Learning Cycle Two

Plotting the Course

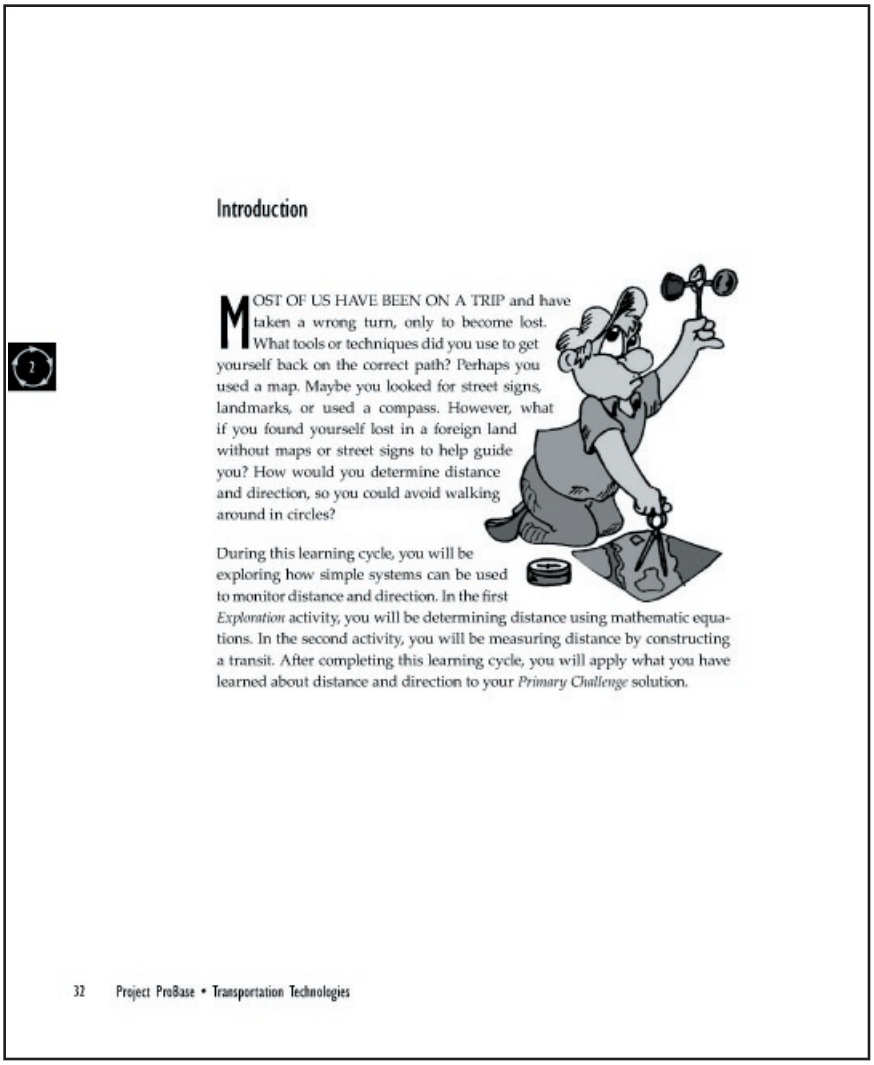
2

Plotting the Course

Introduction

The primary goal of this learning cycle is for students to learn about determining distance and direction. In the *Exploration* phase, the students will calculate distance using mathematics and then construct a transit.

During the *Engagement* activity, students will have the opportunity to expand upon those concepts by using the transit to measure distance. These activities will provide the knowledge needed as part of the solution to the *Primary Challenge.*



