Disorientation and Motion Sickness

Session Time: One, 50-minute session

DESIRED RESULTS

ESSENTIAL UNDERSTANDINGS

Pilots must be aware of their physical and mental condition in order to conduct safe flights.

Geographic, atmospheric, environmental, and physiological conditions may create situations where a pilot's spatial orientation is inaccurate and cannot be relied upon.

Pilots must understand the types and nature of illusions and disorienting conditions they may encounter in flight and how to overcome inaccurate perceptions.

ESSENTIAL QUESTIONS

1. What affects a pilot's spatial orientation?

LEARNING GOALS

Students Will Know

- How the human ear interprets motion.
- Illusions associated with spatial disorientation.
- Techniques pilots can use to cope with spatial disorientation.

Students Will Be Able To

- *Identify* parts of the human ear associated with balance and orientation. [DOK-L1]
- *Predict* sensations a pilot may feel when specific physical motions are encountered. [DOK-L2]
- *List* methods pilots can use to prevent spatial disorientation. [DOK-L1]

ASSESSMENT EVIDENCE

Warm-up
As a class, students will brainstorm ideas about the physical cues a pilot may receive to understand their orientation in space. This will lead into an activity which will test the application of some of those ideas.

Formative Assessment
In small groups, students will contribute to a class effort to correctly identify the parts of the inner ear that affect the vestibular sensory system.

Summative Assessment
In pairs, students will describe how the inner ear contributes to motion and then evaluate realistic scenarios affected by spatial disorientation and determine a corrective course of action.

LESSON PREPARATION

MATERIALS/RESOURCES

- Disorientation and Motion Sickness Presentation
- Disorientation and Motion Sickness Student Activity 1
- Disorientation and Motion Sickness Teacher Notes 1
- Disorientation and Motion Sickness Teaching Aid 1
    - Chair with rotating seat, similar to an office chair
    - Blindfold or sleeping eye mask
    - Ginger candies
    - Peppermint candies
    - Small paper bags, or immediate access to a trash can
- Disorientation and Motion Sickness Teaching Aid 2
    - 1 gelatin ring mold or tube cake pan
    - 2 metal washers (” diameter hole)
    - 1 plastic soft drink straw
    - 1 wooden craft stick
    - 1 hot glue gun and appropriate glue stick
    - 1 paper clip
    - 1 utility knife
    - 1 “Lazy Susan” turntable
    - Water to fill gelatin ring mold

LESSON SUMMARY

Lesson 1: It’s Getting Harder to Breathe
Lesson 2: Your Eyes Are Deceiving You
Lesson 3: Disorientation and Motion Sickness

The lesson begins with a warm-up in which students brainstorm possible cues pilots have in determining their orientation in space. This is followed with an activity in which students observe the physical effects of specific orientation cues using a spinning chair.

Students then explore the details of the vestibular system, and how it provides a person with sensory information about their motion and position. Students also discover the various vestibular illusions, and then learn about the role of the somatosensory system in motion and orientation.

Students also learn about somatosensory illusions which result from sensations generated by nerves in the skin, muscles, and joints. Sensations of weight, pressure, and sounds can sometimes contribute to disorientation.

Additionally, students learn how to prevent and compensate for vestibular and somatosensory illusions.

BACKGROUND

Pilots are sometimes said to fly “by the seat of their pants,” but in reality, relying only on how an airplane “feels” can be dangerous. One of the most important senses to a pilot is their vision, as noted in the previous lesson. But when visibility is obscured or the eyes are “tricked” by the environment, some pilots may instinctively rely on what they physically feel in the aircraft. People normally rely on the inner ear to provide information on movement and balance, but they aren’t used to interpreting the inner ear’s signals in an aircraft–which can move not only left and right, forward and backward, but also up and down. Similarly, pilots can interpret movement based on the forces on their skin, joints, and muscles, but those forces may deceive the pilot into believing the aircraft’s attitude is something other than what it actually is.

