

advanced air mobility

drones



urban air mobility

air
taxis

STEM LEARNING:

**Advanced Air Mobility: Flight
Control Math 3 (Distance/Speed)
Student Guide**

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AIR METRO

NASA is leading the nation to quickly open a new era in air travel called Advanced Air Mobility, or AAM. The vision of AAM is that of a safe, automated, and affordable air transportation system for passengers and cargo in both urban and rural settings.

One aspect of AAM, called air metro, is quite similar to public transportation systems found in many communities around the country. Air metro vehicles carry small groups of passengers along prescheduled routes. In most cases, these electrically powered vehicles are autonomous, meaning that they are controlled by a computer.

Air metro vehicles can only takeoff and land from certain facilities called vertiports. Vertiports can be standalone buildings, or terminals placed atop existing buildings. To maximize the convenience of air metro, vertiports are in both downtown and suburban areas.



Figure 1. Air metro carries small groups of passengers between vertiports following prescheduled routes. Credit: NASA

DISTANCE FORMULA

Distance formula can be used to determine the distance between two points on a graph.

Distance between two points: $P_1(x_1, y_1)$ and $P_2(x_2, y_2)$

$$\text{distance} = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

Example: Determine the distance between a point at (5, 6) and a point at (26, 14) where each point on the graph represents 1 kilometer.

$$\text{distance} = \sqrt{(26 - 5)^2 + (14 - 6)^2}$$

$$\text{distance} = \sqrt{21^2 + 8^2}$$

$$\text{distance} = \sqrt{441 + 64}$$

$$\text{distance} = \sqrt{505}$$

$$\text{distance} = 22.5 \text{ squares} = \mathbf{22.5 \text{ kilometers}}$$

SPEED FORMULA

The speed formula is used to determine the distance an object moves in a certain amount of time. To calculate the speed, divide the distance by the time.

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

Example: A package delivery drone flies 22.5 km in 15 minutes. What speed is the drone flying?

$$\text{speed} = \frac{22.5 \text{ kilometers}}{15 \text{ minutes}} = 1.5 \frac{\text{kilometers}}{\text{minute}}$$

By mathematically rearranging the formula, you can determine the formulas for calculating distance or time.

$$\text{distance} = \text{speed} \times \text{time} \quad \text{***OR***} \quad \text{time} = \frac{\text{distance}}{\text{speed}}$$

STUDENT ACTIVITY

Engineers have designed and built an air metro system in Indianapolis, Indiana. Initially, the system has three downtown vertiports and seven vertiports scattered throughout the suburbs (figure 2). As shown in figure 3, the system has four loops that the aircraft follow.

Using the distance and speed formulas, you must help develop the schedule for the air metro vehicles.

Important:

- All distances should be in kilometers (km) and all times should be in minutes (min).
- All speeds should be in kilometers per minute (km/min).
- Each square of the graph is equal to 1 km.

The coordinates for the vertiports are given in the following table:

Vertiport Number	Coordinate (x)	Coordinate (y)
1	0	0
2	1	4
3	3	2
4	-11	7
5	-11	13
6	-8	-3
7	1	15
8	12	12
9	13	-2
10	20	6

PART 1 : USING THE DISTANCE FORMULA

Begin by determining the distances between the various vertiports. Remember that each square is equal to **1 km**. Use the distance formula to fill in the missing information in the data tables:

Blue Loop

	Distance (km)
Distance between vertiports 1 and 6	8.5
Distance between vertiports 6 and 4	10.4
Distance between vertiports 4 and 5	6.0
Distance between vertiports 5 and 1	17.0

Purple Loop

	Distance (km)
Distance between vertiports 3 and 8	13.5
Distance between vertiports 8 and 10	10.0
Distance between vertiports 10 and 9	
Distance between vertiports 9 and 3	

Red Loop

	Distance (km)
Distance between vertiports 2 and 5	
Distance between vertiports 5 and 7	
Distance between vertiports 7 and 8	
Distance between vertiports 8 and 2	

Green Loop

	Distance (km)
Distance between vertiports 1 and 2	
Distance between vertiports 2 and 3	
Distance between vertiports 3 and 1	

PART 2: USING THE SPEED FORMULA

1. To determine the speed the aircraft can fly for the suburban routes, a test was performed. In this test, the aircraft flew $127 \frac{3}{4}$ km in 1 hour and 4 min.

