Physics 2204
Unit 2: Dynamics
Worksheet 7: Newton's Third Law

Student Name:_____

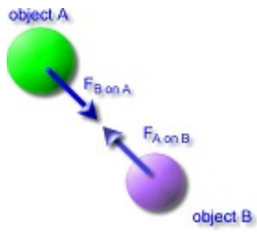
Newton's Third Law

A force is a push or a pull upon an object. This implies there must be two objects; one being pushed and one doing the pushing. Thus, forces result from interactions between objects. According to Newton's Third Law, whenever objects interact with each other they exert forces upon each other. These two forces the objects exert on each other are called action and reaction forces. Friction is one type of reaction force.

Newton's third law states:

If Object A exerts a force on Object B then Object B exerts an equal but opposite force on Object A

$$F_{A \text{ on } B} = -F_{B \text{ on } A}$$



There are two important things to point out:

(1) the minus sign indicates that the directions are opposite.
(2) there are two objects and the so-called "action" and "reaction" forces act on different objects (namely each other).

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 .

Newton's Third Law Implies:

- No Force exists in nature without its EQUAL and OPPOSITE reaction force.
- Forces exist in pairs.
- Action and Reaction Forces act on DIFFERENT bodies.
- Need to objects in the system

Examples of Newton's Third Law:

Bird Flying: . A bird flies by use of its wings. The wings of a bird push air downwards. In turn, the air reacts by pushing the bird upwards

Walking on a flat surface: Your leg and foot push backwards on the floor (the action force) and the floor pushes forward on you with an equal and opposite force.

Swimming: As you swim you move your arm backwards, pushing on the water. The water reacts in the opposite direction to your push and drives you in a forward direction.

Air being released from a balloon. The stretched elastic of the balloon squeezes the air within the balloon and it is forced out the rear of the balloon. As a reaction force, the air forces the balloon forward.

Rocket Launch: As the shuttle's booster rockets ignite, burning exhaust gasses are forced downward with tremendous force – This is the action force. The reaction force is the gases pushing back up against the boosters.

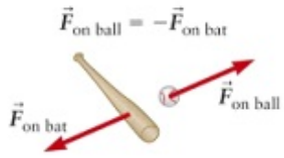
Skate Boarding: Action force is the backward force the person exerts on the ground. The reaction force is the forward force that the ground exerts on the person

Man stepping out of the Boat. as your legs propel your body towards the dock, they also apply to the boat an equal force in the opposite direction, which pushes it away from the dock.

Firing a gun: when you fire a gun and the bullet comes hurtling out of the front, an equal and opposite reaction means the gun recoils into your shoulder

Example 1:

Use Newton's Third Law to explain a bat hitting the ball

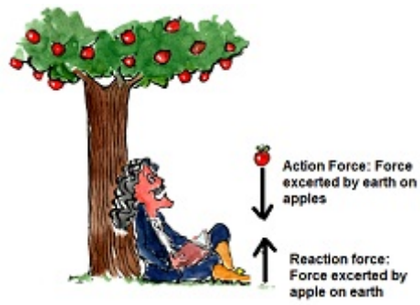


Example 2:

Use Newton's Third Law to explain a 50 N object sitting on a table

Example 3:

A) Use Newton's Third law to explain an apples falling to earth



B) Why doesn't the earth accelerate towards the apple?

Example 4:

While driving down the road, an unfortunate bug strikes the windshield of a bus. Quite obviously, this is a case of Newton's third law of motion. The bug hit the bus and the windshield hit the bus. Which of the two forces is greater: the force on the bug or the force on the bus?

