Forces and Gravity

Required Equipment:

- Vacuum (any lab pump or vacuum cleaner)
- Long glass or plastic tube
- Marshmallows
- Two rubber stoppers
- One light object (feather, piece of paper, etc.)
- One heavy object (coin, eraser, etc.)
- Timer

Pre-Lab Lecture Key Points:

➔ *Force* = something that causes a change in an object's motion

➔ *Gravity* = a force that pulls objects towards Earth's surface

➔ An interesting aside is Isaac Newton, a 17th-century scientist who made many discoveries such as gravity and telescopes

➔ Gravity was also discussed last week as it relates to both topics; if desired, ask students if they recall the definition of gravity before giving it to them

➔ The marshmallow experiment preceding the main experiment is simply to demonstrate the concept of a vacuum to students (in a pretty entertaining way!); it is also an easy way to test if the environment in the tube is actually a vacuum

➔ During the first iteration of the main experiment, two objects are dropped in air to demonstrate that the feather will fall slower due to more air resistance; in the second iteration, the absence of any air resistance will cause any two objects to fall at the same rate; in both cases, the gravity exerted on the objects is the same

Air resistance = a force from the air that slows an object down

➔ After completing the two runs, students are welcome to experiment further by dropping other objects in air and in vacuum

➔ A vacuum attachment will be needed to connect the tube to the vacuum

Student Lab Procedure:

1. Place the long tube flat on a table.

2. Put a marshmallow or two inside the tube and slide them to the middle.

*If students wish, they can draw smiley faces on the marshmallows for more entertainment

3. Now create a vacuum tube by placing a rubber stopper at one end and attaching the vacuum hose to the other end. Ask your teacher for help with this step!

*The setup may take some time and will require some sort of attachment; any setup that produces some sort of vacuum environment in the tube will suffice but it is suggested that the vacuum be attached directly to the tube end or with a pin through the rubber stopper

4. Now turn on the vacuum and record what happens to the marshmallows on your worksheet.

5. After a few minutes, turn off the vacuum and gently pull off the rubber stopper from the tube. Be careful not to pull the stopper off too fast!

*Be careful when releasing the vacuum or there is a chance the tube may crack

6. Remove the marshmallows from the tube and place the two objects (one light and one heavy) inside at one end.

7. With the vacuum turned off and the tube closed at both ends, turn it straight up so that the two objects fall from the top to the bottom.

8. When the objects begin to fall, have two of your classmates time how long it takes either object to reach the bottom of the tube. Record these values on your worksheet!

*If it is difficult to time the fall, then students can simply note the mismatch between the sound of the heavy object falling and the visual cue of the light object falling

9. Place the tube back onto the table and turn the vacuum on.

10. After the vacuum has been on for a few minutes, turn it off. Then turn it straight up so that the two objects fall from the top to the bottom.

11. Have two of your classmates time how long the objects take to reach the bottom and record these values on your worksheet!

12. Try explaining the differences between the four times that you recorded.

Wrap-Up:

- ➔ One last time, ask students to explain why the objects behaved differently in separate environments
- ➔ After the marshmallows are removed from the tube, they will be smaller and more dense than before because all the air from the original structure would have been removed
- ➔ Initially the lab procedure may seem short but it has been found that a large amount of time is spent on vacuum tube setup and explaining the concept of a vacuum
- ➔ The main take-away of this lesson is that objects are pulled towards Earth at roughly the same rate because of gravity but are often slowed down due to air resistance
- ➔ Students are of course welcome to eat leftover marshmallows