Calculate the speed (show your work):

Speed = _____ $\frac{km}{min}$

2. Using the speed you calculated, calculate the time it takes to fly each leg of the Blue Loop. Show your work.

a. From vertiport 1 and vertiport 6:

_____ minutes

b. From vertiport 6 to vertiport 4:

_____ minutes

c. From vertiport 4 to vertiport 5:

_____ minutes

d. From vertiport 5 to vertiport 1:

_____ minutes

3. Houses continue to be built in the eastern suburb, so a new stop is being considered for the Purple Loop. The systems engineers are trying to determine a good location for a new stop.
 - a. The desired flight time to the new stop is between 2.5 min and 8 min. Using the **speed** you calculated previously, calculate how close **and** how far the new stop can be.

b. The engineers have narrowed the search down to two possible spots, (14,10) and (17, 12). Determine which one, or both, of these would be in the desired distance range from both vertiports 8 **and** 10.

4. The first schedule below was created for the Red Loop. Unfortunately, there is an error in the portion of the chart that contains the times. Assume that the aircraft must be on the ground at the vertiport for at least 1 minute, but no more than 2 minutes, making the departures time always 2 minutes later than the arrival time.

Find the error, correct it (as well as any other times that would change), and enter the correct times in the blank schedule.

RED LOOP SCHEDULE
Chart shows first aircraft of the day.

	Arrival	Departure
Vertiport 2		5:30 AM
Vertiport 5	5:37 AM	5:39 AM
Vertiport 7	5:44 AM	5:46 AM
Vertiport 8	5:51 AM	5:53 AM
Vertiport 2	5:59 AM	

Aircraft arrive every 10 minutes until 7:00 PM and then every 20 minutes until 11:30 PM.

IAMS - Indianapolis Air Metro System

RED LOOP SCHEDULE
Chart shows first aircraft of the day.

	Arrival	Departure
Vertiport 2		5:30 AM
Vertiport 5		
Vertiport 7		
Vertiport 8		
Vertiport 2		

Aircraft arrive every 10 minutes until 7:00 PM and then every 20 minutes until 11:30 PM.

IAMS - Indianapolis Air Metro System

Enter the correct times in the table above.

5. For the Green Loop, aircraft fly in the downtown portion of the city. To lower the noise and ensure safety, they fly slower than their capacity. To calculate the average speed, a researcher collects the following data.

Data Collected

	Arrival Time	Time on the Ground (minutes:seconds)	Departure Time
Vertiport 1	3:28 PM	1:55	3:30 PM
Vertiport 2	3:32 PM	1:02	3:34 PM
Vertiport 3	3:35 PM	1:54	3:37 PM
Vertiport 1	3:40 PM	1:55	3:42 PM

Calculate the average speed, in $\frac{km}{min}$, of the aircraft. Only count the time spent flying, not the time on the ground. Show your work. (Hint: To calculate the total time spent flying, subtract the sum of the times on the ground in each vertiport from the time between arriving in vertiport 1 the first time and arriving there the second time.)

