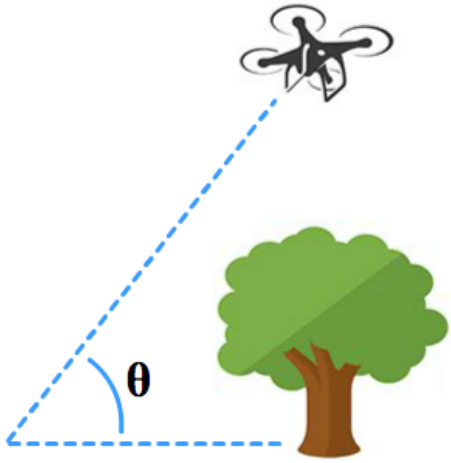
How high is my drone flying?

Introduction

If your drone doesn't have a GPS unit, how can you figure out how high you're flying?

The Challenge: Design and perform one or more experiments to help you identify a way to estimate your drone's height. Use your experience to judge which method provides the most accurate estimates.



Credits

This activity was developed by LuAnn Dahlman for Earth Science Information Partners (ESIP).

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Lesson Format

Hands-on activity.

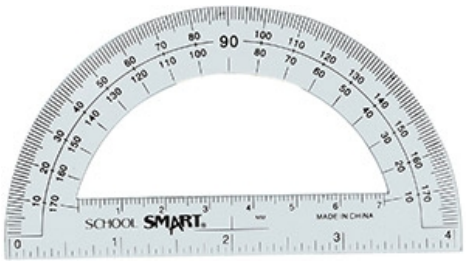
Education Standards Addressed

Next Generation Science Standards

- Science and Engineering Practices
  - asking questions (for science) and defining problems (for engineering)
  - planning and carrying out investigations
  - analyzing and interpreting data
  - using **mathematics** and computational thinking
  - obtaining, evaluating, and communicating information
- Crosscutting Concepts
  - scale, proportion, and quantity
- Disciplinary Core Ideas
  - MS-ETS1.A: Defining and Delimiting Engineering Problems
  - MS-ETS1.B: Developing Possible Solutions
  - HS-ETS1.A: Defining and Delimiting Engineering Problems
  - HS-ETS1.B: Developing Possible Solutions

Instructions

Materials



- One or more UAV (Unmanned Aerial Vehicle or "drone") and the controller used to fly it
- Football or soccer field with marked distances, or a measuring tape
- Instrument for measuring elevation angles; either:
  - Angle-measuring app on a smartphone
  - Protractor inclinometer (find instructions online to make your own)
- Scientific calculator (with trigonometric functions)
- Optional: printed copies of student instructions and data recording table

Directions for Teacher

Encourage students to come up with their own ideas about how to measure height before they start. For example, they might suggest flying near something with a known height, such as a flagpole or a building.

Have students create a data table (like the one below) to record their measurements and results of calculations.

	Distance from Pilot to Observer (D)	Observed angle to drone (a)	Observed angle to the location directly below the drone (b)	Drone height (H)
Example	30 feet	43°	10°	33.3 feet
Trial 1				
Trial 2				
Trial 3				

Think it through: Questions to consider

Before collecting data, have students discuss:

- How many trials will it take for you to feel confident your final answer is accurate?
- How might you check if your answer is reasonable?

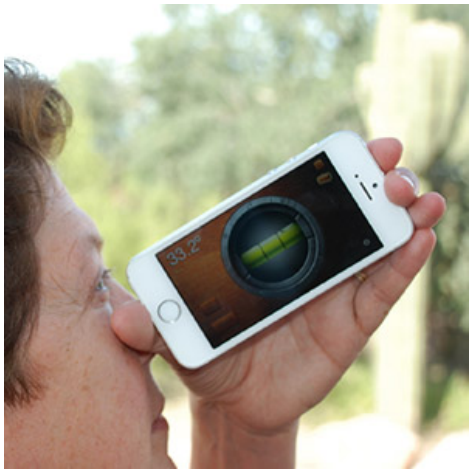
Fly and Collect Data

Set up a flight zone so the drone pilot and observer are a known distance apart. For instance, you might place the students on a sports field so they are 10 yards (30 feet) apart.

Pilot: Have the student pilot fly the drone straight up and hover directly overhead at the height you want students to measure.

