Introduction:

Scientists are often interested in predicting the behavior of whatever they are studying. More often than not, this includes predicting the motion of an object (how a chunk of matter moves). It turns out that there are many different ways to make an object move or change the way it is moving, and all of these methods concern the application of a **force** to the object. This experiment will introduce you to two major forms of force that 'act at a distance' (without direct contact).

Space can be defined as 'what the universe exists in'. Space cannot be captured or bottled or manipulated by humans, beyond the ways that nature has allowed forever (technology has not made humans better at controlling space). Matter is anything that takes up space (has a volume) and has the properties of mass and charge. These two properties effect space in different ways, which leads to the two forces you will investigate today. The actual mechanism that produces these forces is not completely understood, so we will not go into any details.

The notion of force

Our operational definition of a force is something that makes an object move or alters its current motion. This can be done by direct contact with an object, such as lifting a pencil, throwing a baseball, or hitting the pitched baseball with a bat. But, some forces don't require contact to make something move. That is, these forces seem to work when there is a distance between the two objects. Most notably, you've seen this anytime you've dropped a pencil or seen a leaf fall off a tree. In these two cases, a force moved the object toward the ground without grabbing (contacting) the object.

The three most commonly discussed forces that act at a distance are the gravitational, electric, and magnetic forces, though there are many other forms of force.

> **Gravitational force**: the force between two objects due to these objects having the property of mass.
>
> **Electric force**: the force between two objects due to these objects having the property of electric charge.
>
> **Magnetic force**: the force between two objects due to these objects having the property of electric charge in motion.

Whenever these forces act on an object (make it move), we can classify the force as being either *attractive* or *repulsive* by the way the objects move:

> **Attractive forces**: Seem to draw objects closer together. Can be considered as a"pulling" motion.
>
> **Repulsive forces**: Seem to move objects away from one another. Can be considered as a "pushing" motion.

Procedure I: The Gravitational Force

I. Obtain a single balloon for your group. Inflate this balloon and tie-off the end so that it stays inflated.

II. Now, simply drop the balloon and write your observations below.

Questions:

1) The force acting on the balloon is gravity. The Earth and balloon, together, are creating this force. Would you say the force is pushing or pulling the balloon?

2) Can you think of an instance where you would drop <u>your</u> balloon and it would move upward, away from the Earth?

3) Would you say that gravity is always attractive, always repulsive, or can be either attractive or repulsive (depending on the situation)? Explain.

4) Would you say that the gravitational force between the Earth and an object always acts (makes an object move) in a certain direction? If so, what direction is that?

Procedure II: More Things to do with a Balloon

I. Place your balloon against a wall, drop it, and observe what happens. Write your observations below.

II. Rub your balloon against someone's sweater or hair. Do this for a few seconds.

III. Place the balloon against a wall, drop it, and observe what happens. Write your observations below.

Questions:

1) In step I, both the Earth and the wall were gravitationally attracting the balloon. Did the wall's gravitational attraction seem to have any effect on the balloon? Explain how this can be.

2) In step III, the wall exhibits a force on the balloon.
   a. Would you say the wall is pushing or pulling the balloon? Does this make this force an attractive or repulsive force?

   b. Do you believe this to be a gravitational force? Why or why not.

   c. Is this force stronger than the gravitational force between the Earth and the balloon? Explain.

Procedure III: 'Sticky Tape' and the Electric Force

For this experiment, you will need two, 6-8 inch pieces of 'sticky tape'. Sticky tape is really just a generic name for cellophane tape or Scotch Tape ®. You will prepare your samples using two separate methods and observe their interaction.

I. Each member of your group should obtain a 6-8 inch piece of tape from the dispenser. Be careful to not contaminate the tape by getting finger prints on the sticky side or letting it fold/stick onto itself.
II. For both pieces of tape, fold over a ¼ inch piece of the end so that the two sticky sides make contact. This creates a 'handle' for you to use throughout the experiment. The instructor will demonstrate this.
III. Place each piece of sticky tape flat on the table with the handle hanging over the edge. Make sure the sticky side is down and that you smooth out the tape using your finger.
IV. Each member of your group should slowly remove the tape from the surface (holding it by the handle, and pulling it off the table). Be careful to not let the tape bend upward and stick to your arm or clothing, at this point.

V. Face the 'unsticky' sides toward each other and slowly bring the two pieces of tape toward each other. Bring them as close as possible. Write your observations to this action below.

Questions:

1) In step IV, the tape hangs straight down from your fingers. What force is acting on the sticky tape to make difficult for the tape to hang in any other fashion (horizontally, straight up, etc)?

2) When you bring the two pieces of sticky tape together, do they
   a. Exert a force on each other
   b. One piece exerts a force on the other, only.

   Justify your choice.

3) Would you classify this force as a pushing or pulling force? Is this an attractive or repulsive force?

4) Is this force stronger than the gravitational force? How do you know?

VI. Place the longer of the two pieces of sticky tape onto the table (sticky side down) and smooth it out.

VII. Now, place the shorter piece of sticky tape <u>on top of the first</u>, and again smooth it out. Try to make these two pieces overlap as best you can.

VIII. Slowly pull (both handles at once) until the two pieces are removed from the table but are stuck together.

IX. Each member of the group should grab one of the two handles. Slowly pull the two pieces apart, being careful to not let the ends curl up and stick to your body or clothing.

X. With the 'unsticky' sides facing each other, slowly move the two pieces of sticky tape together. Write your observations of this process below.

Questions:

5) When you bring the two pieces of sticky tape together, do they
   a. Exert a force on each other
   b. One piece exerts a force on the other, only.

   Justify your choice.

6) Would you classify this force as a pushing or pulling force? Is this an attractive or repulsive force?

7) Is this force stronger than the gravitational force? How do you know?

Summary Questions:

1) The force between the pieces of sticky tape is the electric force. Would you say that the electric force is always attractive, always repulsive, or can be either attractive or repulsive (depending on the situation)? Explain.

2) Would you say that the electric force between the two objects always acts (makes an object move) in a certain direction? If so, what direction is that?