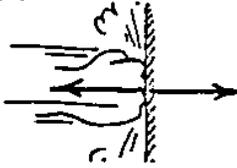


Unit IV Worksheet 5: Newton's Third Law

1. 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:



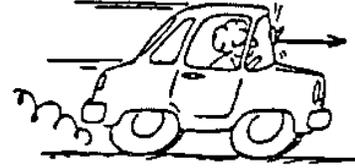
Fist hits wall.

Wall hits fist.



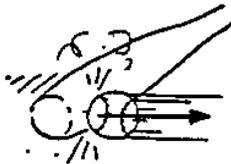
Head bumps ball.

(a) _____



Windshield hits bug.

(b) _____



Bat hits ball.

(c) _____



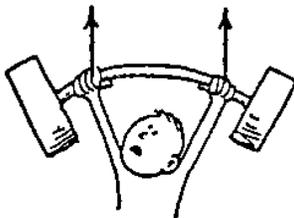
Hand touches nose.

(d) _____



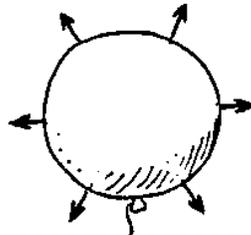
Hand pulls on flower.

(e) _____



Athlete pushes bar upward.

(f) _____

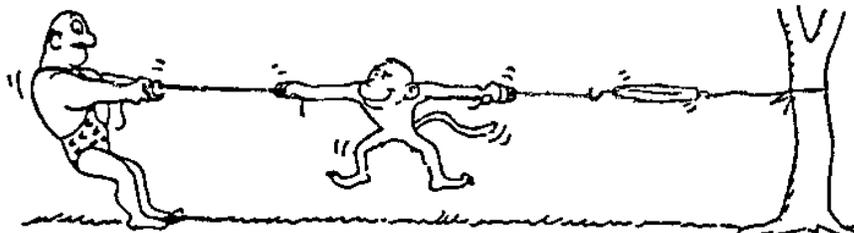


Compressed air pushes balloon surface outward.

(g) _____

(h) _____

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

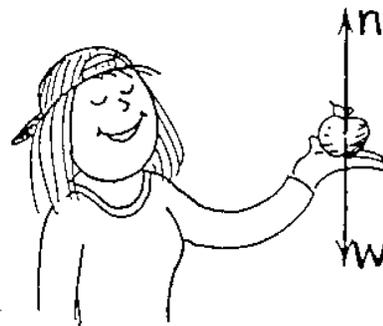


YOU CAN'T TOUCH
 WITHOUT BEING TOUCHED...
 NEWTON'S THIRD LAW



Newton's Third Law

3. Nellie Newton holds an apple weighing 1 newton at rest on the palm of her hand. The force vectors shown are the forces that act on the apple.



- To say the weight of the apple is 1 N is to say that a downward gravitational force of 1 N is exerted on the apple by (the earth) (her hand).
- Nellie's hand supports the apple with normal force n , which acts in a direction opposite to W . We can say n (equals W) (has the same magnitude as W).
- Since the apple is at rest, the net force on the apple is (zero) (nonzero).
- Since n is equal and opposite to W , we (can) (cannot) say that n and W comprise an action-reaction pair. The reason is because action and reaction always (act on the same object) (act on different objects), and here we see n and W (both acting on the apple) (acting on different objects).
- In accord with the rule, "If ACTION is A acting on B, then REACTION is B acting on A," if we say *action* is the earth pulling down on the apple, *reaction* is (the apple pulling up on the earth) (n , Nellie's hand pushing up on the apple).
- To repeat for emphasis, we see that n and W are equal and opposite to each other (and comprise an action-reaction pair) (but do *not* comprise an action-reaction pair).

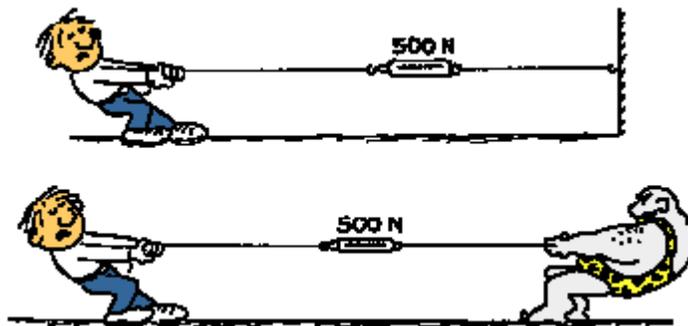
To identify a pair of action-reaction forces in any situation, first identify the pair of interacting objects involved. Something is interacting with something else. In this case the whole earth is interacting (gravitationally) with the apple. So the earth pulls downward on the apple (call it action), while the apple pulls upward on the earth (reaction).

Simply put, earth pulls on apple (action); apple pulls on earth (reaction).

Better put, apple and earth pull on each other with equal and opposite forces that comprise a single interaction.

