G-Shock Trainer Lesson Plan: What Causes Dizziness?

Location of G-Shock Trainer

Gateway to Space

Overview of G-Shock Trainer

The “G-Shock Trainer” display teaches all about the kinds of training astronauts have to do to prepare for their space mission. A *g force* (g from gravitational) is a measurement of acceleration felt as weight. Whether it’s during launch, re-entry, or other maneuvers, astronauts will experience extreme forces called *g forces* while in space. Astronauts train for this on earth in a centrifuge. Themulti-axis trainer (MAT) “G-Shock Trainer” experience in the Gateway to Spacesimulates the disorientation an astronaut would feel in a tumble spin during a spacecraft reentry into the Earth’s atmosphere…or even during a spacewalk gone bad. Three different “gimbal rigs” allow you to experience roll, pitch, and yawwhile inside. A MAT similar to this one was used during NASA’s Project Mercury program to test the physiological effects of spinning, such as eye oscillation and motion sickness. You can find out if *you* have the right stuff by taking a ride on the MAT.

Background Lesson

This lesson plan/unitcould be used independently or to prepare for (or to extend the learning after) a visit to Spaceport America. It can be used by teachers or parents wishing to make the Spaceport visit a richer learning experience (for everyone!).

Have you ever gotten dizzy while spinning around? Most people know that this dizziness is caused by the workings of your inner ear, but do you really know why? In this lesson, your students will experiment to feel the effects of spinning and learn what causes them to feel dizzy.

First, let’s define roll, pitch, and yaw (the three directions of the MAT) in terms kids can understand. Ask them to stand up straight with their arms straight out to the side and pretend they are airplanes. Now imagine, you tell them, that you are going to move through space in different directions. With your feet stationary on the ground bend your body *only at the waist*…

- Roll is when you bend at the waist side to side. One arm seems to go up, while the other goes down.

- Pitch is when you bend at the waist forward and back. Your head seems to go forward and back.
- Yaw is when you twist at the waist right to left and left to right. One arm points to the front while the other points to the back and vice versa.

These three rotations can happen independent of one another, or all at the same time. In the MAT trainer, they happen all at once…over and over again!

Humans, like most mammals, have a vestibular system inside the inner ear. It helps us with balance and sensing motion. There are two main systems that work together: the otoliths (which use gravity to help us balance) and the semi-circular canals (that help us sense motionand acceleration).

The inner ear has two areas called the utricle and the saccule. Each area has cells covered with a gelatinous material and hair-like sensors. On top of this gelatinous material are otolithic organs, tiny crystals of calcium carbonate (chalk!). These are influenced by gravity. As you move your head, gravity pulls them in different directions causing the hair-like sensors to move. They send a message to your brain, and your brain interprets that information to help you know how your head is oriented (upside down, sideways, or right side up). That helps you with static balance.

But what about motion? Just like the three gimbals at right angles to one another inside the MAT trainer, thethree semi-circular canals are at right angles to one another in the inner ear. They are connected at the base in a small space called the ampulla. Inside the semicircular canals is a fluid called endolymph. Each canal is lined with tiny hair-like sensory nerve cells. As you move around, gravity causes the fluid to move against the sensors and sends messages to your brain. Working together the fluid, the sensory nerves, and the brain help you know which way your head is moving.

So, why do you get dizzy? Well, when you spin, the endolymph begins to move, too. Because of inertia (the tendency for an object at rest to stay at rest and for and object in motion to continue in motion in a straight line) the fluid does not move inside the semicircular canal at quite the same rate your head might move. As you continue to spin though, the fluid “catches up” and the tiny hair-like sensors stop being stimulated. But when you stop, inertia makes the fluid keep on going and stimulates the nerves in a different direction. Now your brain is confused; it thinks you are still spinning. This is what causes the dizzy feeling.

Without the earth’s gravity to help the sensory systems in our ears and brain, astronauts in space can also feel dizzy. In fact, the sensation feels like constantly falling…like when you ride in an elevator or on a roller coaster. Because in space there is no clear “up” or “down” astronauts can quickly become disoriented. The multi-axis trainer helps to prepare them for this feeling.

