**MATERIALS**: Solid ball, wadded paper, or bean bag for tossing

Newton's first law of motion states that an object in motion will continue to move at constant speed in a straight line. Only an outside force can change the speed or direction. If the object is at rest, it will remain at rest, unless an outside force is exerted upon it.

Suppose you are standing in the aisle of a jumbo jet parked at its terminal. You jump straight up. Where will you land? That is an easy question to answer. You will land in the same place from which you jumped. But now suppose the jet is moving at a speed of 600 km/hr. You jump straight up again. Where will you land? Try this activity and see if you can answer the question correctly.

*If possible, work with a partner. The partner should stand and view from the side. For each step, predict what will happen (write that briefly). Then, do the experiment and record your results.*

1. While standing still, throw a small solid ball straight up about 2 m high. Does it land in your hand? Sketch on page 2.

Predict: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Actual: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. Now walk at a constant speed and throw the ball straight up. Where does the ball land? Sketch page 2.

Predict: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Actual: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. Continue walking at a constant speed. This time, stop instantly just after you release the ball straight upward. Where does the ball land? Sketch on page 2.

Predict: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Actual: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. Continue walking at a constant speed. Just after you release the ball upward, break into a run. Where does the ball land? Sketch on page 2.

Predict: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Actual: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. Continue walking at a constant speed. Just after you release the ball upward, make a sharp right turn. Where does the ball land? Sketch on page 2.

Predict: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Actual: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6. Where would you land on the jumbo jet that is moving at 600 km/hr?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Draw a sketch for each of #1-5 … use arrows for direction.**

Vector Diagrams

1. While standing still, throw a small solid ball straight up about 2 m high. Sketch.

2. Now walk at a constant speed and throw the ball straight up. Where does the ball land? Sketch.

3. Continue walking at a constant speed. This time, stop instantly just after you release the ball upward. Where does the ball land? Sketch.

4. Continue walking at a constant speed. Just after you release the ball upward, break into a run. Where does the ball land? Sketch.

5. Continue walking at a constant speed. Just after you release the ball upward, make a sharp right turn. Where does the ball land? Sketch.

What is another name for “arrows that indicate direction” in Physics? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

These have \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

**ANSWERS**

1. While standing still, throw a small solid ball straight up about 2 m high. Does it land in your hand?

*Actual: The ball lands back in your hand.*

2. Now walk at a constant speed and throw the ball straight up. Where does the ball land?

*Actual: The ball lands back in your hand.*

3. Continue walking at a constant speed. This time, stop instantly just after you release the ball upward. Where does the ball land?

*Actual: The ball continues to go forward and lands 1-2 meters in front of you.*

4. Continue walking at a constant speed. Just after you release the ball upward, break into a run. Where does the ball land?

*Actual: The ball continues to go forward, but since you accelerate, you go beyond where the ball lands … it lands behind you.*

5. Continue walking at a constant speed. Just after you release the ball upward, make a sharp right turn. Where does the ball land?

*Actual: The ball continues to go straight, while you turn the corner.*

6. Where would you land on the jumbo jet that is moving at 600 km/hr?

*You would land in the same spot that you jumped from because you are moving at the same speed as the jet. Your jump pattern would make a parabolic shape*.

Vector Diagrams

1. While standing still, throw a small solid ball straight up about 2 m high. Sketch.

2 m

2 m

1 m/s

2. Now walk at a constant speed and throw the ball straight up. Where does the ball land? Sketch.

1 m/s

*Vx for you and the ball is the same*

Vx = 1 m/s

3. Continue walking at a constant speed. This time, stop instantly just after you release the ball upward. Where does the ball land? Sketch.

Vx = 1 m/s

4. Continue walking at a constant speed. Just after you release the ball upward, break into a run. Where does the ball land? Sketch.

Vx = 1 m/s

Vx = 2 m/s

Vx = 1 m/s

5. Continue walking at a constant speed. Just after you release the ball upward, make a sharp right turn. Where does the ball land? Sketch.

What is another name for “arrows that indicate direction” in Physics? **Vectors**

These have **magnitude** and **direction**.

Newton’s Second Law of Motion F = m x a

Explain your answers

The force applied to objects A, B, and C in the diagram below is equal. The masses of the objects being pushing are indicated. Based on this information, answer the questions below.

**Starting Line** **Finish Line**

**5.0 kg**

**A**

B

**2.5 kg**

**C**

**0.5 kg**

1. The contestant whose object accelerates most is \_\_\_\_\_\_ .

2. The contestant whose object accelerates less than B's is \_\_\_\_\_\_ .

3. The contestant whose object accelerates twice as much as A's is \_\_\_\_\_\_ .

4. The contestant whose object accelerates ten times less than C's is \_\_\_\_\_\_ .

5. Assuming a force of 50 N is applied to each object by each contestant, what is the acceleration of object A? \_\_\_\_\_\_ B? \_\_\_\_\_\_ C? \_\_\_\_\_\_ [SHOW WORK]

6. Now suppose the race ends in a tie and all objects have the same acceleration. This means that the force applied to each object is different. If the acceleration is 50 m/sec/sec, what force is applied by A? \_\_\_\_\_\_ B? \_\_\_\_\_\_ C? \_\_\_\_\_\_ [SHOW WORK]

Newton’s Second Law of Motion F = m x a

**Starting Line** **Finish Line**

**5.0 kg**

**A**

B

**2.5 kg**

**C**

**0.5 kg**

1. The contestant whose object accelerates most is C

*a = f/m since the force is equal, the smallest mass will accelerate the most*

2. The contestant whose object accelerates less than B's is A.

*a = f/m since the force is equal, the largest mass will accelerate the least*

3. The contestant whose object accelerates twice as much as A's is \_\_\_\_\_\_ .

*a = f/m since the force is equal, the largest mass has twice the mass of B*

4. The contestant whose object accelerates ten times less than C's is \_\_\_\_\_\_ .

*a = f/m since the force is equal, the largest mass has 10 times the mass of C*

5. Assuming a force of 50 N is applied to each object by each contestant, what is the acceleration of object A? 10 m/s/s B? 20 m/s/s C? 100 m/s/s

*a = f/m A a =50 N/5 kg B a =50 N/2.5 kg C a =50 N/0.5 kg*

6. Now suppose the race ends in a tie and all objects have the same acceleration. This means that the force applied to each object is different. If the acceleration is 50 m/sec/sec, what force is applied by A? 250 N B? 125 N C? 25 N

*f = ma FA =5 kg(50 m/s/s) FB =2.5 kg(50 m/s/s) FC =0.5 kg(50 m/s/s)*