- Another pair of forces is n [shown] and the downward force of the apple against Nellie's hand [not shown]. This force pair (is) (isn't) an action-reaction pair.
- Suppose Nellie now pushes upward on the apple with a force of 2 N. The apple (is still in equilibrium) (accelerates upward) and compared to W , the magnitude of n is (the same) (twice) (not the same, and not twice).
- Once the apple leaves Nellie's hand, n is (zero) (still twice the magnitude of W), and the net force on the apple is (zero) (only W) (still $W - n$, which is a negative force).

4. While driving, Anna Litical observed a bug striking the windshield of her car. Consider one force to be the bug hitting the windshield.
- What is the Newton's Third Law pair to this force?
 - Which of the two forces is greater?
5. Rockets are unable to accelerate in space because
- there is no air in space for the rockets to push off of.
 - there is no gravity in space.
 - there is no air resistance in space.
 - nonsense! Rockets do accelerate in space.
6. A gun recoils when it is fired. As the gases from the gunpowder explosion expand, the gun pushes the bullet forwards and the bullet pushes the gun backwards. How do these two forces compare? The acceleration of the recoiling gun is
- The force of the gun on the bullet is larger.
 - The force of the bullet on the gun is larger.
 - The forces are the same.
- greater than the acceleration of the bullet.
 - smaller than the acceleration of the bullet.
 - the same size as the acceleration of the bullet.
- How do you know?
7. In the top picture, a physics student is pulling upon a rope which is attached to a wall. In the bottom picture, the physics student is pulling upon a rope which is held by the Strongman. In each case, the force scale reads 500 Newtons. The physics student is pulling



- with more force when the rope is attached to the wall.
- with more force when the rope is attached to the Strongman.
- the same force in each case.

8. A high school student hits a nail with a hammer. During the collision, there is a force
- on the hammer but not on the nail.
 - on the nail but not on the hammer.
 - on the nail and also on the hammer.
9. A woman weighing 500 N sits on the floor.
- | | |
|------------------------------------|------------------------------------|
| She exerts a force on the floor of | The floor exerts a force on her of |
| a. 5 N . | a. 5 N . |
| b. 50 N . | b. 50 N . |
| c. 250 N . | c. 250 N . |
| d. 500 N . | d. 500 N . |
| e. 1000 N . | e. 1000 N . |
10. A person is attracted towards the center of the earth by an 800 N gravitational force. The force with which the earth is attracted toward the person is
- very very small.
 - very very large.
 - 800 N .
11. An unfortunate bug splatters against your face as you run the 100 meter dash. Compared to the force of your face on the bug, the force of the bug on your face is
- larger.
 - smaller.
 - the same.
 - Need more information to say
12. An unfortunate bug splatters against your face as you run the 100 meter dash. Compared to the deceleration of your face, the deceleration of the bug is
- larger.
 - smaller.
 - the same.
- How do you know?
13. A Mack truck and a Volkswagen Bug traveling at the same speed have a head-on collision. The vehicle to undergo the greater change in velocity will be the
- Volkswagen.
 - Mack truck.
 - Both the same
14. Two people pull on a rope in a tug-of-war. Each pulls with 400 N of force. What is the tension in the rope?
- Zero
 - 400 N
 - 600 N
 - 800 N



15. A bottle sits on the ground as in the diagram above. Draw a separate force diagram for the bottle and for the Earth on the diagram to the right. Remember, the length of a force arrow represents the magnitude of the force. Use the following interaction notation.

\vec{F}_{gEb} = Force of gravity of the Earth pulling down on the bottle

\vec{F}_{gbE} = Force of gravity of the bottle pulling up on the Earth

\vec{F}_{NEb} = Normal force of the Earth's surface supporting the bottle

$\vec{F}_{N bE}$ = Force of the bottle pushing down on the Earth's surface



Earth

- a. Compare the magnitude and direction of \vec{F}_{gEb} with the magnitude and direction of \vec{F}_{gbE} . How do you know?
- b. Compare the magnitude and direction of \vec{F}_{NEb} with the magnitude and direction of $\vec{F}_{N bE}$. How do you know?
- c. Compare the magnitude of F_{gEb} with the magnitude of F_{NEb} . How do you know?
- d. Compare the magnitude of F_{gbE} with the magnitude of $F_{N bE}$. How do you know?

16. A 70 kg Mother and her 35 kg son are standing at rest on an ice rink, as shown above. They push against each other, causing them to glide apart. Assume friction is negligible. Draw a separate force diagram for the woman and for her son as they push each other apart. Remember, the length of a force arrow represents the magnitude of the force. Use the following interaction notation.



\vec{F}_{MS} = Force of the Mother pushing on her son
 \vec{F}_{SM} = Force of the son pushing on his Mother.



- a. Compare the magnitude and direction of \vec{F}_{MS} with the magnitude and direction of \vec{F}_{SM} . How do you know?
- b. Given your answer to (a), who is moving faster after they separate? How do you know?

- c. Compare the magnitude of the force of gravity acting on the Mother (\vec{F}_{gM}) and the magnitude of the force of gravity acting on the son (\vec{F}_{gS}). How do you know?