ZERO-G
WEIGHTLESS LAB

Zero Gravity Corporation (ZERO-G) offers educators and students a unique "weightless laboratory" in which to conduct simple but powerful experiments. This safe yet fun environment is the same one used today by NASA astronauts to train for space flight and by some of the world's top scientists and researchers to conduct experiments.

The experiments outlined in this document may be used in a variety of ways to support all education levels in several disciplines including:

- Art
- Engineering
- History
- Language Arts
- Mathematics
- Science
- Social Studies
- Technology

TYPICAL AGENDA

ZERO-G's education program includes the following:

- About ZERO-G
- What is Weightlessness?
    - Math and Science Concepts
    - Apply the Concepts - Working in Zero Gravity
- Mission Briefing
- Catered Flight Friendly Lunch
- Experiments
    - The Profile – What to Expect
    - Team Work – Documenting the Data
    - Get it in the Classroom
- Experiment Screening
- Parabolic Flight
- Regravitation Celebration

BENEFITS TO TEACHERS AND STUDENTS

Professional Development Credit: Completion of the workshop training and flight program meets most educators' professional development requirements.

Stand Out Above the Rest: Perfect for your resume and or college application.

Amazing School Projects: Students have a once–in–a–lifetime chance to conduct experiments in a weightless environment. It's an amazing opportunity for a stellar school project!

Improved Classroom Environment: Three years of evaluations show that teachers who participate in the ZERO-G Education Program see immediate improvements in students' classroom participation, attendance, college/career ambitions, and understanding of complex science, technology, engineering and math (STEM) concepts. Initial results indicate an improvement in student achievement in standardized testing.

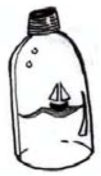
Documentation for Classrooms: Captured in high definition video and photos, every flyer receives a video of their flight as well as photos to support curriculum. Flyers are also encouraged to bring a small camera or video recording device to record personal experiments.

National Standards Alignment: The ZERO-G Education Program aligns with several National Standards for Mathematics and Science. A list is provided below. Additional alignments are in process.

MATHEMATICS	SCIENCE
Standard 1: Mathematics as Problem Solving	Standard A: Abilities necessary to do scientific inquiry; understandings about scientific inquiry
Standard 2: Mathematics as Communication	Standard E: Abilities of technological design; understandings about science and technology
Standard 3: Mathematics as Reasoning	Standard F: Understanding about science and technology in society
Standard 4: Mathematical Connections	Standard G: Understanding of science as a human endeavor; understanding of the nature of science
Standard 7: Computation and Estimation	Standard H: Understanding of the history of science
Standard 8: Pattern and Functions	
Standard 11: Probability	
Standard 13: Measurement	

EXPERIMENTS

Density Bottles



Description: A sealed plastic bottle containing liquids of varying densities. ZERO-G's density bottles contain water dyed with food coloring and standard vegetable oil. Density bottles may also contain small, plastic floating objects.

Procedure: Shake the bottle in Lunar, Martian, and Zero-G to see what occurs. Shake the bottle in 1.8Gs to see the effects. Let the bottle float during Zero-G rather than holding the bottle.

Classroom Applications: Observe what happens when gravity isn't pulling the densest material to the bottom. What happens to the liquids in Lunar, Martian, Zero and 1.8Gs? What would happen if different liquids were added – such as corn syrup or motor oil? What's the chemistry? Does viscosity affect the separation? Create your own density bottles in class using different liquids and see the effects in 1G.

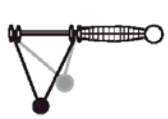
Objects in a Bottle

Description: A small sealed plastic bottle or gallon sized Ziplock baggie with small objects (plastic toys, Goldfish crackers, etc).

Procedure: Observe the small objects in the bottle or bag as you experience Zero Gravity. Release the bottle and see how the objects react in different gravities.

Classroom Applications: How do objects of different masses react in relation to each other? Does this relationship change from one gravity environment to the next? Which of Newton's Laws are demonstrated? Describe how? What are the net forces? Acceleration due to gravity is a factor – describe why and how.

Klacker



Description: A "Klacker" is a handle with two balls connected at equal lengths by plastic rods.

Procedure: Flip the handle of the Klacker up and down. While the balls move around the handle, they possess momentum. A stationary ball has no momentum. When the moving ball hits the stationary ball, it passes its momentum to the stationary one.

Suggested Lessons: Observe what happens to the Klacker at 1G, Lunar-G, Martian-G, and Zero-G. Have students predict the motion of the Klacker in each gravity environment and then observe the outcomes. Students can also predict what might happen to the Klacker's motion on other planets with greater and lesser gravities. What is Conservation of Momentum? How is it demonstrated? What would happen in a higher G environment?

Kendama

Description: A Kendama is a ball tied by a piece of string to a cup.

Procedure: When you try this experiment in the presence of 1G, gravity acts on the ball and makes it follow a familiar, curve path. With a little practice, it is not hard to get the ball into the cup - much like a skilled basketball player is able to shoot a basketball through a hoop. Once the ball is in the cup, gravity keeps it there.

