LUNAR-CAMP™

Sample Lesson:
“Microgravity”

Objective
Discuss the physical characteristics of the moon including topics like moon composition, presence of water, magnetic field, atmosphere of the moon, etc.

National Standards Met
NCSS 3–People, Places and Environments
NSES 2–Physical Science

Microgravity

Objectives

- Students will be able to explain why astronauts experience weightlessness in space if there is gravity.
- Students will prove through physics/mathematics that there is gravity in a “zero g” environment.
- Students will develop an experiment in which a microgravity environment must be utilized.

Grade level

10-12

Subject Area(s)

Physics
Astronomy

Timeline

1-2 90-minute blocks

Background

Students must be familiar with Newton’s laws and forces in physics.

Materials

Visual on microgravity resources
Water bottle
Wooden frame
Balloon
Rubber bands
Cork with pin in it

Lesson Outline

1. Prior knowledge discussion.
2. Discussion on satellites/space ships as falling projectiles
3. Discussion on weightlessness not caused by gravity but by freefall
4. How much gravity is in the shuttle? This part creates a cognitive dissonance when comparing earth’s orbit with the moon. Weightlessness does not coincide with the amount of gravity present.
5. Defining what weightlessness really is.
6. Demonstrations: Assessing students’ understanding at this point.
7. Applications of Microgravity and places where microgravity can be simulated.
8. Formal Assessment.

Lesson

1. Prior Knowledge:
    a) Show a short movie clip of a popular movie showing astronauts floating in the space ship or Apollo command module.
    b) Ask questions to gauge the students understanding of microgravity
        1. How come the astronauts float?
        2. Is there gravity in space?
        3. Why doesn't the space ship float away in space?
        4. What keeps the moon in orbit?
        5. How much gravity is in the space shuttle if there is any? (Ask students to give an estimate as a percentage of the earth's gravity.)
2. Newton's Cannon:
    a) Ask students to imagine a cannonball shot and where it might land if it was shot faster and faster. Eventually the cannonball would be shot so fast its trajectory would match the earth's curvature and it would fall around the earth instead of landing on it. The cannonball would start orbiting the earth; so essentially a satellite or space ship is a falling projectile.
3. Why do you float when you're in a space ship in orbit? - Elevator Example.
    a) "What does your body feel if you're in an elevator that is going up a very tall building?" - Ans. You feel heavier
    b) "What if you go down that elevator pretty quickly?"– Ans. You feel decreased weight. This is similar to various amusement park rides.
    c) "What if the elevator cord got cut while you were inside?"– Ans. You would be in freefall with the elevator and you would be floating.
    d) "Is there gravity in an elevator?"- So even in an environment where there is gravity you can have "apparent weightlessness"; so gravity seems to be irrelevant.
4. So how much gravity is there in a space shuttle?
    a) If we look at what Isaac Newton did, he formulated the universal law of gravitation $F = \frac{Gm_1m_2}{r^2}$ that states that a gravitational force always acts between objects. Even if r gets really large F will get closer to 0 but it will never get to 0 so there will always be a force. If gravity never equals 0 and weight = mass x gravity than weight will never equal 0 and real weightlessness can never exist. (You can ask the students leading questions to get them to this conclusion if you have time.) So we know that there is gravity on the space shuttle, but how much?
    b) If you plan to figure out the force of gravity on a satellite we can use $F = \frac{Gm_sm_e}{r_s^2}$

        m_s = mass of satellite
        m_e = mass of earth
        r_s = radius of satellite orbit to center of the earth
        If we want to know the force of gravity on a satellite as a percentage of the force of gravity of somebody on earth's surface we can set up a ratio between the two.
        $\frac{F_s \text{ (force on satellite)}}{F_e \text{ (force on person on earth's surface)}}$