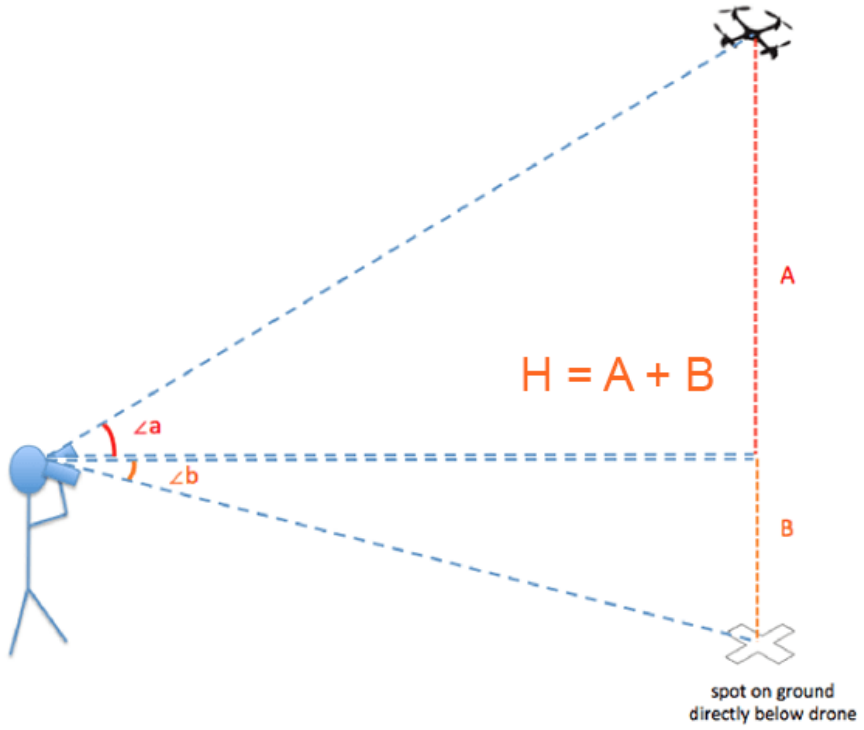
Observer: Have the student observer use a level app on a smartphone (or make and use a simple inclinometer) to:

1. Measure and record the angle to the drone - students will use this value to calculate the height of the drone above eye level.
2. Measure and record the angle to the spot directly below the drone - students will use this value to calculate the height of their eyes above the ground.
3. Have students use the angles and formulas (which use the tangent function - tan - on a scientific calculator) to calculate the height of the drone above the ground.



Calculate Height

Students will use the two angle measurements together to calculate the height of the drone. As shown in the diagram below, the height (H) of the drone equals the height above eye level (A) of the drone plus the distance below eye level (B) of the location directly beneath the drone.



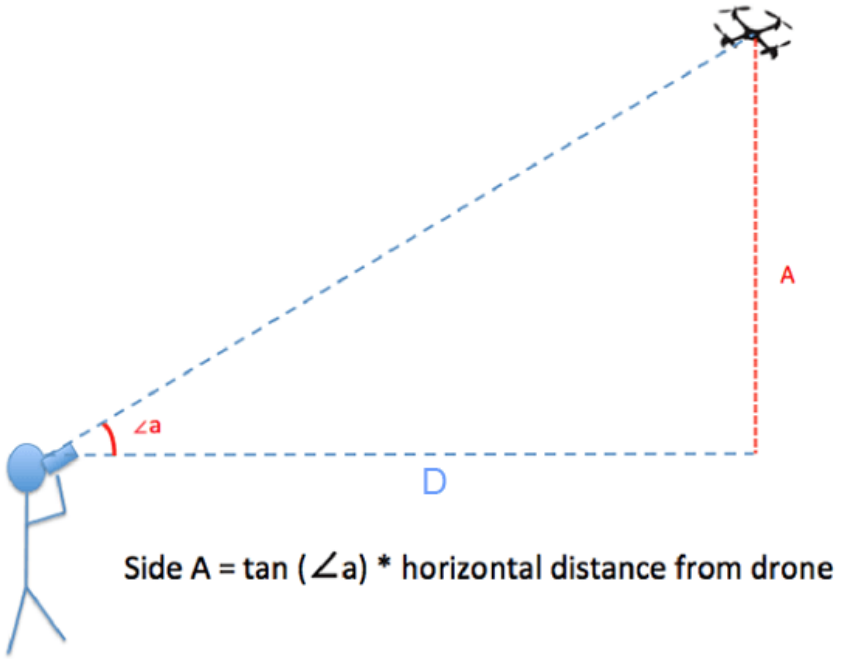
Students will use the horizontal distance to the drone (D) along with the tangent function ("tan" on a scientific calculator) to calculate the distance A from angle ∠a. They will use the horizontal distance (D), tangent function, and angle ∠b to calculate distance B.

