How do changes in gravity affect a falling ball?

Introduction

Beginning in elementary school students are taught that Earth's gravity pulls objects toward its surface. Students learn that mass is a determining factor in an objects gravitational pull, and often view Apollo astronaut footage as an example of how reducing gravitational pull affects motion. This is typically the extent of resources made available to students, which often does not fully resonate.

Connecting class experiments with the same experiment on board G-Force is a powerful way to deepen student understanding of balanced/unbalanced forces and Newton's Laws. A common misconception among students is that when dropped in lunar gravity, a ball will bounce higher than the dropping point. In this experiment, students investigate the speed at which a ball drops on earth, and how conservation of energy prevents that ball from returning to its original height. Student predict how movement would change on Mars, the moon, or in microgravity.
The same experiment will be flown on board G-Force One, and the recording will be shared and discussed with students.

Target Grade Level: 6th-12th
Suggested Time Frame: 3 days (50 minute class periods)

US Next Generation Science Standards (NGSS)

PS2.B: Types of Interactions
PS3.A: Definitions of Energy
ESS1.A: The Universe and its Stars
ETS1.A: Defining and Delimiting Engineering Problems
ETS1.B: Developing Possible Solutions
ETS1.C: Optimizing the Design Solution

Objectives

- Understand that transformation and conservation of energy principals do not change in reduced gravity or microgravity.

- Predict how reduced gravity changes motion of a falling ball using Newton's 2nd Law of Motion.

Purpose

To investigate how gravitational changes affect a falling ball

Hypothesis

Materials

24" and 36" clear plastic cylinder, open at end (optional for classroom)
Meter stick
Golf ball
Video camera

Procedures

1. Hold ball at 24" with meter stick in camera's field of view
2. Start video camera (slow motion)
3. Drop the ball.
4. Record time time of fall.
4. Replay the video and record the height of the first bounce
5. Repeat two more times
6. Repeat at height of 36"

Results

	Height of Bounce 24" drop	Time of Fall (sec) 24" drop	Height of Bounce 36" drop	Time of Fall (sec) 36" drop
Drop 1				
Drop 2				
Drop 3				
AVERAGE				

Assessment

1. What force causes the ball to fall?

2. What other forces are acting on the ball as it falls?

3. What force causes the ball to bounce up?

4. Does the bounce back to the original height? **Explain**.
   Consider conservation and transformation of energy!

5. What percentage of gravitational pull does Mars have compared to Earth?

6. How would would our results change if the ball were dropped on Mars? **Explain**.

7. What percentage of gravitational pull does the moon have compared to Earth?

8. How would would our results change if the ball were dropped on the moon? **Explain**.

9. How would dropping the ball on the International Space Station change the results? **Explain**.

10. How is this experiment an example of energy transformation and energy conservation? (**Explain)**.

Procedures- In flight

At Initiation of Mars-g

1. Start video (slow motion)
2. Drop ball from a height of 24” into clear plastic cylinder with attached meter stick.
3. Repeat if needed.
4. Repeat at initiation of lunar-g

Results- Post flight

1. Show video of ball drop in Mars gravity and lunar gravity
2. Record time of each drop and record in table below.

Ball drop from 24” (G-Force One)

	Earth gravity (Average- class experiment)	Mars gravity (____% earth)	Lunar gravity (____% earth)	Microgravity (____% earth)
Mars-g: Time of fall (sec)				
Mars-g: Height of first bounce (cm)				
Mars-g: Observations				
Lunar-g: Time of fall (sec)				
Lunar-g: Height of first bounce (cm)				
Lunar-g: Observations				
Zero-g: Observations				

Assessment

1. Compare/contrast the results of dropping a ball in Earth gravity (1-g), Mars-g, lunar-g, and 0-g.

2. Explain differences or similarities in height of bounce in each gravitational environment.

3. Explain differences in time of fall using Newton's laws of motion.

4. Explain and illustrate how this experiment demonstrates each of Newton's Laws of Motion.

   - 1st Law (Inertia)
   - 2nd Law (Acceleration)
   - 3rd Law (Force pairs)

What sport or activity do you enjoy? How would it be different if played on the moon? How would the equipment and rules need to be changed?

(Essay, with illustrations)

Resources

https://sciencenotes.org/how-to-calculate-weight-on-other-planets/

https://www.aps.org/programs/outreach/physicsquest/past/falling-physics.cfm

https://www.teachengineering.org/activities/view/pur-2576-lunar-olympics-physics-online-activity

https://www.nasa.gov/pdf/591752main_Science-Sports.pdf