Of course, our eyes also work with our ears and brains to help us keep a sense of balance while moving. In fact, this is why we sometimes get motion sickness. When *feeling* motion but not *seeing* it (for example, when you are in a boat focusing inside the boat and not looking at the ocean), the inner ear transmits to the brain that it senses motion, but the eyes tell the brain that everything is still. Your brain comes to the conclusion that either the eyes or the earsare hallucinating, and it assumes you have ingested poison. The brain then responds by inducing vomiting to clear the supposed toxin. This same effect can happen when riding in a car and trying to read. Since your eyes are focused inside the car and *cannot* detect motion while the ears and rest of your body *can* detect motion, the brain is confused and responds with nausea.

Rotating devices such as centrifuges used in astronaut training and amusement park rides cause motion sickness in many people. While the interior of the centrifuge does not appear to move, your body will experience a sense of movement. Also, centrifugal force can cause the fluid in the vestibular system to sense that *downward* is in the direction away from the center of the centrifuge rather than the true downward direction.

Grade Level

Grades K-8

Learning Objectives

The student will:

- Be able to describe pitch, roll, and yaw.
- Experiment to feel the effects of spinning and discover what causes them to feel dizzy.
- Draw conclusions about how the ears, eyes, and the brain work together to help you balance and perceive motion.
- Create a drawing/model of the human inner ear.

Assessment

When shown a diagram of the human ear, students will be able to locate the semicircular canals and relate them to a sense of balance.

Required Materials

Internet for research
Drawing paper
Markers or colored pencils
Play-Doh or modeling clay (optional for making models)

Time Required

One class period.

Step-By-Step Procedures

1. Show the animations about Roll, Pitch, and Yaw (link found in Other Resources).
2. (Experiments might best be performed outside in the grass.) Have the students perform the roll, pitch, and yaw body movements as stated in the Lesson Background. Discuss the three planes of movement. If you have already visited Spaceport America, relate this to the multi-axis trainer's three planes of motion.
3. Ask the students to perform the movements again, but this time with their eyes closed. Discuss how you can still tell which position your head is in.
4. Younger students might enjoy "flying around" like an airplane. Talk about how they are able to stay balanced as they move around, even with their eyes closed.
5. Now, with their eyes open, ask the students to spin around to the right 5-10 times. Then ask them to stop abruptly. Note the feeling of dizziness. Ask them how their eyes are behaving.
6. Once they have recovered, ask them to do it again, but this time, instead of stopping abruptly, ask them to spin around in the other direction the same number of times. Note if there is any difference in the feeling of dizziness. (They should not feel as dizzy because the fluid in the inner ear will stabilize having been pushed back to the ampulla where it has become stationary.)
7. Once back inside, show students a diagram of the human ear. Point out the semi-circular canals. (See Other Resources for links.) Explain how the fluid moves inside these canals as explained in the Lesson Background.
8. Distribute art materials.
9. Allow students to draw (or simply label) the ear. As an alternative, you may wish to have your students create a model of the ear using modeling clay or Play-Doh.

Alignment to Next Generation Science Standards

The following Next Generation Science Standards align well with this unit.

- 4-LS1-2. Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.
- MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

Other Resources:

- Roll, Pitch, and Yaw – This animated page shows the three rotations in a way that is easy to understand. http://howthingsfly.si.edu/flight-dynamics/roll-pitch-and-yaw

- NASA - The Gimbal Rig Mercury Astronaut Trainerhttp://www.nasa.gov/centers/glenn/about/history/mastif.html#.U-kUgPldWkY
- What makes you dizzy when you spin? http://science.howstuffworks.com/science-vs-myth/everyday-myths/question4831.htm
- Diagram of the human ear anatomy with labels. http://commons.wikimedia.org/wiki/File:Anatomy_of_the_Human_Ear.svg
- Diagram of the human ear anatomy without labels. http://commons.wikimedia.org/wiki/File:Anatomy_of_the_Human_Ear.svg#mediaviewer/File:Anatomy_of_the_Human_Ear_blank.svg
- Great drawing of the semicircular canals (showing each ampulla), the utricle, and the saccule. http://www.answers.com/topic/vestibular-system-1