Pilots sometimes do fly “by the seat of their pants,” but they are at their best when they acknowledge the limitations of their senses. For example, a pilot can be in a steady, descending, banked turn, and yet be convinced by their eyes, inner ear, and body forces that they are in level flight. When a pilot’s perception differs from reality like this, they are said to be experiencing spatial disorientation.

Though beyond the scope of this lesson, some students may be interested to know that spatial disorientation may fall into one of three categories.

- Spatial disorientation can be recognized when one of the three sensory systems disagrees with the others, and the pilot knows there is a discrepancy in their senses. While uncomfortable, the pilot is aware enough to realize that something is wrong and is able to take corrective action.
- Sometimes, however, the three sensory systems can agree but also be different than reality, so a pilot won’t even know they’re disoriented. This is unrecognized spatial disorientation. Unrecognized spatial disorientation is dangerous because pilots are unaware they need to correct their flight attitude, which could lead to a loss of aircraft control or impact with the ground.
- The third type of spatial disorientation is incapacitating spatial disorientation. In these cases, pilots may be aware that they are disoriented, but the disorientation is so severe that they are incapable of correctly applying the necessary corrective measures to right the airplane on their own.

Flying in good visibility during the day and in smooth air is the best way to prevent spatial disorientation. When that is not possible, pilots are trained to refer to flight instruments: the attitude indicator, turn coordinator, heading indicator, airspeed indicator, altimeter, and vertical speed indicator. The instruments are considered trusted and true: even when a pilot’s body feels as though they are in a turn, a level attitude indicator and a steady heading indicator tell the pilot they are flying straight and not turning. If a pilot feels they must be descending, the steady altimeter, vertical speed indicator, and airspeed indicator tell the pilot they are holding altitude in level flight. If the pilot can overcome their physical sensations and trust the instruments, these instruments will help a pilot overcome the limitations of the human body.

A disconnect between what the body feels and what it sees can cause disorientation. Consider an example where a pilot feels turbulence, but also sees the inside of the aircraft, which is not moving in relation to the pilot’s body. The disconnect between what is seen and felt is a common source of motion sickness. Because an aircraft moves in different ways than a car, motion sickness in the air, or airsickness, is more common than carsickness.

Airsickness is common, especially in the early stages of flight training. Flying is not something to which the human body is accustomed. Normally, the tendency to feel airsick decreases as a pilot gains experience flying. However, even highly-experienced pilots encounter airsickness. For example, astronauts talk about experiencing motion sickness, and many astronauts have extensive flight experience.

MISCONCEPTIONS

Students may think that only inexperienced passengers or pilots can get motion sickness while flying. In fact, anyone of any experience level can get airsickness. Various mental, environmental, and physiological factors affect the body and can contribute to almost anyone feeling disoriented or ill while flying. For example, experienced pilots may feel sensations of airsickness if they fly on an empty stomach.

Students may think that if a pilot experiences airsickness on an introductory flight, they should not try learning to fly. Flying exposes a person's vestibular, somatosensory, and visual systems to new sensations. Once a pilot becomes accustomed to the new sensations associated with flight, tendencies toward airsickness usually subside.

DIFFERENTIATION

To support student comprehension in the **EXPLAIN** section, have students create a table matrix to document the conditions, results, and coping strategies for conditions discussed in slides 15–19. This strategy will strengthen student recall.

To prepare students to perform well in the **EVALUATE** section, provide students with similar scenarios that they will encounter in the **Summative Assessment**. Demonstrate one or two scenarios through a think-aloud, where the instructor is able to explain the thinking process as they apply the learning concepts to the scenario.

LEARNING PLAN

ENGAGE

Teacher Material: Disorientation and Motion Sickness Presentation

Slides 1-3: Introduce the topic and learning objectives of the lesson.

Slide 4: Conduct the **Warm-Up**.

Warm-Up

Pilots' senses can help them orient themselves in space (for example, knowing which way is "up") and detect movement.

As a class, brainstorm: What physical cues might pilots use to know their orientation, including if they are moving and in what direction?