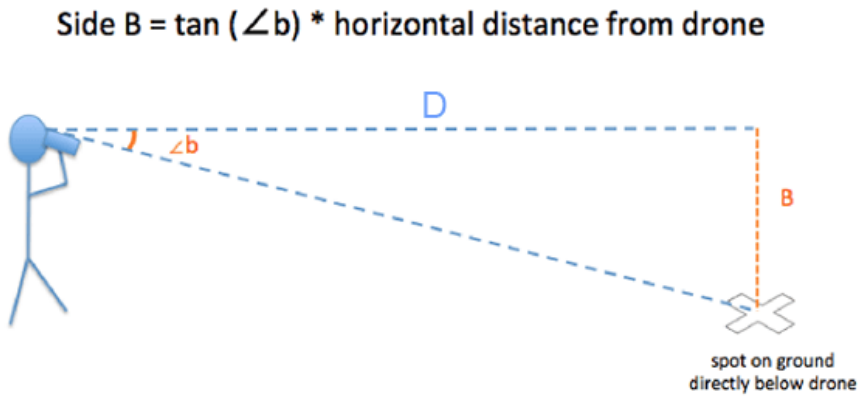
Here is a sample calculation using the values in the **Example** row in the table above of D = 30 feet, ∠a = 43° and ∠b = 10°:

A = D x tan ∠a = (30 feet) x tan 43° = (30 feet) x 0.93 = 28 feet

B = D x tan ∠b = (30 feet) x tan 10° = (30 feet) x 0.18 = 5.3 feet

H = A + B = 28 feet + 5.3 feet = 33.3 feet





Follow up

Ask students to discuss:

- What can you do with the information about the height of your drone? For example, if students want to capture a time series of photos from a UAV, showing how a natural area looks every week over a year, how can they ensure that they are always flying at the same height?
- How else might you use the technique you used to estimate height?
- What other objects might you use this technique to measure?

Assessment

Have students present their results to classmates. Presentations should include data and results of calculations as well as responses to the questions in the **Think it through: Questions to consider** and **Follow up** sections above.

Student Instructions

Introduction

If your drone doesn't have a GPS unit, how can you figure out how high you're flying?

The Challenge: Design and perform one or more experiments to help you identify a way to estimate your drone's height. Use your experience to judge which method provides the most accurate estimates.

Think it Through

Before you start, think of some ideas of your own about how to measure the height of a flying drone.

Instructions

Measuring a horizontal distance along the ground is much easier than estimating large vertical distances or heights. Did you know that if you measure the horizontal distance to an object and the angle at which it appears from that distance, you can calculate its height?

Create a data table (like the one below) to record your measurements and results of calculations... or print this page and use the data table on your printout.

	Distance from Pilot to Observer (D)	Observed angle to drone (a)	Observed angle to the location directly below the drone (b)	Drone height (H)
Example	30 feet	43°	10°	33.3 feet
Trial 1				
Trial 2				

Trial 3				

Think it through: Questions to consider

Before collecting data, discuss the following questions with your group:

- How many trials will it take for you to feel confident your final answer is accurate?
- How might you check if your answer is reasonable?

Fly and Collect Data

Set up a flight zone so the drone pilot and observer are a known distance apart. For instance, you might stand on a sports field so you are 10 yards (30 feet) apart.

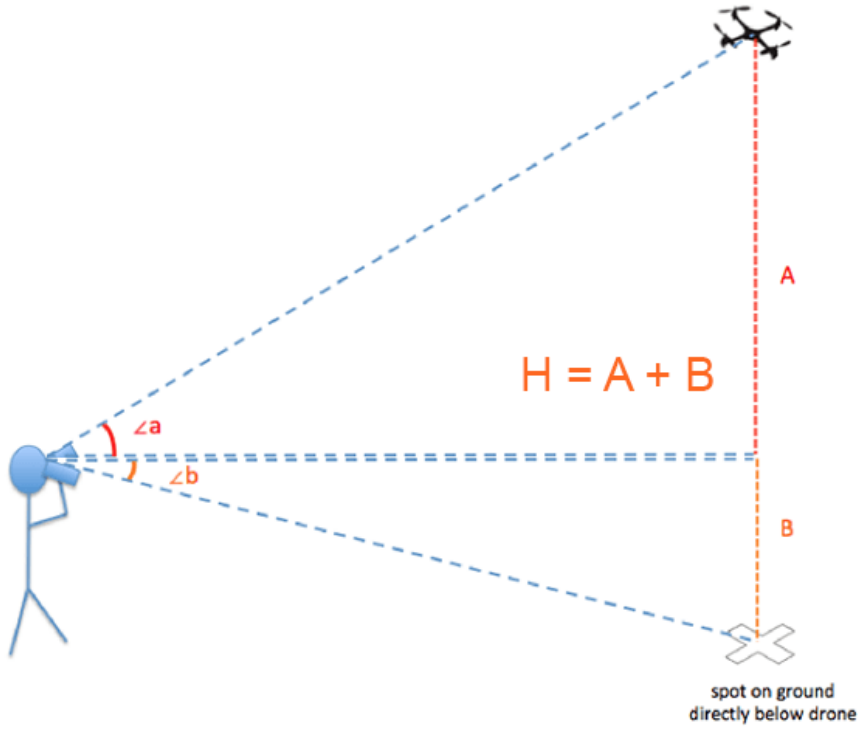
Pilot: Fly the drone straight up and hover directly overhead at the height you want to measure.

