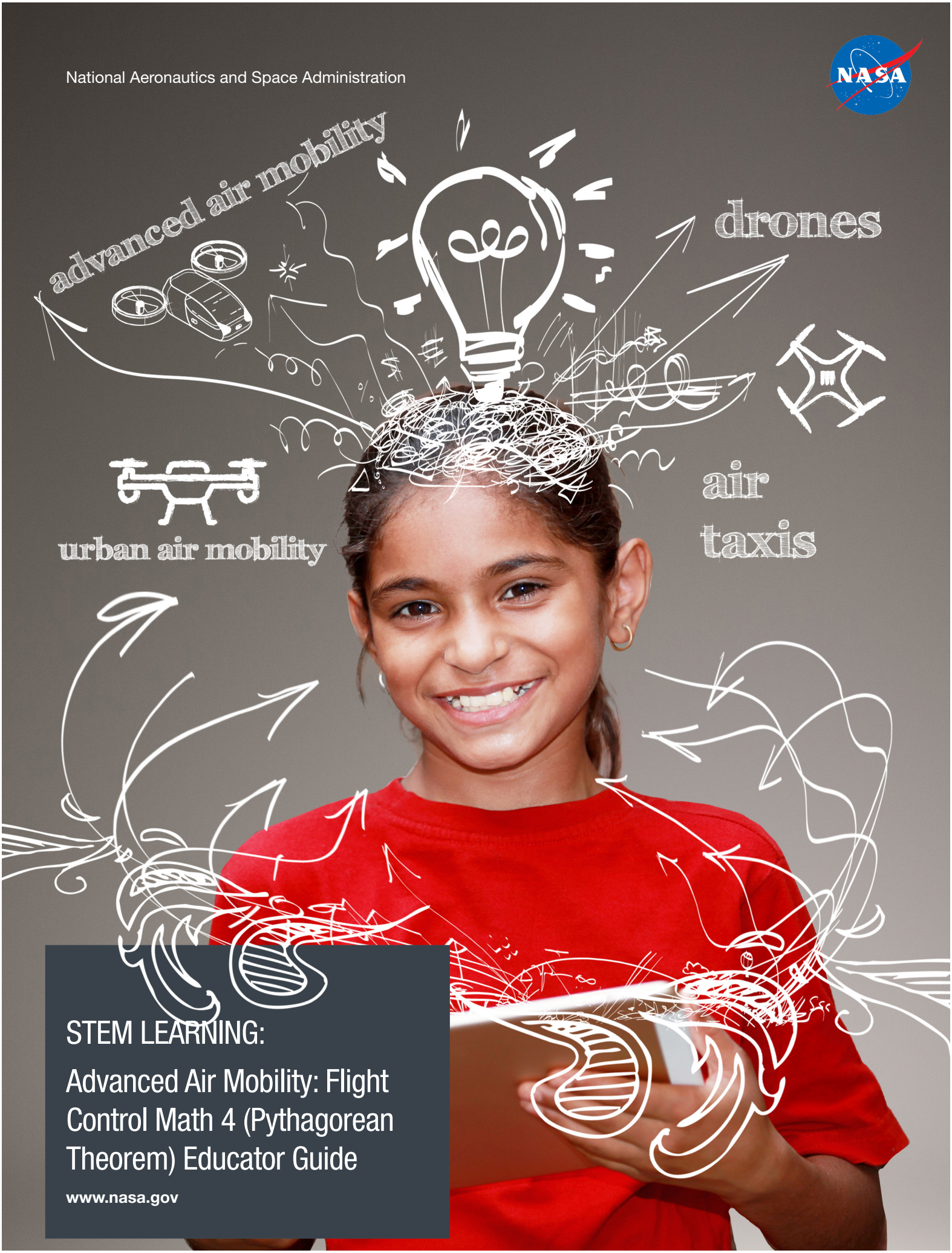
National Aeronautics and Space Administration



STEM LEARNING:

Advanced Air Mobility: Flight Control Math 4 (Pythagorean Theorem) Educator Guide

www.nasa.gov

OVERVIEW

This lesson uses real-world scenarios through which students use the Pythagorean Theorem to calculate airspeed, wind speed, and groundspeed.

Objectives

Students will be able to:

- Solve for one side of a right triangle when given the other two sides.

Standards

CCS.MATH.CONTENT.8.G.B.8: Apply the Pythagorean Theorem to find the distance between two points in a coordinate system.

Next Generation Science Standards

Science and Engineering Practices

- Developing and using models
- Using mathematical and computational thinking

Materials

- Student Guides (one per student)

Lesson Modifications

This lesson can be modified depending on student needs. Coordinates can be changed to adjust the difficulty of the calculations. Additional problems can be added to provide more opportunities for practice.

The difficulty can be varied by allowing or prohibiting the use of calculators. If calculators are not used, answers will need to be expressed as square roots unless locations are added that lead to perfect squares.

Grouping Students

This activity is designed to be completed independently. Grouping can, however, be used if necessary. Students working in pairs can independently solve the problems and then compare answers to validate their solutions or find errors.

Steps

1. Use a warm-up or other method to introduce the students to the concept of Advanced Air Mobility (AAM) and the effect of weather on Unmanned Aerial Vehicles (UAVs). Students can read through the information found in the student guide as an introduction to this topic.
2. Review the Pythagorean Theorem with students to ensure they understand how to use it.
3. Distribute the student guide(s) and allow students to begin working.
4. As students are working, their work should be checked to discover if they are making errors. If they are, they can be shown the correct method.