Example 5:

Identify the action –reactions pairs for the picture below:

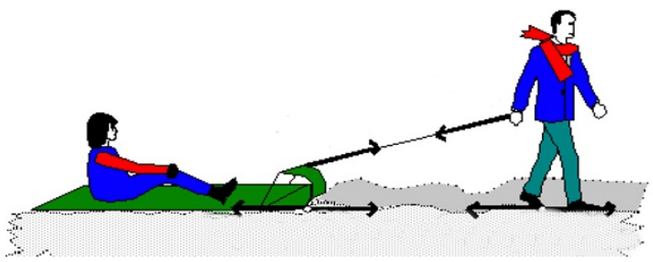
Example 6:

Identify the action –reactions pairs for the picture below:

Mary and Jane both want to dance with John. Mary pulls on one of his arms with a force of 50N,and Jane pulls on the other arm in the opposite direction with a force of -50 N. “

Example 7:

A) Apply Newton's 3rd Law of Motion to the situation where a father drags his daughter on a toboggan. Draw and label all horizontal action-reaction pairs.

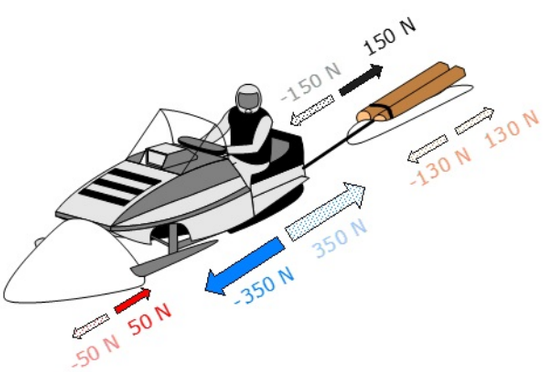


B) All action reaction forces are balanced. Therefore they cancel out and it is impossible for the man and toboggan to move forward.” Is this argument correct?

Example 8:

A) How many action –reaction forces are shown below?

B) Draw a FBD for the ski –doo?



C) What is the net force acting on the ski doo?

PART A: MULTIPLE CHOICE

Instructions: Shade the letter of the correct answer on the computer scorable answer sheet provided

1. Forces always occur

   (A) As a single quantity
   (B) By themselves
   (C) In pairs
   (D) In triplets

2. A 500 N woman sits on the floor. She exerts a force on the floor of

   (A) 1000 N
   (B) 500 N
   (C) 250 N
   (D) 50 N

3. A 500 N woman sits on the floor, the floor exerts a force on her of

   (A) 1000 N
   (B) 500 N
   (C) 250 N
   (D) 50 N

4. If you blow up a balloon, and then release it, the balloon will fly away. This is an illustration of

   (A) Newton's first law
   (B) Newton's second law
   (C) Newton's third law
   (D) Newton's law of gravitation

5. Two cars collide head-on. At every moment during the collision, the magnitude of the force the first car exerts on the second is exactly equal to the magnitude of the force the second car exerts on the first. This is an example of

   (A) Newton's first law
   (B) Newton's second law
   (C) Newton's third law
   (D) Newton's law of gravitation

6. If you exert a force F on an object, the force which the object exerts on you will

   (A) Depend on whether or not the object is moving.
   (B) Depend on whether or not you are moving.
   (C) Depend on the relative masses of you and the object.
   (D) Always be F.

7. Action-reaction forces

   (A) Sometimes act on the same object.
   (B) Always act on the same object.
   (C) May be at right angles.
   (D) Always act on different objects.

8. Action-reaction forces are

(A) Equal magnitude and point in the same direction.
(B) Equal magnitude but point in opposite directions.
(C) Unequal magnitude, point in the same direction.
(D) Unequal magnitude, point in opposite directions

9. An object of mass **m** sits on a flat table. The Earth pulls on this object with force **mg**, which we will call the action force. What is the reaction force?

(A) The table pushing up on the object with force **mg**.
(B) The object pushing down on the table with force **mg**.
(C) The table pushing down on the floor with force **mg**.
(D) The object pulling upward on the Earth with force **mg**.

10. A child's toy is suspended from the ceiling by means of a string. The Earth pulls downward on the toy with its weight force of 8.0 N. If this is the "action force," what is the "reaction force"?