Responses may vary, but should include:

- *Visual cues (position of the horizon/sky/ground, what the instruments read, relative motion of objects compared to each other or parts of the aircraft)*
- *Inner ear (swaying, balance; semicircular canals respond to acceleration in any axis)*
- *Hearing (sound of rushing air, tires rolling over pavement, changes in engine sounds)*
- *Nerves/sense of touch (force of gravity, feelings of pressure on skin)*

Recall the discussion on visual illusions from the previous lesson (Lesson 8.B.2). Like visual sensations, in which a pilot may "see" an image that does not reflect reality, physical sensations can be a common cause of spatial disorientation in the same manner. Due to physical sensations, pilots can "feel" that they are flying one way when in fact they are flying another way.

EXPLORE

Teacher Materials: Disorientation and Motion Sickness Presentation, Disorientation and Motion Sickness Teaching Aid 1

Slide 5: Conduct the Barany chair demonstration using **Disorientation and Motion Sickness Teaching Aid 1**. Complete the activity by discussing the students' ideas of possible impacts of disorientation to a pilot flying an aircraft.

Teaching Tips

The Barany chair is named for physiologist Robert Bárány. Bárány used the chair in his research into the inner ear's role in the sense of balance, for which he won the 1914 Nobel prize in Physiology for Medicine. The Barany chair is still used for physiology training today by various flying organizations, including the U.S. Air Force.

EXPLAIN

Teacher Materials: Disorientation and Motion Sickness Presentation, Disorientation and Motion Sickness Teaching Aid 2

Slides 6: The human body determines its orientation based upon information from three primary systems:

- The **visual system** uses the eyes to sense position based on what is seen visually.
- The **somatosensory system** uses the nerves in the skin, muscles, joints, and the sense of hearing. This system senses position based on gravity, touch, and sound.
- The **vestibular system** uses the inner ear, which measures balance and acceleration.

Slides 7-8: The inner ear has three semicircular tubes that are arranged at approximately right angles to each other. This allows each to sense movement on one axis in all three dimensions. This can be described as the x, y, and z axes: in aviation, these are known as the pitch axis, roll axis, and yaw axis. Each semicircular canal contains a liquid called endolymph fluid that moves as the head is moved. As the head moves, the fluid passes through tiny hairs which are located in the cupola of the otolith organ. One example of this canal and organ is shown in the diagram on the slide. The hairs deflect, which creates a signal that is transmitted via the vestibular nerve to the cerebellum as nerve impulses that the brain recognizes as motion.

Review the parts of the inner ear with students using the diagram on slide 8.

Slide 9: In an ideal environment, each of these three systems (somatosensory, visual, vestibular) provides complementary information to the brain, which integrates those signals to give a strong, clear idea of where the body is and how it is moving. When one or more of the systems doesn't agree, problems can arise. Taking the human body and putting it in an aircraft in flight can challenge the body's systems. For example, as seen in the lesson on visual illusions, a pilot's eyes can be deceived by a false horizon. While the eyes may think the pilot is level as they see the false horizon, the vestibular system may believe the pilot is in a banked turn. This disconnect between sensory systems can cause discomfort, confusion, and even motion sickness.

Slide 10: Have the students watch the following two videos. The first is a basic explanation of the inner ear, and the second explains how the vestibular system communicates with the brain about motion and balance.

- "How the Inner Ear Balance System Works" (Length 1:20)
  https://video.link/w/s9g3
  For teachers unable to access Safe YouTube links, the video is also available here: https://www.youtube.com/embed/YMIMvBa8XGs?start=0&end=80

- "Understanding the Causes of Vertigo" (Length 2:53)
  https://video.link/w/lCg3
  For teachers unable to access Safe YouTube links, the video is also available here: https://www.youtube.com/embed/kx4mQB0QzvQ?start=0&end=173

Teaching Tips

The previous videos focused on the biology of what causes vertigo. For a more basic understanding of what vertigo is, watch the following video:

- "What is Vertigo?" (Length 1:31) https://video.link/w/34g3
- For teachers unable to access Safe YouTube links, the video is also available here: https://www.youtube.com/embed/j04qNXaCm0Y?start=0&end=91

