____

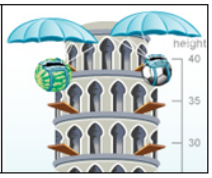
Activity B: **Air Resistance**	Get the Gizmo ready: • Select the **Experiment** tab. • Click **Reset**. • Under **Choose atmosphere**, select **Air**.	

Question: How does air affect falling objects?

1. Observe: In **Air**, drop the objects from different levels of the tower. Look carefully at the speedometers as the objects drop. What do you notice? _____
2. Form hypothesis: When objects fall through the air, they are pushed by a force called **air resistance**. How do you think air resistance affects falling objects? _____
3. Experiment: Each platform on the tower is 5 meters higher than the one below it. Drop the ping pong ball from the lowest (5 meter) platform, then the next platform (10 m) and so on. For each height, record the final speed of the ping pong ball in meters per second (m/s).

Height	5 m	10 m	15 m	20 m	25 m	30 m	35 m	40 m
Speed								

4. Analyze: As an object falls through air, the object does not get steadily faster but approaches **Terminal Velocity**.
   A. What is the terminal velocity of the ping pong ball? _____
   B. Select the **Graph** tab. How does the graph show terminal velocity? _____
5. Compare: Drop the soccer ball and the golf ball from the top of the tower. Which ball was slowed down more by air resistance? _____
6. Extend your thinking: A soccer ball is heavier than a golf ball. Why do you think the soccer ball fell more *slowly* than the golf ball? _____

Activity C: **Parachutes**	Get the Gizmo ready: • Select the **Experiment** tab. • Click **Reset**. • Check that **Air** is still selected.	

Question: How does a parachute affect a falling object?

1. Observe: Drag objects with parachutes to the tower. (Parachutes look like little backpacks.) As the objects drop, click **Open parachute(s)**. Compare how parachutes affect each object.
2. Form hypothesis: How will a parachute change the air resistance and terminal velocity of an object?

   _____
3. Collect data: Find the terminal velocity of each object when the parachute is open.

   Ping pong ball with parachute: _____ Soccer ball with parachute: _____

   Golf ball with parachute: _____ Watermelon with parachute: _____
4. Analyze: The watermelon is heaviest, followed by the soccer ball, golf ball and ping pong ball. How does the weight of an object relate to how fast it falls with a parachute?

   _____
5. Interpret: Select the **Graph** tab. How does the graph show when the parachute is opened?

   _____
6. Predict: Will a parachute work in a vacuum? _____ Why or why not? _____

   _____
7. Test: Use the Gizmo to test your prediction. Did the parachute work? _____
8. Summarize: What controls how fast an object falls? _____