Observer: Use a level app on a smartphone (or make and use a simple inclinometer) to:

1. Measure and record the angle to the drone - you will use this value to calculate the height of the drone above eye level.
2. Measure and record the angle to the spot directly below the drone - you will use this value to calculate the height of your eyes above the ground.
3. Use the angles and formulas (which use the tangent function - tan - on a scientific calculator) to calculate the height of the drone above the ground.

Calculate Height

Use the two angle measurements together to calculate the height of the drone. As shown in the diagram below, the height (H) of the drone equals the height above eye level (A) of the drone plus the distance below eye level (B) of the location directly beneath the drone.



Use the horizontal distance to the drone (D) along with the tangent function ("tan" on a scientific calculator) to calculate the distance A from angle ∠a. Use the horizontal distance (D), tangent function, and angle ∠b to calculate distance B.

Here is a sample calculation using the values in the **Example** row in the table above of D = 30 feet, ∠a = 43° and ∠b = 10°:

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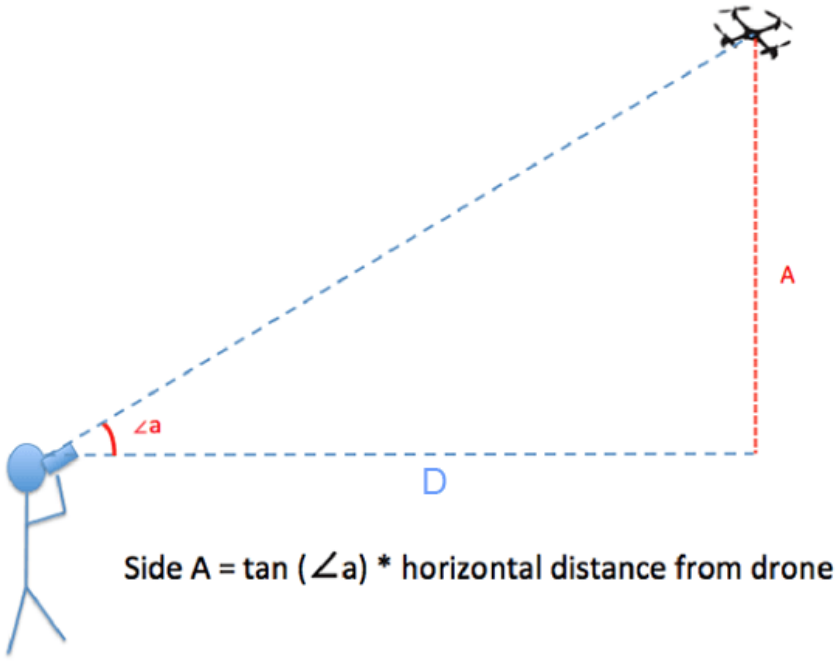

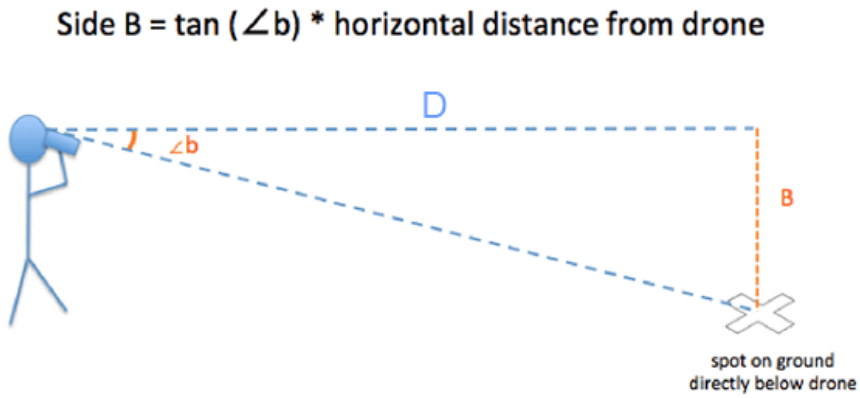

Follow up

After you fly and calculate the drone's height, discuss:

- What can you do with the information about the height of your drone?
- How else might you use the technique you used to estimate height?
- What other objects might you use this technique to measure?

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