(A) The string pulling up on the toy with an 8N force.
(B) The ceiling pulling up on the string with an 8N force.
(C) The string pulling down on the ceiling with an 8N force.
(D) The toy pulling up on the Earth with an 8N force.

11. A golf club hits a golf ball with a force of 2400 N. The golf ball hits the club with a force

(A) Slightly less than 2400 N
(B) Exactly 2400 N
(C) Slightly more than 2400 N
(D) Close to 0 N

12. A 20 000 kg truck collides with a 1500 kg car and causes a lot of damage to the car. Since a lot of damage is done on the car

(A) Force on truck is greater than force on the car.
(B) Force on the truck is equal to the force on the car.
(C) Force on the truck is smaller than the force on the car.
(D) The truck did not slow down during the collision.

13. How does Newton's third law explain how a rocket takes off?

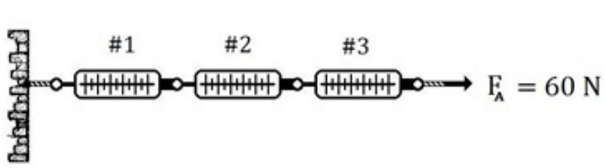
(A) The rocket's acceleration is positive, while the gasses acceleration is negative but the direction is the same. The motion is therefore both "equal and opposite"
(B) The rocket is at rest until ignition.
(C) The hot gasses move in one direction, while the rocket moves in the opposite direction but with equal force.
(D) The hot gasses cause global warming

14. What is the reaction force when a book rests on a table?

(A) Force of book on table
(B) Force of ground on table
(C) Force of table on book
(D) Force of table on ground

15. Three spring scales are connected and a 60 N force is applied to scale #3. What would be the reading on scale # 2?

(A) 20 N
(B) 30 N
(C) 40 N
(D) 60 N



16. Which law states "For every action force there is an equal and opposite reaction force"?

(A) Newton's Law of Universal Gravitation
(B) Newton's First Law of Motion
(C) Newton's Second Law of Motion
(D) Newton's Third Law of Motion

17. A road truck filled with gravel crashes into a small car and does a lot of damage to the car and not much to itself. Which statement below is the true one?

(A) Force on the car is greater than the force on the truck
(B) Force on the truck is equal to the force on the car
(C) Force on the car lasts for a longer time than does the force on the truck
(D) Force on the car lasts for a shorter time than does the force on the truck

18. 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

(A) Greater than 800N
(B) Less than 800N
(C) Equal to 800 N
(D) Not enough information provided

19. 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?

(A) 0 N
(B) 400 N
(C) 600 N
(D) 800 N

20. An archer shoots an arrow. Consider the reaction force to be the bow string against the arrow. The reaction to this force is the

(A) Weight of the arrow
(B) Air resistance against the bow
(C) Grip of the archers's hand against the bow
(D) Arrow's push against the bowstring

PART B: WRITTEN RESPONSE

1. A diver dives off of a raft - what happens to the diver? The raft? How does this relate to Newton's Third Law?

2. A tennis racquet hits a tennis ball. Why doesn't the racquet swing backwards when the ball hits it? (Shouldn't it swing back because of action-reaction forces?)

3. What action-reaction forces are involved when a rocket engine fires? Why doesn't a rocket need air to push on

4. If two people each standing on a scooter board push off of each other what happens (relate to Newton's Third Law)?

5. In #4 how would the distance moved by the scooter boards compare if one person had a lot more mass than the other person?

6. If a person standing on a scooter board pushes off of a wall, what happens? Can this situation be explained in terms of Newton's Third Law (action-reaction)?

7. How is shooting a shotgun related to Newton's Third Law?

8. Why does a rifle have less "kick" than a shotgun?

9. You are waiting in line to use the diving board at your local pool. While watching people dive into the pool from the board, you realize that using a diving board to spring into the air before a dive is a good example of Newton's third law of motion. Explain how a diving board illustrates Newton's third law of motion.

10. You dribble a basketball while walking on a basketball court. List and describe the pairs of action-reaction forces in this situation