

Exponential Friction

Overview: This is a classic experiment where a small kid can totally win a bet with the entire football team. When I demonstrate this activity, I'll pick the smallest kid and three of the largest to perform in front of the class. The small kid always wins, especially after a quick lesson in how you can get friction to grow exponentially.

What to Learn: Students will learn how friction can grow exponentially, and learn how to identify forces acting on a single static object.

Materials

- rope (nylon, 10 feet or longer)
- column or pillar
- people (two at least – more is better)

Lab Time

1. Stand by the column and put the rope around the pole (without looping it... have it make a U-turn around the pole for right now).
2. Have students pull on either end of the rope. Note that the friction is minimal.
3. Loop the rope around one time, so it's wrapped around one and a half times. What happens now when it's pulled on either end?
4. Try another loop (two and a half turns) and pull.
5. Note how the friction grows quickly!

Exponential Friction Data Table

Number of Turns Around the Pole	Number of Friends on the Other End of the Rope	What Happened?

Reading

For this experiment, you'll need to find a smooth, cylindrical support column, such as those used to support open-air roofs for breezeways and outdoor hallways. You'll be winding a length of rope around the column and pulling on one end while three friends pull on the other in a tug-of-war fashion, so make sure it's a sturdy pole you've selected.

This is a great demonstration of what "exponential growth" truly means. There is friction between the rope and the support column that you can feel as you tug on the rope. With every additional turn around the pole, the amount of friction increases exponentially until it skyrockets so much the rope feels as if it's welded to the pole. Experiment with the number of friends and the number of winds around the column. Can you hold your end with just two fingers against an entire team of football players? You bet!

Einstein himself stated that "exponential growth" was the eighth wonder of the world!

Exercises Answer the questions below:

1. How much money would you earn on Day 20 if I gave you one penny on Day 1, and doubled it every day after so Day 2 you received 2 pennies, and Day 3 you got 4 pennies?
2. Why do you think this experiment with friction works? Does it work with a flat surface the same way as a curved surface?

Answers to Exercises: Exponential Friction

1. How much money would you earn on Day 20 if I gave you one penny on Day 1, and doubled it every day after so Day 2 you received 2 pennies, and Day 3 you got 4 pennies? (Day 20 = \$5,242.88)
2. Why do you think this experiment with friction works? Does it work with a flat surface the same way as a curved surface? (There is friction between the rope and the support column that increases with every additional turn around the pole, since there's more contact between the rope and the pole with every turn. Since the pole is curved, this adds to the friction exponentially.)