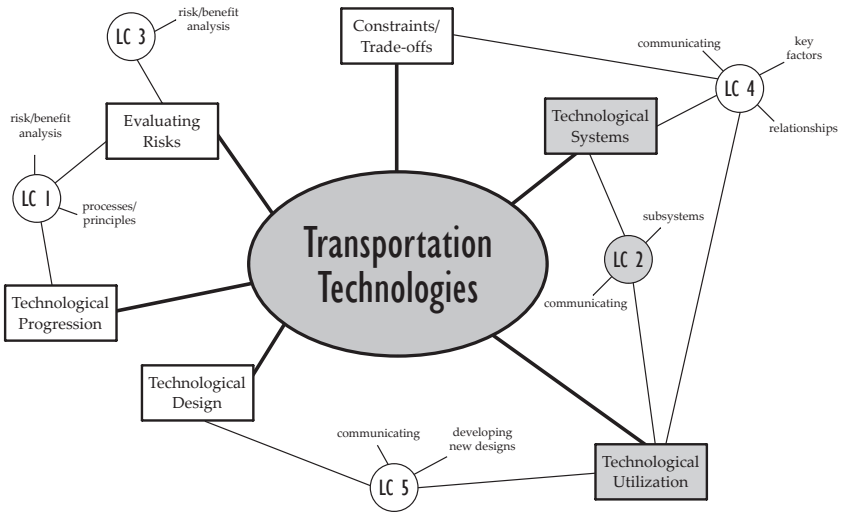
Introduction

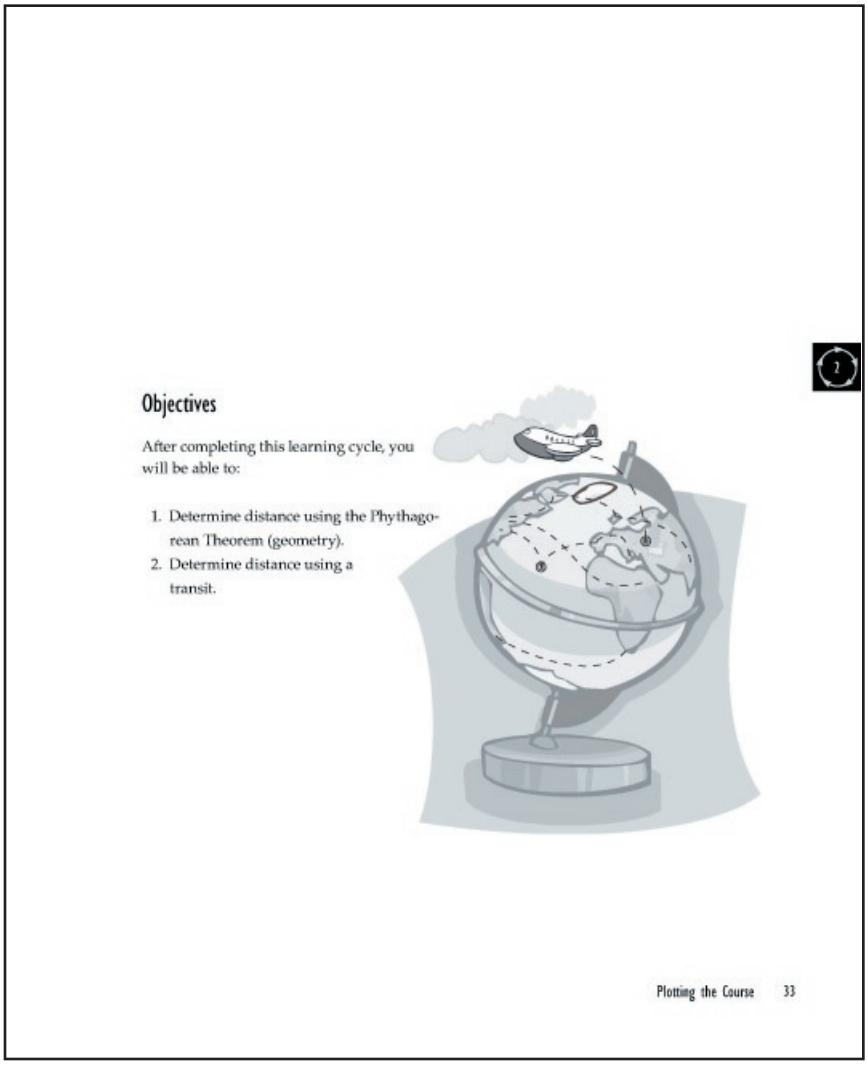
MOST OF US HAVE BEEN ON A TRIP and have taken a wrong turn, only to become lost. What tools or techniques did you use to get yourself back on the correct path? Perhaps you used a map. Maybe you looked for street signs, landmarks, or used a compass. However, what if you found yourself lost in a foreign land without maps or street signs to help guide you? How would you determine distance and direction, so you could avoid walking around in circles?

During this learning cycle, you will be exploring how simple systems can be used to monitor distance and direction. In the first *Exploration* activity, you will be determining distance using mathematic equations. In the second activity, you will be measuring distance by constructing a transit. After completing this learning cycle, you will apply what you have learned about distance and direction to your *Primary Challenge* solution.

32 Project ProBase • Transportation Technologies

Transportation Technologies
Learning Cycle Two Concept Map





Objectives

After completing this learning cycle, you will be able to:

1. Determine distance using the Phythagorean Theorem (geometry).
2. Determine distance using a transit.

Plotting the Course 33

Objectives and Essential Questions

After completing this learning cycle, students will be able to:

1. Determine distance using the Pythagorean Theorem (geometry).

Essential Question 9b: How are technologies used to control devices or systems and provide information to humans?

4. Determine distance using a transit.

Essential Question 4a: What are the systems and subsystems involved in the various contexts of technology?

Equipment and Materials

Based on a class of 28 students:

(7) Photocopies of protractor

(1) 50' Tape Measure

(1) Laser measuring device with visible laser beam and a range of 60 feet

Glue guns and glue

1/4″ Plywood

Band or scroll saw

1/2″ PVC pipe

Power drill and drill bits

Screws and washers

Facility Requirements

Exploration I and II work best in a classroom with large tables. The *Engagement* activity works best when you can make use of the largest possible area outside of your building. If possible, use the football field, tennis courts, soccer field, etc.