In weightlessness, the ball behaves differently. It follows a straight path until it is snapped back when the string is stretched all the way out. Astronaut Casper was able to get the ball into the cup by redirecting the ball toward it, but he had a hard time keeping the ball in the cup. The ball kept bouncing back out because gravity wasn't helping to keep it in.

Suggested Lessons: Observe what happens to the Kendama at 1G, Lunar-G, Martian-G, and Zero-G. Have students predict the motion of the Kendama in each gravity environment and then observe the outcomes. Does the string arc? Does the ball bounce out of the cup? What happens to the ball in each gravity situation if it is not projected away from the cup first? Describe how Conservation of Momentum is involved with this experiment? What are the net forces acting on the Kendama in each gravity environment?

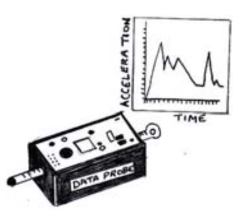
Falling Objects

Description: Soft objects of varying size and mass are provided. These may be dropped during the different gravity environments.

Procedure: During the Martian and Lunar parabolas, drop objects (balls of different sizes, masses, and materials – ping pong, koosh, nerf). Record the time it takes for each object to fall.

Suggested Lessons: Calculate the speed and acceleration and determine the differences in each of the different gravity environments. Do objects of varying masses fall at different rates in reduced gravity? Which of Newton's Laws are demonstrated? Have students measure, calculate, and graph the time and/or distance of various objects. Describe the forces at work? How does acceleration impact the falling objects in each gravity environment?

Data Collection: Probes and Sensors



Description: (Probes and sensors not currently provided by ZERO-G)
Data collection devices (e.g. Pasco's GLX, Vernier's Wireless Dynamics Sensor with accelerometer/altimeter attachment; heart rate sensors and blood pressure monitors).

Procedure: Probe ware will be allowed to collect data about acceleration in 3 dimensions (X, Y, & Z) throughout the flight. Likewise, various sensors such as heart rate, respiration, and blood pressure monitors may be worn comfortably under the flight suit for data collection.

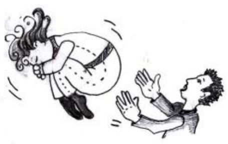
(It should not be necessary to monitor most data during the flight. It is possible for flyer to wear the device, and just turn the instrument on at the beginning of the flight. Probes and sensors must meet all safety guidelines as reviewed by TSA on flight day.)

Suggested Lessons: Take various measurements and compare to student predictions. Does the flyer's heart rate change as the environment changes - Lunar, Martian, Zero-G, and 1.8 G? Using the collected data, have students calculate and graph data sets: acceleration, heart rate, respiration, blood pressure, etc.

Physical Feats

Description: Several physical demonstrations are recommended for Lunar, Martian and Zero G environments. These may be done in conjunction with a flight partner or coach.

Teacher Toss



Procedure: Two flyers will toss the teacher back and forth while experiencing micro-gravity. After the 1.8G pull, each of the "tossers" will stand and secure one foot under the padding on the floor (so they don't float away) so they are across from each other. The teacher to be tossed will stand and curl up into a "ball" to be tossed. The secured teachers then toss the "teacher ball" across the cabin. Observe the reaction on each of the flyers.

Superhuman Strength: Pushups, Superman, Hand stands, Spiderman Cabin Crawl, Flips

Push Ups: When in different levels of gravity, do the following push ups:

- with one hand behind your back
- on your fingertips
- clapping in between each push up
- with a pyramid of teachers stacked above you

Superman Flight: Lie on your stomach until the Zero-G parabola begins. Roll over and gently push yourself up and away with arms outstretched in front of you like Superman. You will find yourself flying across the cabin.

Spiderman Cabin Crawl: Lie with your head toward the wall. Once the Zero-G parabola begins, roll over onto your stomach and quickly pull yourself around the interior of the cabin. You won't need to use your legs and feet, only your hands. Be quick though, or you'll float right off the ceiling!

Flips: After the Zero-G parabola begins, stand and curl into a ball. Ask your coach to twirl you forward, sideways, and even backward. Close your eyes and see if you can tell where you are in the cabin. Without gravity and sight to guide your senses, you probably won't know which way is down.

Suggested Lessons: Perform (or attempt to perform) the various physical feats on Earth with your students. See if your students can perform these feats. How does the physical activity change with each gravity environment? What would it be like to do these physical feats on other planets? What is the difference in performing these feats in a pool? On a trampoline? In outer space? How does gravity affect the speed, direction, and force of the teacher in the teacher toss? How would the effects change in different gravities if the teacher weighed 100 pounds more? Describe the forces at work in each physical feat.

Additional Education Items

Balls (soft materials; various shapes and sizes), small basketball and hoop set, bathroom scale, hula hoops, Koosh balls and plastic Slinkys.

** Safety is ZERO-G's number one objective. Our flights are approved by the FAA and operate at the FAA's highest levels of safety (Part-121). We have proudly flown over 5,000 individuals and have welcomed back many repeat guests.*