Newton's Third Law (Force Pairs)

Sir Isaac Newton
(1642-1727)

Draw a picture and write about it.

Introduction: A force is a push or a pull resulting from an interaction between two objects, these forces always come in pairs. Whenever there is a force, there are two objects involved with both objects pushing/pulling on each other in opposite directions. While the direction of the push/pull are opposite the strength, or magnitude, is equal. For every action force there is a reaction force equal in magnitude and opposite in direction.

For Example:

A variety of action-reaction force pairs are evident in nature. Consider the propulsion of a fish through the water. A fish uses its fins to push water backwards. But a push on the water will only serve to accelerate the water. Since forces result from mutual interactions, the water must also be pushing the fish forwards, propelling the fish through the water. The size of the force on the water equals the size of the force on the fish; the direction of the force on the water (backwards) is opposite the direction of the force on the fish (forwards). For every action, there is an equal (in size) and opposite (in direction) reaction force. Action-reaction force pairs make it possible for fish to swim.

Consider the flying motion of birds. A bird flies by use of its wings. The wings of a bird push air downwards. Since forces result from mutual interactions, the air must also be pushing the bird upwards. The size of the force on the air equals the size of the force on the bird; the direction of the force on the air (downwards) is opposite the direction of the force on the bird (upwards). For every action, there is an equal (in size) and opposite (in direction) reaction. Action-reaction force pairs make it possible for birds to fly.

Consider the motion of a car on the way to school. A car is equipped with wheels that spin. As the wheels spin, they grip the road and push the road backwards. Since forces result from mutual interactions, the road must also be pushing the wheels forward. The size of the force on the road equals the size of the force on the wheels (or car); the direction of the force on the road (backwards) is opposite the direction of the force on the wheels (forwards). For every action, there is an equal (in size) and opposite (in direction) reaction. Action-reaction force pairs make it possible for cars to move along a roadway surface.

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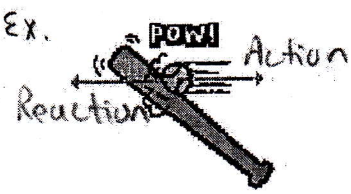
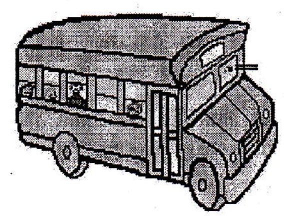
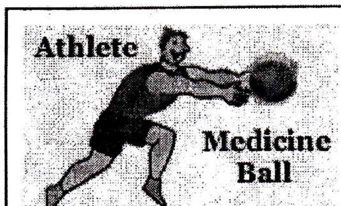
1. For each stated *action force,* identify the *reaction force.*





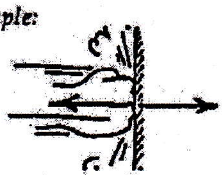
Bat hits ball.	Man pushes car.	Bus hits bug.
Ball hits bat	______	______

2. Identify by words the action-reaction force pairs in each of the following diagrams.

3 In the example below, the action-reaction pair is shown by the arrows (vectors), and the action-reaction described in words. In (*a*) through (*g*) draw the other arrow (vector) and state the reaction to the given action. Then make up your own example in (*h*).

Example:

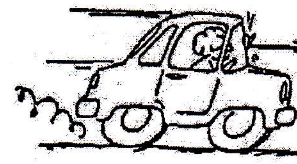


Fist hits wall.

Wall hits fist.

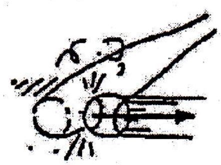
Head bumps ball.

(*a*) ______________________



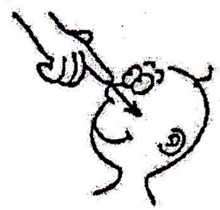
Windshield hits bug.

(*b*) ______________________



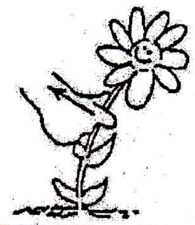
Bat hits ball.

(*c*) ______________________



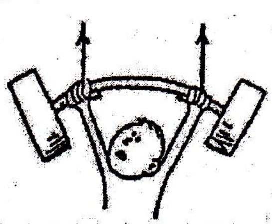
Hand touches nose.

(*d*) ______________________



Hand pulls on flower.

(*e*) ______________________



Athlete pushes bar upward.

(*f*) ______________________

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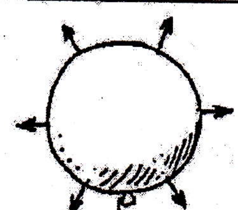

Compressed air pushes balloon surface outward.

(*g*) ______________________

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(*h*) ______________________

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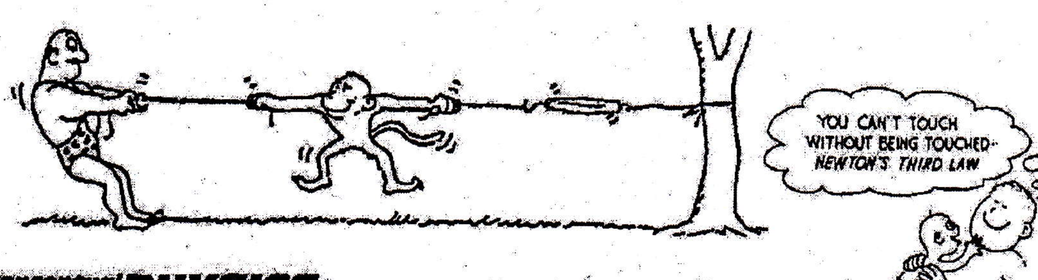
4 Draw arrows to show the chain of at least six pairs of action-reaction forces below.



