Testing in Microgravity- Drop Towers

Did you know that the **International Space Station (ISS)** is constantly in free fall around Earth? It moves forward so fast that as it falls, Earth's surface curves away, keeping it in orbit. Because everything inside the ISS is falling at the same rate, astronauts and objects appear to float, experiencing microgravity.

Free fall creates **microgravity** because when an object is falling under the influence of gravity alone, without any other forces acting on it (like air resistance or support from the ground), it experiences weightlessness. This happens because both the object and everything inside it accelerate at the same rate due to gravity, removing any sensation of weight.

Similarly, **drop towers** create microgravity by allowing objects to fall freely for a few seconds. During this time, the objects inside the experiment experience weightlessness, just like astronauts on the ISS, because there is no force holding them up. In both cases, microgravity is achieved because the objects are in free fall, meaning they are accelerating due to gravity but not experiencing a normal force (the force that usually gives us weight on the ground).

Scientists use drop towers to study how materials and fluids behave in space-like conditions, an essential area of research for advancing space exploration and spacecraft design. These experiments provide valuable data for:

- **Spacecraft Design**: Engineers study fuel sloshing in tanks to develop more efficient propulsion systems.
- **Medical Research**: Scientists test fluid dynamics in microgravity to improve drug delivery systems and medical devices for astronauts.
- **Material Science**: Researchers examine material solidification in microgravity, leading to the development of stronger, more durable materials.
- **Convection Studies**: Understanding how heat transfer occurs in microgravity, where the absence of buoyancy-driven convection affects fluid flow, helps scientists design more efficient thermal management systems for spacecraft

By using drop towers, researchers can conduct repeatable, cost-effective experiments before testing in more expensive environments like parabolic flights or the ISS.

Why Does This Matter?

Microgravity research is essential for advancing science in space and on Earth. From designing sustainable life support systems for deep space missions to improving technologies used here on Earth, understanding how microgravity affects different systems is key to innovation.

In this experiment, you will design and conduct your own drop tower tests to observe the effects of microgravity on various objects. By analyzing the results, you will gain insight into how scientists study microgravity and how this research applies to real-world challenges in aerospace, medicine, and engineering.

Materials

Drop tower setup: Minimum 6-foot drop.

- Plastic tubs with lids. Large rubber bands to ensure securement of lids
- A table-top, ladder, or balcony works well
- Drop area free from obstruction
- Cushioned impact surface. A large catch net is a great way to involve a classroom when drop testing from a balcony!

Testing materials (examples):

- Small clear containers with lids (for liquids, powders, or small objects)
- Water and food coloring (to observe fluid motion)
- Iron filings and small magnets
- Tea candle (for convection demonstration)
- Small rubber, plastic, Styrofoam balls (to compare movement under different conditions)
- Velcro, strong tape (securing camera and testing items inside box)
- Camera or smartphone with slow-motion recording (to analyze motion)
- Timer

Procedure

1. **Prepare the Drop Tower Setup**

- Testing area, materials table
- Discuss classroom procedures and safety
- If using a simple setup, place the drop test items in a secure box or tube that can fall freely.

2. **Prepare Test Samples**

- Secure drop test items with Velcro in a box.
- Secure camera in the box, with testing items within field of view.
- If investigating motion of liquid, it is best to use a small amount of liquid (ex: colored water) for visibility and space for fluid motion.

3. **Conduct the Drop Test**

- Measure drop height
- If students are holding a net, be sure the net is fully under the drop area, and that all students are securely holding the net so that it is tight.
- Turn the camera ON to record the fall from the moment of release. Slow motion is best.
- Secure lid on box. XL rubber bands can be used to ensure that the lid does not come off during drop.
- Drop the experiment box or containers from the top of the tower into a net or cushioned area.
- Record the time it takes to fall using a stopwatch.
- Observe how the contents behave mid-fall.

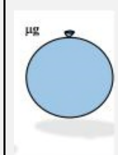
4. **Analyze Motion in Microgravity**

- Replay the high-speed footage, frame by frame during free fall. Analyze how different materials react during free fall.
- Compare the behavior of liquids, small particles, and solid objects.
- Identify signs of microgravity, such as suspended motion, spherical liquid formations, adhesion of liquids to surfaces, visual observations of changes in net force, such as movement of iron filings.

5. **Compare with Ground-Level Behavior**

- Repeat the experiment with the same materials at ground level (without dropping them).
- Observe differences in motion, shape, or interactions compared to the drop test.

Collecting Data: Ground Test vs Drop Test

	Earth Gravity (1-G)			Drop Test (microgravity)		
	Question: Include materials	Illustration: Show net force arrows	Hypothesis: What do you expect to see in microgravity?	Observation	Illustration: Show net force arrows	Explanation
Example	Will a ball "float" in microgravity?		The water balloon is pulled downward by gravity. It will not be pulled as much when the net force is zero	The water balloon is round		There is zero net force, therefore the balloon is not pulled downward
Drop 1						
Drop 2						
Drop 3:						

Food for thought: Why is a flame pointed on Earth, but round in microgravity?

NASA [STEMonstrations](#) Video: Surface Tension

Calculating Free Fall Time:

$$t = \sqrt{\frac{2d_v}{g}}$$

t = time
d = height (m)
g = acceleration due to gravity (9.81 m/s^2)