Slide 11: The videos explain why the Barany chair has the effects that it does on the body. The rotation of the chair causes the endolymph within the semicircular canal of the inner ear to begin moving. At first, the inertia of the fluid causes it to lag behind the motion of the pilot's body. This causes the cupola and its hair cells to bend, which the pilot perceives as motion. If the chair achieves perfectly steady motion, the fluid in the ear will stabilize and the hairs will straighten, which the brain will perceive as no motion even though the body continues to move. When the chair is stopped, the momentum of the endolymph causes it to continue moving even though the pilot's head and semicircular canals have stopped. This pushes the hair cells in the opposite direction, which sends a false signal to the brain that the direction of motion has reversed.

Slide 12: To help understand what effect the vestibular system may have on a pilot, watch the following video:

- "Aeromedical Factors" (Length 2:32) https://video.link/w/NDg3

  For teachers unable to access Safe YouTube links, the video is also available here: https://www.youtube.com/embed/xK44nFczul0?start=1002&end=1154

Slide 13: Ask the questions below about system disconnects.

Questions

Have you ever experienced a disconnect between what you saw and what you felt? Have you ever had any kind of motion sickness? How could this happen?

Responses will vary, but may include experiences in vehicles (airplanes, cars, boats), roller coasters, playground equipment (merry go-rounds) or similar. In each case, what the person saw became disconnected from what the person was feeling, which may have contributed to discomfort and nausea. Students may also recognize that stress, illness, excitement, anxiety, or familiarity affected their relative propensity to experience motion sickness.

One fairly common example of vestibular disorientation is the feeling of motion sickness while reading in a moving car. Motion sickness in a car can be experienced if a person is focused on something that is not moving relative to their eyes in the car (as when reading), but the car is in motion. The motion of the car causes the endolymph fluid to move about, but the eyes don't see the motion. The conflicting information being sent to the brain can contribute to motion sickness.

Slide 14: Ask the question below about semicircular canals.

Questions

How do the semicircular canals relate to the movements of the aircraft?

Each of the three semicircular canals is related to an axis of aircraft motion (pitch, roll, yaw).

Slide 15: Just like the eyes, the vestibular system can also cause illusions. Because they are a "feeling" or physical sensation rather than a sight, these illusions can sometimes be quite disorienting and difficult to overcome, even if a pilot knows they are experiencing an illusion.

The **Coriolis illusion** occurs when the ear becomes stabilized in a turn and the pilot suddenly moves their head on a different axis. The head movement may cause the fluid in the ear to move, and this in turn creates the illusion of the aircraft itself turning or accelerating on a different axis. The pilot may think the aircraft is performing a maneuver it is not, and maneuver the aircraft in an attempt to stop the perceived (but non-existent) motion. The result can place the aircraft in a potentially dangerous attitude. To minimize the potential of a Coriolis illusion, pilots should develop the habit of cross-checking instruments such as the attitude indicator, altimeter, heading indicator, airspeed indicator, turn coordinator, and vertical speed indicator.

Slide 16: The **Leans** is the most common vestibular illusion, and it is generally experienced after terminating a long, slow turn, especially an unintentional or unnoticed turn. The human ear can't sense a turn acceleration of 2 degrees per second or lower, so a very gradual turn may not even be noticed by the pilot. If the pilot levels the wings after such a turn, this may cause an illusion that the aircraft is banking in the opposite direction. In response to such an illusion, a pilot may lean in the direction of the original turn in a corrective attempt to regain the perception of a correct vertical posture. If not corrected, this could lead to a "graveyard spiral" (see next slide). To cope with or mitigate this illusion, pilots need to continuously cross-check the horizon and their instruments.