        $F_s = \frac{Gm_sm_e}{r_s^2}$ $F_e = \frac{Gm_sm_e}{r_e^2}$

        r_e = radius of the earth

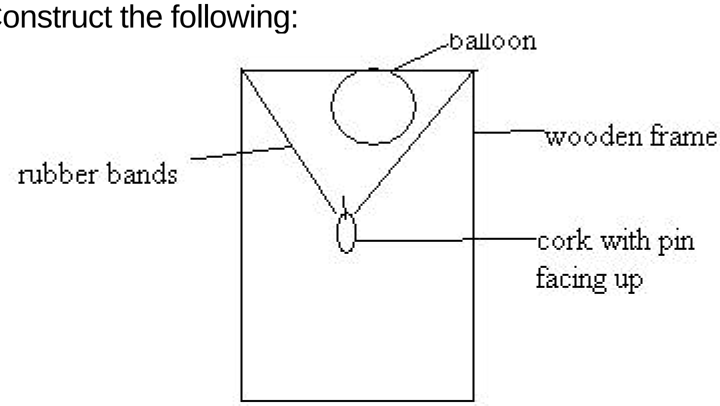
$$\frac{\frac{Gm_s m_e}{r_s^2}}{\frac{Gm_s m_e}{r_e^2}} = \frac{Gm_s m_e}{r_s^2} \times \frac{r_e^2}{Gm_s m_e} = \frac{r_e^2}{r_s^2} = \frac{F_s}{F_e}$$

r_e = 8000 mi
r_s = 8225 mi

There is 94% of the earth's gravity on the space shuttle.

c) "How much of the earth's amount of gravity is on the moon?" (Have the students guess.) – Ans. 17%
d) "Is there enough gravity to walk on the surface of the moon?" – Ans. Yes
e) "So if there is more gravity on the space shuttle than there is on the moon but you can walk on the moon but not on the space shuttle, must "apparent weightlessness" have anything to do with the amount of gravity at that time? – Ans. No, it has to do with freefall!

5. Defining terms:
   Scientists like to say that gravity's <u>effects</u> are greatly reduced in earth orbit not gravity. They call this state microgravity, which literally means small gravity because "zero g" and "weightlessness" can be misleading.
6. Demonstrations: Assess students' understanding at this point.
   a) Construct the following:



Ask the students what will happen when the device is dropped and get possible answers. (Balloon pops in mid air, balloon pops when device hits the floor, or balloon doesn't pop at all.) – Ans. Balloon will pop in mid air. "Why?" – Ans. Once in freefall the cork will experience weightlessness and the tension on the rubber bands will no longer exist and the cork hits the balloon. Students might also state Newton's 1st law, which can also help explain the situation.

   b) Obtain a water bottle with a hole in the side.
      i. Ask the students what will happen if you put water in the bottle. – Ans. It will pour out.
      ii. "What will happen if I drop the bottle at the same time?" – Ans. It will not pour out.
      iii. "What will happen if you toss it up into the air?" (try to lob the bottle up without tumbling)- it will not pour out
      iv. "Why?" – Ans. Both the bottle and water are in freefall, there is no effect of gravity on the water making it pour out of the bottle.

7. Applications of microgravity: Obtain or create a visual of the different ways that microgravity can be experienced here on earth. (Posters can be obtained at the Education Resource Center at the Space Foundation.) Briefly go through the ways NASA can prepare its astronauts or where scientists can run experiments. (KC -135 "Vomit Comet", Black Brant Sounding Rocket, or shot drop towers) It would be beneficial to discuss making bullets in the drop towers or some of the various experiments done on the KC-135 to give the students an idea of their uses.
8. Assessment: Have students get in groups of 2-3's and have them answer the following questions and do the following activity.
    a) If there is gravity in space, why do astronauts experience "apparent weightlessness"?
    b) Is there gravity in the space shuttle? How much? How did we figure this out as a class?
    c) Name two other examples mentioned in class besides the space shuttle where the amount of gravity has nothing to do with the effects of gravity that your body notices?
    d) Activity: You are a group of scientists and your experiment will fly on the KC-135 and it will eventually fly on the space shuttle. Describe an experiment that a scientist might want to perform that can only be done in an "apparent weightlessness". (Hint: Think of things on earth that require gravity to occur or function properly i.e. plant growth, fluid movement, animal movement) You must include 1. your problem you are trying to solve 2. hypothesis 3. experiment with step-by-step procedure.

    (Have students answer questions #1-2 with a 3-5 sentence paragraph, question #4 should be well developed.)

Extensions

Lesson plans can be done on Saturn's moons/satellites and their orbital speeds and periods as well as geostationary orbits can be done after this one to extend discussion on these topics.

Evaluation

- Embedded: probe students during discussion times
- Demonstrations: students should be able to predict and explain outcomes after microgravity discussion
- Questions/experiment design: at the end of the lesson in groups

Resources

Education Resource Center at the Space Foundation
310 S. 14th street
Colorado Springs CO 80904

Lesson concept taken from Space Discovery graduate course, "Biological & Physical Research."