STUDENT ACTIVITY

PART 1: SOLVING FOR GROUNDSPEED

A company uses package delivery drones to deliver its products to customers. These drones fly with an airspeed of 60 $\frac{km}{hr}$ when carrying a package and 80 $\frac{km}{hr}$ when not carrying a package.

1. A drone is carrying a package to be delivered to a customer. As it flies, it encounters a headwind of 8 $\frac{km}{hr}$.
   Calculate the groundspeed for the drone.

   $$groundspeed = airspeed - wind\ speed = 60 - 8 = 52\ \frac{km}{hr}$$

2. After dropping off the package, the drone flies back in the opposite direction. Now it is not carrying a package and the wind is blowing from directly behind it. Calculate the groundspeed for the drone.

   $$groundspeed = airspeed + wind\ speed = 80 + 8 = 88\ \frac{km}{hr}$$

3. If the drone carries a package and encounters a crosswind of 9 km/hr, what is the groundspeed?

   $$c^2 = a^2 + b^2 = 60^2 + 9^2 = 3600 + 81 = 3681$$
   $$c = \sqrt{3681} = 60.7\ \frac{km}{hr}$$

4. Complete the following chart:

Airspeed $\frac{km}{hr}$	Wind Type and Speed $\frac{km}{hr}$	Groundspeed $\frac{km}{hr}$
30	Headwind of 7	23
75	Crosswind of 12	75.95
50	Crosswind of 15	52.20
45	Tailwind of 5	50
90	Crosswind of 9	90.4
40	Crosswind of 12	41.76

5. An air taxi is trying to fly to a spot that is directly east of the vertiport from which it takes off. There is a wind blowing from the north toward the south. When programming the drone's flightpath (the airspeed and its direction), which of the three paths shown below (A, B, or C) should the programmers use? Explain why you chose the answer that you chose.

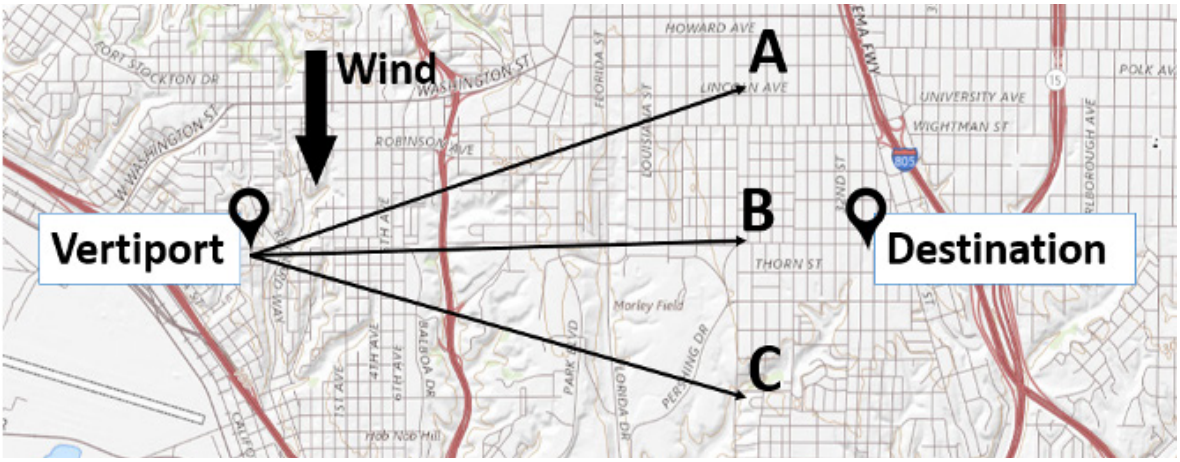


Figure 3. The three possible paths for the drone's flight. Credit: USGS

It should be programmed to fly path A. The wind will deflect the flightpath southward, so it should fly toward a point that is north of the desired destination.

PART 2: SOLVING FOR AIRSPEED OR WIND SPEED

1. An engineer looks at the data from an air taxi and notices that it achieves a groundspeed of 53 $\frac{km}{hr}$ when flying northward through a headwind, and 68 $\frac{km}{hr}$ when it is flying southward. What is the airspeed of the taxi? Show your work.

   For tailwind: groundspeed = airspeed + wind speed
   68 = airspeed + wind speed

   For headwind: groundspeed = airspeed – wind speed
   53 = airspeed – wind speed

   Add the two equations together:
   68 = airspeed + wind speed
   +53 = airspeed – wind speed
   121 = 2 * airspeed

   airspeed = 60.5 $\frac{km}{hr}$

2. What is the wind speed in question 1? Show your work.

$$groundspeed = airspeed - wind\ speed$$

$$53 = airspeed - wind\ speed$$

$$53 = 60.5 - wind\ speed$$

$$-7.5 = -wind\ speed$$

$$wind\ speed = 7.5\ \frac{km}{hr}$$

3. Another air taxi has an airspeed of $50\frac{km}{hr}$, but it is flying with a crosswind. The pilot measures the air taxi's groundspeed at $50.8\frac{km}{hr}$. Use the Pythagorean Theorem to calculate the wind speed.

$$c^2 = a^2 + b^2 \rightarrow (50.8)^2 = 50^2 + b^2 = 2580.6 = 2500 + b^2$$

$$b^2 = 80.6 \rightarrow \quad b = \sqrt{80.6} = 9\ \frac{km}{hr}$$

4. Complete the following chart:

Airspeed $\frac{km}{hr}$	**Crosswind Speed** $\frac{km}{hr}$	**Groundspeed** $\frac{km}{hr}$
20	15	25.00
40	5	40.31
35	10	36.40
45	13	46.84
18	4	18.44

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