Show the following video:

- "The leans illusion. How pilots get disoriented." (Length 1:46)
  https://video.link/w/YDV5

  For teachers unable to access Safe YouTube links, the video is also available here: https://www.youtube.com/watch?v=5ZG17H8yizI

Slide 17: The **graveyard spiral** occurs when a pilot thinks they are straight and level but are, in fact, turning. Since the pilot doesn't realize they're turning, the aircraft's nose drops below the horizon and the aircraft begins to descend. The pilot recognizes the descent and attempts to fix it by pulling back on the yoke to raise the nose, as they would if they were in level flight. However, because they are actually turning, pulling back tightens the turn and increases the altitude loss. If not corrected, the illusion may lead to loss of aircraft control or impact with terrain. To cope with or mitigate this illusion, pilots need to continuously cross-check the horizon and their instruments.

Slide 18: The **somatogravic illusion** is caused by acceleration or deceleration. For example, on takeoff, the rapid acceleration may stimulate the otolith organs in the ear the same way as if the head had been tilted backward. The pilot may feel this as a "pitch up," particularly when visibility is low, like a night or poor weather takeoff. Failing to acknowledge this condition or correct for the illusion could result in a pilot pushing the nose down when they should not do so, which could result in an unintended nose-down or dive attitude. Similarly, a rapid deceleration could cause the sensation of a pitch down, which, if not understood, could cause the pilot to raise the nose, potentially resulting in an unintended nose-up or stall attitude. To mitigate this hazard, pilots should try to use small, smooth inputs in their flying.

Slide 19: The **inversion** is caused when a pilot in a climb abruptly levels off, which creates the sensation of tumbling backward. As a result, the pilot may feel the need to push forward, which could exacerbate the illusion and lead to a dangerously nose-low condition.

The **elevator illusion** is caused by an abrupt upward or downward acceleration, normally caused by an updraft or downdraft. The draft causes an apparent vertical acceleration, and a pilot may try to "correct" by pushing into a nose-low or pulling into a nose-high attitude that is unnecessary.

To cope with or mitigate these illusions, pilots need to be aware of their potential and pay close attention to the horizon, their attitude, and their instruments while flying.

Slide 20: Conduct the inner ear demonstration using **Disorientation and Motion Sickness Teaching Aid 2**. Ask students: *How does this demonstration relate to the earlier Barany chair demonstration?* (The teaching resource contains a sample response.)

Slides 21-22: Complete the **Formative Assessment**.

Formative Assessment

There are a variety of ways the teacher may administer this **Formative Assessment**. Display Slide 21 (the unlabeled diagram of the inner ear). Students may write answers in their notebooks and discuss the answers as a class.

Another option would be to divide the class into small groups. Start with the first group and have them identify a part of the inner ear. Rotate through the groups, allowing them to discuss the answer among themselves for a few seconds if needed.

Alternatively, have groups compete to provide the answer in the shortest time. Slide 22 contains the correct identifying labels.

[DOK-L1; *identify*]

Slide 23: Besides the visual and vestibular systems, the **somatosensory system** is another way the body determines its orientation and motion. It is composed of the skin, joints, and muscles, and the sense of hearing. Pressures on the body and the sounds around it normally help the body determine position and motion, and the movement of an aircraft can influence these senses. Flying by this "feel" is what is often referred to as "flying by the seat of the pants." When combined with visual and vestibular cues, it can be an effective means for sensing one's orientation. However, relying solely on the somatosensory system can cause problems, because many flight conditions "feel" the same. For example, in a well-executed, coordinated, and steady-rate turn, all force is directed "down" through the pilot's spine. There is no acceleration, and the feeling the pilot experiences is similar to that when no turn is happening. Thus, even though the aircraft is turning, the signals sent by the somatosensory system may send signals to the brain that the aircraft is in level flight.

An example of this is shown in the diagram on the slide, which illustrates that the "feeling" the pilot experiences in each of the three unique flight conditions is the same, even though the condition of the airplane varies widely.

To emphasize the fact that an occupant in an aircraft that is flying in a coordinated condition may always sense that "down" is toward the floor of the aircraft and not necessarily toward the ground, watch the video below. In order for the water to be poured into the cup without spilling, the effective force must be toward the floor of the aircraft. When done correctly, a person's somatosensory system may be fooled, and the pilot may think they are upright even if the aircraft is not.

