LAB 32: BERNOULLI'S PRINCIPLE

QUESTION

How does spin affect the motion of a projectile?

SAFETY

It is best to do this activity outside on a day with no wind to avoid hitting someone or breaking something.

MATERIALS

Plastic ruler with groove down the middle or a cardboard paper-towel tube, Ping-Pong ball

PROCEDURE

Air exerts pressure on surfaces. Bernoulli's principle says that when air is moving parallel to a surface, it does not impart much force to that surface. The faster the air is moving, the less force it imparts. This is part of the explanation for how an airplane wing works (it also has to do with "angle of attack"). It's also why a "ragtop" convertible top on a car bulges upward on the freeway. When the car is at rest, air pressure inside and outside are equal, and the top stays flat. As the car speeds up, the fast flowing air along the top of the car exerts less pressure than when at rest, while the air pressure inside the car remains constant. There is more pressure upward than downward, so the soft top bulges upward.

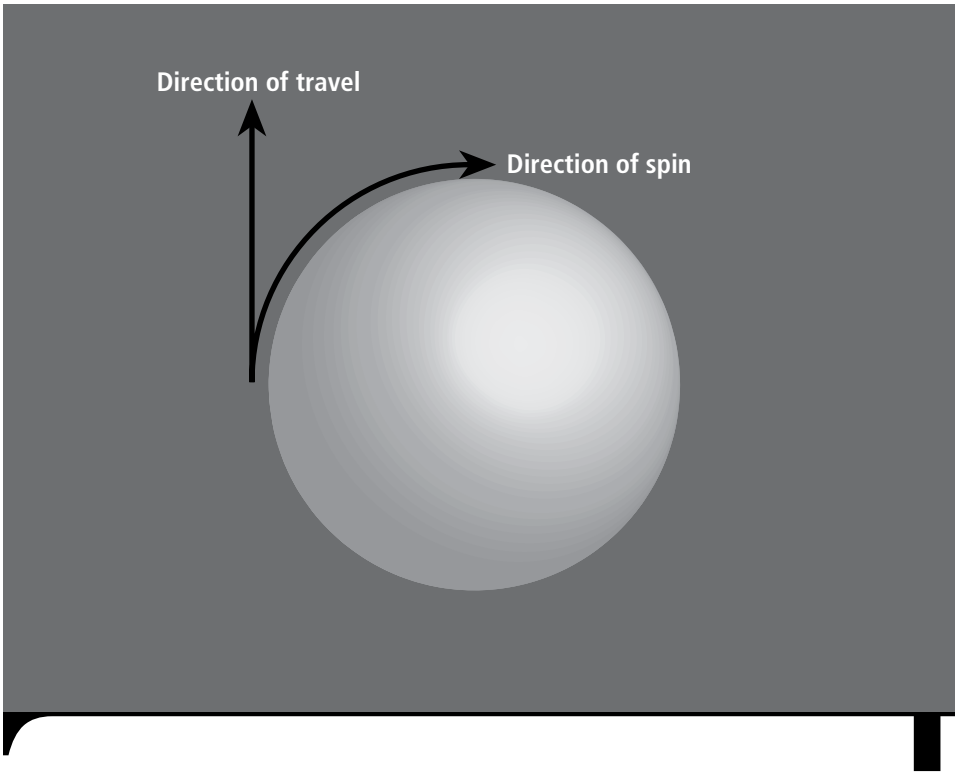
When an object is spinning and moving (see Figure 32.1), the air moves across one side faster than on the other side of the spinning object, so a similar force is created. In this activity, you will determine how the direction of spin is related to the direction that the ball curves. Keep in mind that when a ball moves through the air, there is "wind" flowing past it. If the ball is spinning into that "wind," it slows it down. If it is spinning away from that "wind," it speeds it up.

Note that there is another explanation of how a ball curves that relies on the Magnus effect. It says that the spinning ball throws air in one direction and action/reaction moves the ball in the opposite direction. It is likely that both effects contribute to the motion.

Remember that Bernoulli's principle only applies when the air is flowing along a surface, not when it collides directly with it. The front grill on a car does not experience Bernoulli's forces because the air collides with it directly.

Figure 32.1

Diagram of a Spinning Ball



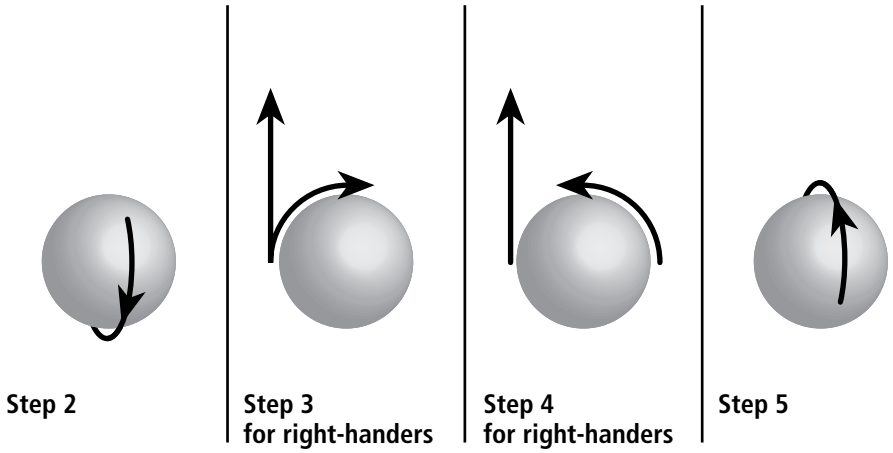
1. You will be using a ruler with a groove in it to throw a Ping-Pong ball. Allow the ball to roll quickly along the ruler and launch it with a "whipping" motion to create a high spin.
2. Throw the ball overhand so that the bottom is spinning in the direction of motion (backspin). Record whether the ball moves up, down, left, or right compared to a spinless throw.
3. Throw the ball sidearm so that the side closest to you is spinning in the direction of motion. Record whether the ball moves up, down, left, or right compared to a spinless throw.
4. Try to throw the ball with the opposite spin from Step 3. Either use the same hand but with a backhand motion (your throwing arm starts across

your body) or use the other hand. Record whether the ball moves up, down, left, or right compared to a spinless throw.

5. Now attempt to throw the ball underhand so that the top of the ball is spinning in the direction of motion. Record whether the ball moves up, down, left, or right compared to a spinless throw.
6. If you have difficulty doing this with a ruler, use a cardboard paper towel tube.

Post-Lab Questions

1. Looking at the ball from above, draw an arrow on each one of the diagrams below to show which way the ball was diverted from its normal path.



2. Write a general rule for which direction the ball will move compared to its spin.
3. Draw a diagram for Steps 2, 3, 4, and 5 similar to those in question 1 and include:
   a. direction of spin
   b. observed direction of motion
   c. side of the ball where the air is moving faster relative to the spinning ball (top or bottom for Steps 2 and 5 and left or right for Steps 3 and 4)
   d. side of the ball where the air is moving slower relative to the spinning ball
   e. direction that Bernoulli's principle predicts the ball will move based on the difference in pressure

   Did the direction that Bernoulli's principle predicts match your observations in question 1?