Need a lift? Use the force!

The Magnus Force

Sometimes a long pass from the defensive end can set up a great fast break. Let′s investigate how science can assist with passing!

WHAT YOU WILL NEED:

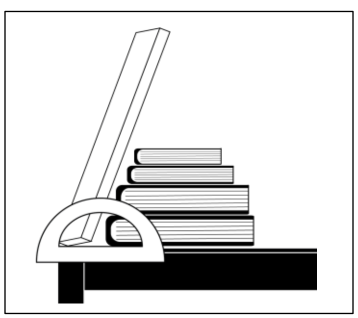
- Meter stick
- Toilet paper tube
- Sheet of paper
- Scissors
- Protractor
- Stack of books or box
- Masking tape (2 colors)
- A board at least 12 cm wide and 60 cm long
- Pencil
- Journal
- A table or raised surface
- Large rubber band or several small rubber bands
- Stack of books or a box
- Variety of balls of different sizes, weights, and materials

WARM-UPS

Let's explore how materials and motion affect the distance and path an object travels. This will require teamwork!

To get started, use the board and the stack of books or box to make a ramp on top of your table or raised surface. The ramp should be at an approximately 45º angle, positioned between the table's legs so that there is open space underneath, and such that if an object rolls off the ramp it has a straight path to the ground.

Line the bottom of the ramp up just over the edge of the table with no part of the table sticking out. The angle, which you'll find with your protractor, doesn't have to be exact — but be sure to use the same angle for each trial. You will need a partner to hold the ramp in place.



Use tape to mark a line on floor that is even with the table edge above. This will be your baseline.

One by one, roll your different balls down the ramp making sure to hold each ball right at the top of the ramp so they all travel the same distance. Carefully observe the path they take.

Mark with tape on the floor where each lands. Use the same ball several times to see if the path remains the same. Record your observations in your journal

Do the balls all land in the same spot? Do they land on the same side of the baseline? Do you notice any patterns?

GAME TIME

This time, repeat the activity, but with two cylinders. Use a toilet paper tube for one cylinder. Construct a second tube using the paper and tape. Make it the same size and shape as the toilet paper tube, with just a little overlap of the edges. The tape should be as flat as possible with no wrinkles or bumps.

Look closely, compare the two cylinders and record your observations in your journal. How are they alike? How are they different? What types of things could you measure about the tubes to show their differences?

Place the toilet paper tube at the top of the ramp and let it roll down. Watch its path and record where it lands with tape. Use the meter stick to measure the distance the tube landed from the tape baseline on the floor. Record the distance and the side of the baseline it lands on in your journal.

Remember that scientists use multiple data points, so release the toilet paper tube in the same manner several times. Record the distance from the original tape mark each time and make observations about the path of the toilet paper tube. You may find it helpful to draw the path the toilet paper tube took from the ramp to the ground.

Repeat the process with the paper cylinder, making sure that the ramp is at the same angle as before. With a different color tape, mark where the cylinder lands and record the distance just like before. Collect multiple data points by releasing the paper tube in the same manner several times. Record the distance from the tape and make observations about the path of the toilet paper tube. Draw the path of the paper cylinder.

ANALYZE THE REPLAY

What happened?

Review the similarities and differences between the paths of the toilet paper tube and the paper cylinder. Use the different tape marks and your journal to make the comparisons.

- How were the paths of the two cylinders different?
- Were the conditions the same when the toilet paper tube was released as they were when the paper cylinder was released?
- If there were any differences in the paths of the two cylinders, what caused this? What evidence did you use to come to this conclusion?
- Did each cylinder roll down the ramp the same way?
- Compare the cylinder paths to the paths of the balls from earlier. Were any of the paths the same? If not, how were the paths different?
- How do you think adjusting the height or angle of the ramp would affect the path of the toilet paper tube?
- Based on your observations so far, predict the path an empty soda would make if you rolled it down the ramp. What information would you need to make your prediction? Use your recorded observations to support your idea.

OVERTIME

Let's take it a step further

Using the same cardboard toilet paper tube, let's experiment again.