- “Bob Hoover Barrel Roll” (Length 0:45)
  https://video.link/w/oXW5

For teachers unable to access Safe YouTube links, the video is also available here: https://www.youtube.com/watch?v=V9pvG_ZSnCc

Teaching Tips

Watching the “Bob Hoover Barrel Roll” video more than one time may be helpful. Tell the students that even in a roll, the force vector from the ceiling to the floor of the aircraft cabin can be made to feel like gravity.

During the video, note the fact that the tea remains level in the glass. Also, there is a white ball hanging from a string (under the glass). Notice that it remains in a position where it appears to be hanging straight down at all times.

Ask students: *Did anyone experience any confusion from your senses while watching the video?*

Slide 24: Failure to understand or properly respond to the limitations of these body orientation systems can result in minor discomfort or even major accidents. There are three areas of emphasis about which pilots should be aware (and which are discussed on the following slides): motion sickness, VFR into IMC, and VFR at night.

Slides 25-26: Motion sickness is caused by the brain receiving conflicting messages about the state of the body. It usually includes general discomfort, nausea, dizziness, pale complexion, sweating, and vomiting. It is not uncommon to experience motion sickness during early flights in training. Anxiety and stress can compound the issues of disorientation and contribute to motion sickness, but anxiety and stress generally decrease with increased experience in the airplane.

Emphasize that airsickness is not a reflection on a person’s ability as a pilot. It is a natural response to the environment and stresses on the body that, while potentially detrimental to a pilot’s performance, can be overcome with time, training, and experience.

Slide 27: “VFR into IMC” is a phrase that refers to a pilot flying under visual flight rules (VFR) who inadvertently flies into instrument meteorological conditions (IMC). In simpler terms, this occurs when a pilot who was flying by visual references inadvertently flies into a cloud. In IMC, visual references are lost as the pilot can no longer see the horizon. Unfortunately, without a visual reference, the vestibular and somatosensory systems can be misleading. If not dealt with properly and quickly, the pilot could become dangerously disoriented. As a result of this risk, the FAA requires that even pilots who are only authorized to fly under VFR conditions receive some training on how to fly in IMC. While they should not plan to enter IMC, VFR pilots who inadvertently encounter IMC are trained to transition their visual scan to their cockpit instruments, where they will find an artificial horizon to determine their orientation. The recommended procedure to follow when this happens is to use the attitude indicator and heading indicator to make a 180-degree turn. This should allow the pilot to return to visual meteorological conditions.

Slide 28: Flying **VFR at night** is another scenario that lends itself to opportunities for disorientation. As noted in the lesson on visual illusions (8.B.2), there are few visual cues at night, and the cues that are present may be misleading. Pilots train and plan to include their cockpit instruments in their visual scan with greater frequency than during the day to mitigate some of the loss of outside visual references.

EXTEND

Teacher Material: Disorientation and Motion Sickness Presentation

Slide 29: To cope with disorientation and motion sickness, it is important to understand what causes it. To recap, the primary source of disorientation is a disconnect between what the body is feeling and what the eyes see, and it can be compounded by anxiety and stress. Learning to use and trust cockpit instruments is crucial to avoiding or dealing with disorientation. All pilots receive training on the fundamentals of instrument flying, which can help mitigate disorientation in the event visual cues are lost. Inadvertent flight into IMC is still dangerous however, and pilots should exercise good decision making to avoid the potential of such a situation. Pilots should also make sure they are "fit to fly" in accordance with FAA recommendations by using the "IMSAFE" or other appropriate self-check checklists. Pilots should remember they are ultimately responsible for the safe operation of their aircraft, and should not fly into conditions beyond their capabilities.

Teaching Tips

While training is a valid means of preparation and can help mitigate the effects of disorientation, it is actually quite difficult for pilots to train for the illusions associated with these three sensory systems because they depend on motion and acceleration. Organizations like the US Air Force continue to use physiological training methods (including the Barany chair) for illusion training, instrument confidence, and airsickness. However, classroom academics or simulators (even so-called "full motion simulators"), while helpful, cannot duplicate the physical sensations associated with flight that lead to spatial disorientation. The best training for pilots is for them to experience the actual flight conditions in an intentional, controlled environment with an experienced instructor pilot onboard.