5 Use Newton's Third Law and Newton's Second Law (F=MA) to complete the following statements by filling in the blanks.

a. A bullet is loaded in a rifle and the fired. The force experienced by the bullet is ____________ (less than, equal to, or greater than) the force experienced by the rifle. The resulting acceleration of the bullet is ____________ (less than, equal to, or greater than) the resulting acceleration of the rifle.

b. A bug crashes into a high speed bus. The force experienced by the bug is ____________ (less than, equal to, or greater than) the force experienced by the bus. The resulting acceleration of the bug is ____________ (less than, equal to, or greater than) the resulting acceleration of the bus.

c. A massive linebacker collides with a smaller halfback at midfield. The force experienced by the linebacker is ____________ (less than, equal to, or greater than) the force experienced by the halfback. The resulting acceleration of the linebacker is ____________ (less than, equal to, or greater than) the resulting acceleration of the halfback.

d. The 10-ball collides with the 14-ball on a billiards table (assume equal mass). The force experienced by the 10-ball is ____________ (less than, equal to, or greater than) the force experienced by the 14-ball. The resulting acceleration of the 10-ball is ____________ (less than, equal to, or greater than) the resulting acceleration of the 14-ball.

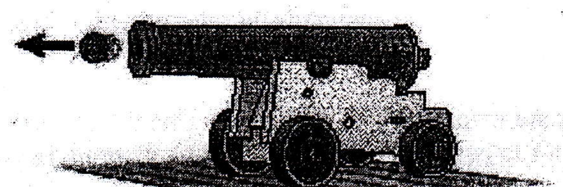


Figure A

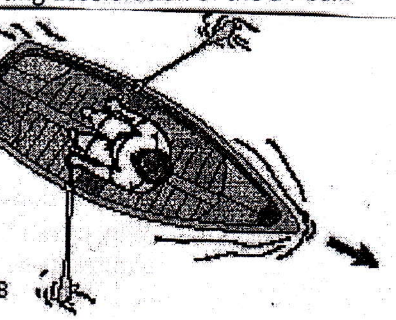


Figure B

6 Draw an arrow on Figure A to show the direction the cannon will move when the cannonball is fired.

7 Draw arrows on Figure B to show the direction the oars must move to propel the boat forward.

8 Does the arrow you drew on Figure A represent an action force or a reaction force?

9 Do the arrows you drew on Figure B represent an action force or a reaction force?

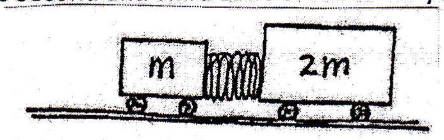
10 If the force that propels the cannonball forward is 500 N, how much force will move the cannon backwards? Explain.

11 A diver dives off of a raft floating on a lake. Draw and Label a diagram of this event. Explain what is happening using Newton's Third Law of Motion.

12 If two people (of equal mass) standing on skateboards push off one-another what happens in terms of their motion? Draw and Label a diagram of this event. Explain what is happening using Newton's third law of motion.

a) How would the distance traveled by the people on skateboards compare if one person had twice as much mass?

13 Suppose two carts, one twice as massive as the other, fly apart when the compressed spring that joins them is released. How fast does the heavier cart roll compared to the lighter car? Use Newton's Second and Third Laws of Motion in your explanation.



Newton's Third Law: Action-Reaction Force Pairs

Procedure:

- Attach one end of the fishing line to the white-board with tape. Hold the other end of the fishing line horizontal.
- Blow up a balloon and hold the end shut (do not tie a knot). Tape a straw to the balloon. Thread the fishing line through the straw and hold the balloon at the start of the fishing line (opposite the white-board).
- Assign one group member to time the event. Start timing when the balloon is released. Stop timing when the balloon hits the white board. Record the distance traveled and the flight time in the data table AND calculate the average speed (m/sec) then acceleration (m/sec^2)
- Repeat the procedure three times and calculate averages for speed and acceleration for all three trials.
- Use the average acceleration you calculated and the mass of your balloon to calculate the force applied causing the observed acceleration using **Newton's Second Law: Force = Mass × Acceleration**

Data Table:

	Distance (M)	Time (Sec)	Speed (m/sec)	Acceleration (m/sec^2)
Trial 1				
Trial 2				
Trial 3				
Average				
Mass of Balloon =	Acceleration of Balloon =		Force acting on balloon =	

Questions: (answer these on the back-side of this paper)

1. What made your rocket move?
2. How is Newton's Third Law of Motion demonstrated by this activity?
   a. What is accelerating?
   b. What is providing the force?
3. Draw and Label a diagram to show the action and reaction forces acting on the balloon as it flies.