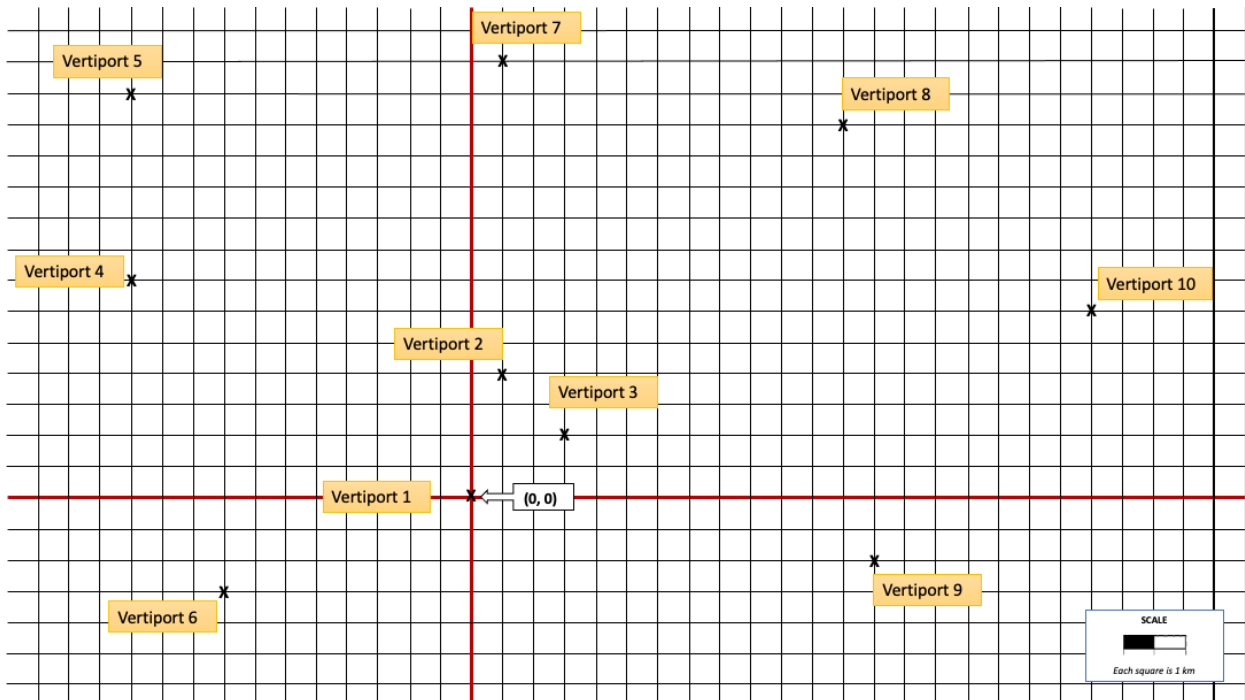


Figure 2. Locations of vertiports.

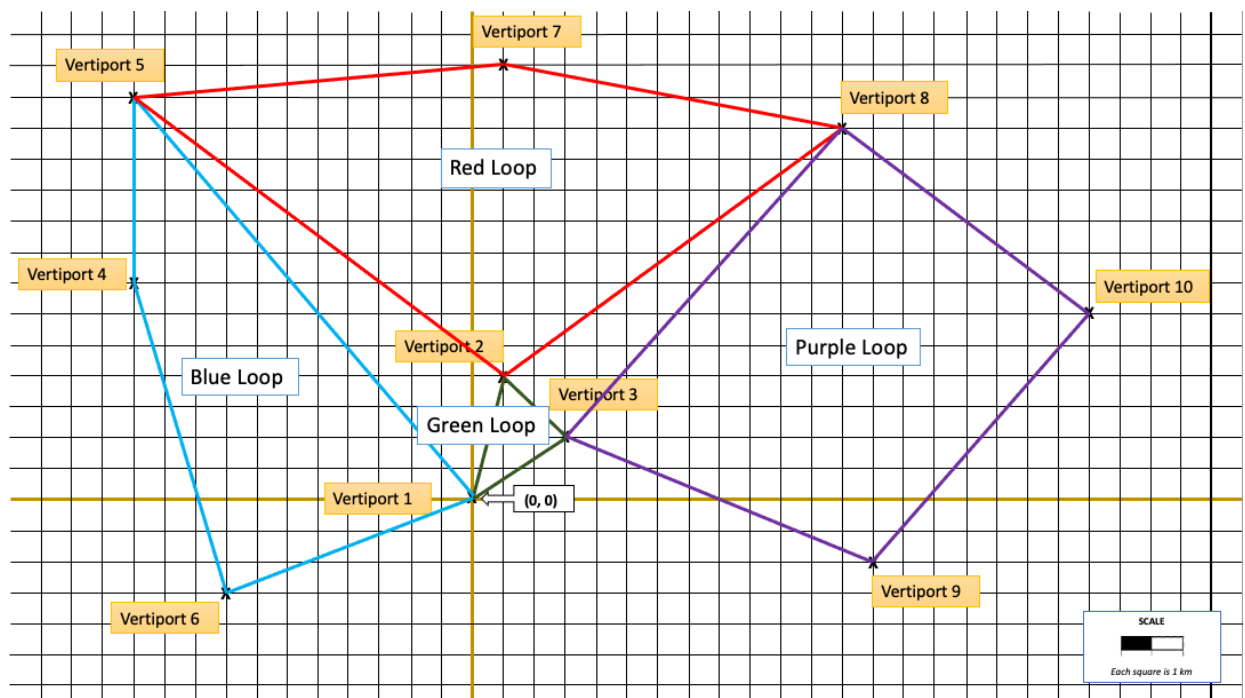


Figure 3. Aircraft loops for Indianapolis Air Metro System.

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