Slide 30: To mitigate other potential issues with disorientation and motion sickness, pilots (and passengers) should look out the window at reliable, fixed reference points on Earth's surface. If airsickness becomes an issue in training or during a flight, pilots should:

1. Fly more often. Consistently exposing the body to the aircraft and flying environment will build confidence, decrease anxiety, and help the body become accustomed to the motions of the aircraft. Delaying flights or flying less often decreases the ability of the body to build up this experience and tolerance.
2. Inform the instructor if they are experiencing discomfort during a flight. Instructors cannot help if they don't know what is happening.
3. Continue to fly the aircraft as much as possible. The concentration required for piloting can help distract a pilot from feelings of sickness, and the immediate connection between the aircraft's yoke and its movement can help reduce the disagreement in the body's sensing systems that may contribute to sickness.
4. If in training, consider shorter flights and avoiding turbulence. Shorter flights provide less time for the body's discomfort to increase and can aid in building a tolerance to the unique environment of flight. Pilots may be able to avoid turbulence by, for example, flying in the calmer early morning hours. Gaining experience during this time will allow a student pilot to build confidence and experience in the aircraft and reduce the propensity for airsickness in future flights.
5. Open fresh air vents or the window, if possible, and direct air onto the face.
6. Avoid head movements and focus on the distant horizon.
7. When preparing for a flight, stay hydrated and eat a small amount of food. They should not eat large or greasy meals, but also do not avoid food, as flying on an empty stomach can be equally upsetting.
8. Not take medications not approved by the FAA. This includes over-the-counter motion sickness medications, many of which have side effects that include drowsiness. However, some studies have found that ginger or peppermint candies can help alleviate feelings of nausea.

EVALUATE

Teacher Materials: Disorientation and Motion Sickness Presentation, Disorientation and Motion Sickness Teacher Notes 1
Student Material: Disorientation and Motion Sickness Student Activity 1

Slides 31-42: Review the summary questions.

Slide 43: Conduct the **Summative Assessment**.

Summative Assessment

Distribute **Disorientation and Motion Sickness Student Activity 1**. Students will individually review the components of the vestibular system and evaluate scenarios for disorientation and motion sickness. If desired, divide class into pairs and allow partners to complete the assessment together. Potential responses are available in Disorientation and Motion Sickness **Teacher Notes 1**.

[DOK-L1; *identify; list*] [DOK-L2; *predict*]

Summative Assessment Scoring Rubric

- Follows assignment instructions
- Responses show evidence of one or more of the following:
  - Correct recall of body system, spatial disorientation, and coping mechanics
  - Reasonable application of system, orientation, and mechanics to scenarios
  - Evidence and explanation of the above that demonstrate understanding of the material
- Contributions show understanding of the concepts covered in the lesson
- Contributions show in-depth thinking including analysis or synthesis of lesson objectives

Points	Performance Levels
9-10	Correctly understands all body systems, spatial disorientation, and coping mechanics, and makes a reasonable application and analysis of those factors to scenarios, with appropriate explanations.
7-8	Correctly understands most body systems, spatial disorientation, and coping mechanics, with some errors, and makes generally reasonable application and analysis of those factors to scenarios, with some incomplete analysis or errors.
5-6	Correctly understands some body systems, spatial disorientation, and coping mechanics, with errors, or makes generally reasonable application and analysis of those factors to scenarios but lacks adequate explanation.
0-4	Provides few, if any, correct ideas about body systems, spatial disorientation, and coping mechanics, and/or makes poor application and analysis of those factors to scenarios with inadequate explanation.

STANDARDS ALIGNMENT

COMMON CORE STATE STANDARDS

- **RST.11-12.2** - Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
- **RST.11-12.4** - Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 11-12 texts and topics*.
- **WHST.11-12.6** - Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.
- **WHST.11-12.8** - Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
- **WHST.11-12.9** - Draw evidence from informational texts to support analysis, reflection, and research

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