Do Changes in Mass in Microgravity Effect Oscillation Frequency of a Spring?

Introduction-

This is one of two experiments conducted on board G-Force One to determine whether mass and/or tension changes oscillation frequency of a spring-mass system.

The purpose of this experiment is to determine whether mass affects oscillation cycle of a spring system in microgravity. A common misconception among students is that, due to weightlessness, mass will not be a factor in oscillation in microgravity, or that oscillation will not occur at all. This experiment will help students understand that spring force is independent of gravitational force. In fact, spring-mass systems are used on board the International Space Station to determine weight of many things, including astronauts.

Students design, build, and develop testing procedures for flight on G-Force One. The experiment is tested at 1-g in the classroom and subsequently repeated in microgravity on board G-Force One.

Students are engaged in potential and kinetic energy, forces, engineering, experimental design, and critical thinking, even before the actual flight. These projects can be modified to suit any classroom.

Target grade level- 6th -12th grade

US Next Generation Science Standards (NGSS)

PS2.A: Forces and Motion
PS3.A: Definitions of Energy
ETS1.A: Defining and Delimiting Engineering Problems
ETS1.B: Developing Possible Solutions, ETS1.C: Optimizing the Design Solution.

Objectives

- To determine if mass will affect oscillation cycle of a spring in microgravity.
- To demonstrate that spring force is distinct from gravitational force.
- To deepen student understanding of Newton's laws
- To deepen student understanding of potential and kinetic energy

Procedures

Build apparatus for use on G-Force One

- Three spring systems will be secured in a frame, with a mass secured between two springs (see photo).
- Spring system 1 and 2 will have springs with the same tension but different masses (25g and 50g).
- Spring system 2 and 3 will have springs with different tension and the same mass (50g).
- Upon weightlessness, the masses will be pulled down and released simultaneously.
- Oscillation cycle will be determined by counting the number of oscillations in a 10 second period.

Procedures (In-class)

1. Start video camera
2. Set timer to 10 seconds
3. Pull down weight "A" to the mark and release. Start timer at same time as release.
4. Count the number of full oscillation cycles in 10 seconds. Stop movement at 10 seconds. Record number of oscillation cycles on data table below
5. Repeat with weight "B"
6. Repeat experiment 3 times.

Student Results (1-g)

	Oscillations in 10 seconds Mass"A" ____	Oscillations in 10 seconds Mass"B" ____
Rep 1 (classroom 1-G)		
Rep 2 (classroom 1-G)		
Rep 3 (classroom 1-G)		

- What force causes the mass to move?

- What is the relationship between mass and oscillation cycle of a spring?

- Do you think mass of a spring would affect the oscillation cycle in a microgravity? EXPLAIN

Procedures (In-flight)

1. Start video camera
2. Set timer to 10 seconds
3. Upon weightlessness, the masses on "A" and "B" will be pulled down and released simultaneously.

Oscillation cycle will be determined by counting the number of oscillations in a 10 second period.

Procedures- Post-Flight:

1. Watch video of results.
2. Complete data form below and answer questions

Results

Oscillation frequency in microgravity (10 seconds)

	Oscillations in 10 seconds Mass"A" ____	Oscillations in 10 seconds Mass"B" ____
Rep 1 (microgravity)		
Rep 2 (microgravity)		
Rep 3 (microgravity)		

Conclusion

- In essay format, compare oscillation frequency of a spring-mass system in 1-g and microgravity.
- Explain changes (or lack of changes) of oscillation frequency in varying gravitational environments.
- Investigate and describe how this information is used on board the International Space Station

Additional Resources:

Article: The Complex Contraption Astronauts Use to Weight Themselves in Space

https://www.popularmechanics.com/space/a14427198/the-complex-contraption-astronauts-use-to-weigh-themselves-in-space/

Video: Weight in Space https://nerdfighteria.info/v/Zzi4EQKBbOY/

pHET Masses and Springs (Simulations)

https://phet.colorado.edu/en/simulations/masses-and-springs-basics

https://phet.colorado.edu/en/simulations/masses-and-springs

https://phet.colorado.edu/en/simulations/hookes-law