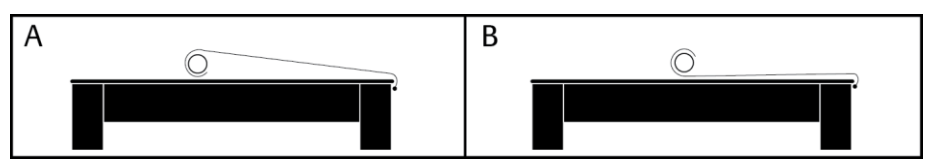
Begin by cutting a large rubber band so it is no longer a loop but is instead a long ribbon. If you do not have a large rubber band, several small rubber bands can be tied together.

Find a large flat surface without any items on top. This could be the table that you were using. Tape one end of the rubber band on the underside of the table so that the rubber can be stretched across the surface of the table.

Wrap the rubber band tightly around the cardboard tube twice like you would a yo-yo. For the first trial wrap the rubber band over the top of the tube like **Diagram A.** Pull the tube straight back from the edge and toward the center of the table until the band offers no more stretch. Mark this spot on the table with tape. With the rubber band aligned on the center of the tube, release the roll. Describe the motion and draw an illustration of what happened in your journal. Repeat the experiment, stretching back to the same line each time to get multiple data points.

For the next experiment, wrap the rubber band so that it is on the underside of the tube and stays flat to the table like **Diagram B.** With the rubber band in the center of tube and pulled back to the tape mark from before, let the tube go. Describe the motion and draw what happened in your journal. Repeat the experiment, stretching back to the same line each time to get multiple data points. Compare your results of the different directions of wrapping.

- How was this activity similar to the Game Time experiments?
- Did the way the rubber band was wrapped have any impact on the trajectory of the tube? What were the similarities or differences?
- Using the evidenced gathered from all of the experiments, what do you think affects the path these objects take?



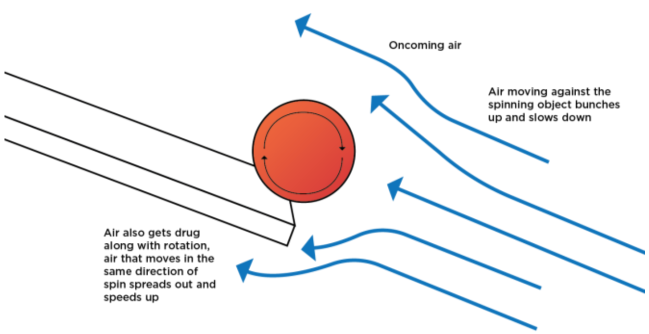
COACH'S CORNER

Additional information and explanations for parents and educators

The phenomenon that just occurred in these activities is known as the Magnus effect.

When a cylinder freely rolls down a ramp it rotates forward, or has "top spin." As it travels, it naturally picks up speed because of gravity. As it spins forward through the air, a pressure difference is created. Air moving across the top opposes the forward spin and slows down, while air that travels around the spinning tube along the bottom moves with the spin and speeds up. The difference from top slower moving air (which creates a higher air pressure) and bottom faster moving air (which creates lower air pressure) changes the path that the tube moves.

This **Magnus effect** specifically addresses motion in spinning objects. The weight and speed of the different cylinders play a role in how much it impacts the path traveled. The lighter paper tube compared to the heavier cardboard toilet paper tube was one way to observe the differences.



The paper cylinder that you made was much lighter and the resulting Magnus effect was easier to observe than on the heavier toilet paper tube.

In the Overtime experiment with the toilet paper tube and rubber band, the toilet paper tube was moving much faster and the effect was easier to observe. You may have found that the placement of the rubber band also had a very noticeable effect on the path.

The Magnus effect was first described in the 1850s by Heinrich Gustav Magnus while he was investigating the paths of cannon balls.

The Magnus effect can be used to great effect in many sports because it does not only effect cylinders, but also spheres of all sorts including tennis balls, soccer balls, baseballs, and even basketballs.

You have probably seen the Magnus effect in sports. Sometimes it's quite dramatic such as soccer player Roberto Carlos' 1997 free kick featured in the video (link below).

Do you recall ever seeing the Magnus effect in a basketball game? If you were playing a game of basketball, how would you use the Magnus effect to your advantage?

Want to see an impressive demonstration of the Magnus Force using a basketball? Check out this impressive video!
https://www.youtube.com/watch?v=2OSrvzNW9FE

Want to see Brazilian soccer player Roberto Carlos stun everyone with a fantastic free kick that used the Magnus effect?
http://physicsbuzz.physicscentral.com/2012/06/perfect-free-kick-and-magnus-effect.html

DO YOU WANT TO LEARN MORE?
Research:
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