6 Aerial Navigation

Content Area:	**Science**
Course(s):	**Aerospace Engineering**
Time Period:	**Semester 1**
Length:	**3 Weeks**
Status:	**Published**

Standards

12.9.3.ST-ET	Engineering & Technology Career Pathway
12.9.3.ST-ET.2	Display and communicate STEM information.
12.9.3.ST-ET.3	Apply processes and concepts for the use of technological tools in STEM.
12.9.3.ST-ET.5	Apply the knowledge learned in STEM to solve problems.
12.9.3.ST-SM	Science & Mathematics Career Pathway
12.9.3.ST-SM.1	Apply science and mathematics to provide results, answers and algorithms for engineering and technological activities.
12.9.3.ST-SM.2	Apply science and mathematics concepts to the development of plans, processes and projects that address real world problems.
SCI.9-12.HS-PS4-5	Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.
SCI.9-12.HS-PS4-2	Evaluate questions about the advantages of using digital transmission and storage of information.
SCI.9-12.HS-PS4	Waves and Their Applications in Technologies for Information Transfer
SCI.9-12.HS-PS4-1	Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
	Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the earth.

Enduring Understandings

1. All angles must be measured with respect to some reference, and on Earth this reference could be true north (the northern point of the Earth's rotational axis) or magnetic north (the location of the Earth's north magnetic pole).

2. The motion of an object in the air, with respect to the ground, is related to both its own motion and the motion of the air in which it is traveling.

3. A magnetic compass, such as used for navigation, always gives direction based on the angle the object is pointed with respect to magnetic north.

4. If the object's speed with respect to the ground is known, basic kinematics can be used to compute the time required to travel given distances.

5. Electronic aides to navigation, be they a ground or space-based transmitter, can be received by a radio receiver in the aircraft to find the aircraft's position relative to the transmitter or transmitters and make aerial navigation easier.

Essential Questions

1. How can a pilot navigate from one location to another with a stopwatch and magnetic compass?

2. How can relative motion be solved using vector mathematics?

3. How can electronics and radio transmissions be used to simplify aerial navigation (or navigation at sea)?

Knowledge and Skills

Knowledge:

- The direction of travel of any object on Earth is given as the angle between the object's motion and either true north (the northern point on the Earth's axis of rotation) or magnetic north (the location of the earth's magnetic north pole).
- The angle between true north and magnetic north varies, and in aviation is known as "magnetic variation". In other disciplines, such as nautical or wilderness navigation, it is known as the angle of declination.
- The motion of an aircraft relative to the ground is the vector sum of the aircraft's velocity vector with respect to the ground and the air's velocity vector with respect to the ground. The air's velocity vector with respect to the ground is known as wind; it is the motion of the air. The pilot or navigator knows the magnitude and direction of the wind vector, and knows the direction of the required motion over the ground, and must use vector subtraction to find the required heading of the airplane to compensate for the wind. The aircraft's airspeed over the ground is based on the airplane's performance and can be found on performance charts.
- The vector navigation problem can be solved graphically with a ruler and a protractor using a wind triangle, or it can be solved using a slide rule computer, or modern software.
- To compute the aircraft's compass heading to navigate to a destination, the pilot must measure the true course to be flown, compute a true heading the compensates for wind, then account for magnetic variation to convert the true heading to a magnetic heading.
- Magnetism is formed by charges in motion, thus the proximity of a compass to electrical wires would affect the compass reading. This error is known as "magnetic deviation" and is usually reported on a printed card next to every compass.
- The same vector problem that finds the true heading also finds the aircraft's groundspeed. Basic kinematics can be used to compute the time of flight given the groundspeed and the distance traveled.
- The process of using compass headings and times to navigate is known as "deduced reckoning", or "dead reckoning" for short and was traditionally used to navigate boats and aircraft.
- Just as lighthouses helped ships at sea navigate, radio beacons on the ground can help pilots. Modern electronic navigation uses two electronic navigations systems, one ground based, and one space based. The ground-based navigation system employs navigational beacons, or radio transmitters in buildings on the ground to send out radio signals that a receiver in the plane can receive to help the pilot find location. This system is known as "Very-High Frequency Omnidirectional Range" navigation, or VOR navigation. This VOR navigation system forms the highways in the sky flown in the national airspace system.
- Finally, satellites in space can send precise navigational signals to special receivers that use

trigonometry to identify the aircraft's position relative to a database of locations (a map) in real time. This system is known as the Global Positioning System, or GPS.

Skills:

- Students will have the ability to navigate with a stopwatch and compass by making measurements off of a map and performing navigational calculations.
- Students will be able to solve relative motion problems using vector diagrams.
- Students will be able to convert times between hours, minutes, and seconds, and change between time zones, and report times in Coordinated Universal Time (UTC, or "time zulu").

Transfer Goals

- Students will be able to recognize and distinguish vector quantities from scalar quantities and use scale diagrams as an alternative to trigonometry to solve vector problems.
- Students will recognize that angular measurement, like measurements of position, are relative to some given reference (a datum) and this given datum must be stated or understood when interpreting angles.
- Students will recognize that locations on the Earth are given in terms of coordinates of latitude and longitude and be able to convert angular units in degree-minutes-seconds into decimal and fractional degrees.
- Students will be able to work with times given in Coordinated Universal Time, and convert between UTC (time "zulu") and local time, accounting for both standard time and daylight savings time.

Assessments

https://docs.google.com/document/d/1wR7bQF-8AQoRrt0g4C3hKja0yjwDjC9_BiAmONWbTcI/edit?usp=sharing

Modifications

https://docs.google.com/document/d/1ODqaPP69YkcFiyG72fIT8XsUIe3K1VSG7nxuc4CpCec/edit?usp=sharing