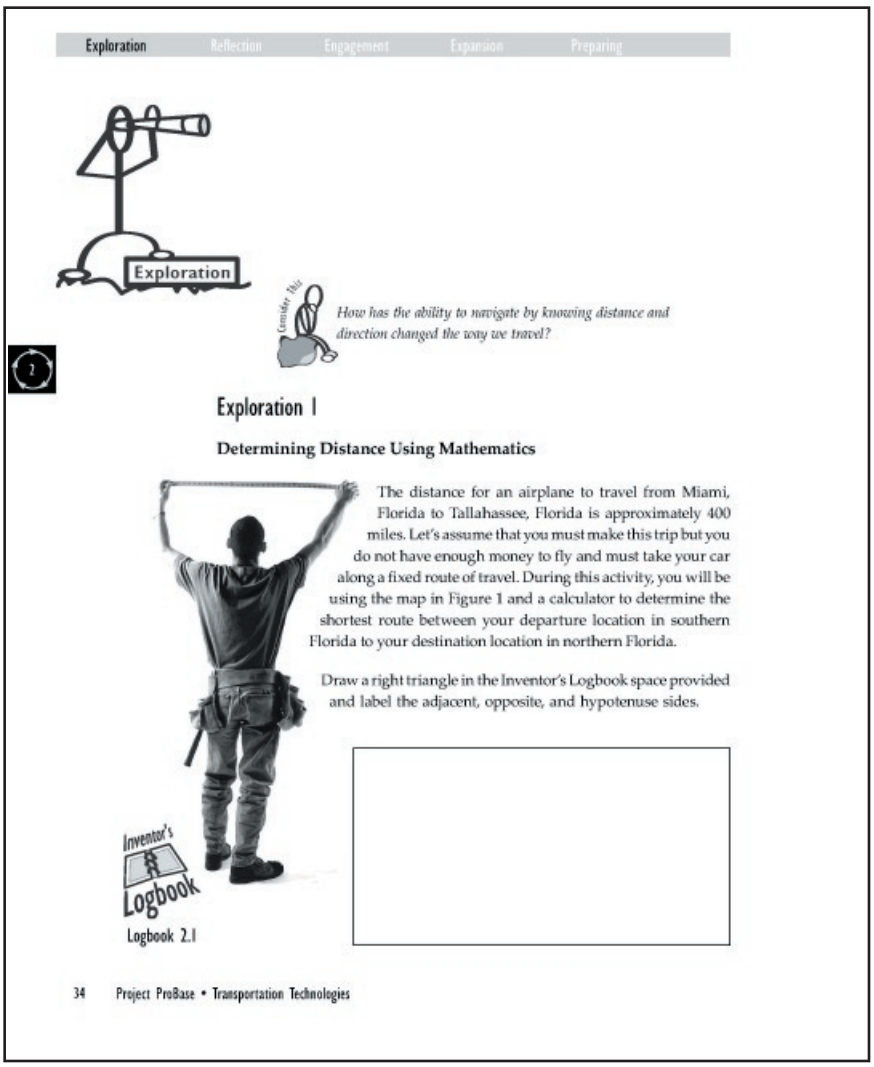
Exploration I

Determining Distance Using Mathematics

This activity requires students to have a basic understanding of the Pythagorean Theorem:

$$(a^2 + b^2 = c^2)$$

Students should be able to locate the correct formula for determining the length of a side of a right triangle. Given a map of the State of Florida (p. 35 in the Student Guide), students must determine which route will enable them to travel the fewest number of miles and still reach the appointed destination.



Exploration Reflection Engagement Expansion Preparing

Exploration

Consider This

How has the ability to navigate by knowing distance and direction changed the way we travel?

2

Exploration I

Determining Distance Using Mathematics

The distance for an airplane to travel from Miami, Florida to Tallahassee, Florida is approximately 400 miles. Let's assume that you must make this trip but you do not have enough money to fly and must take your car along a fixed route of travel. During this activity, you will be using the map in Figure 1 and a calculator to determine the shortest route between your departure location in southern Florida to your destination location in northern Florida.

Draw a right triangle in the Inventor's Logbook space provided and label the adjacent, opposite, and hypotenuse sides.

Inventor's Logbook

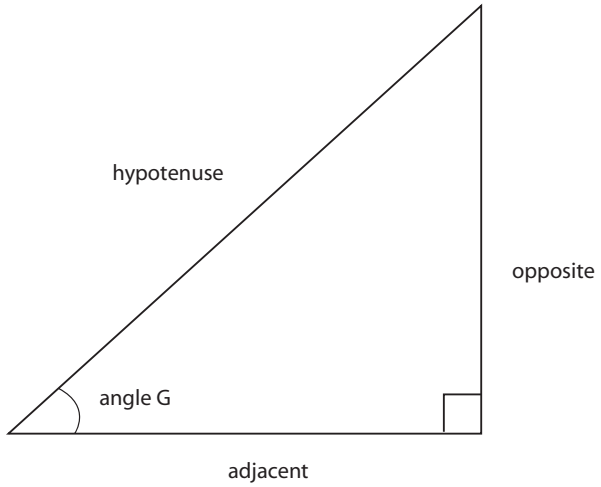
Logbook 2.1

34 Project ProBase • Transportation Technologies

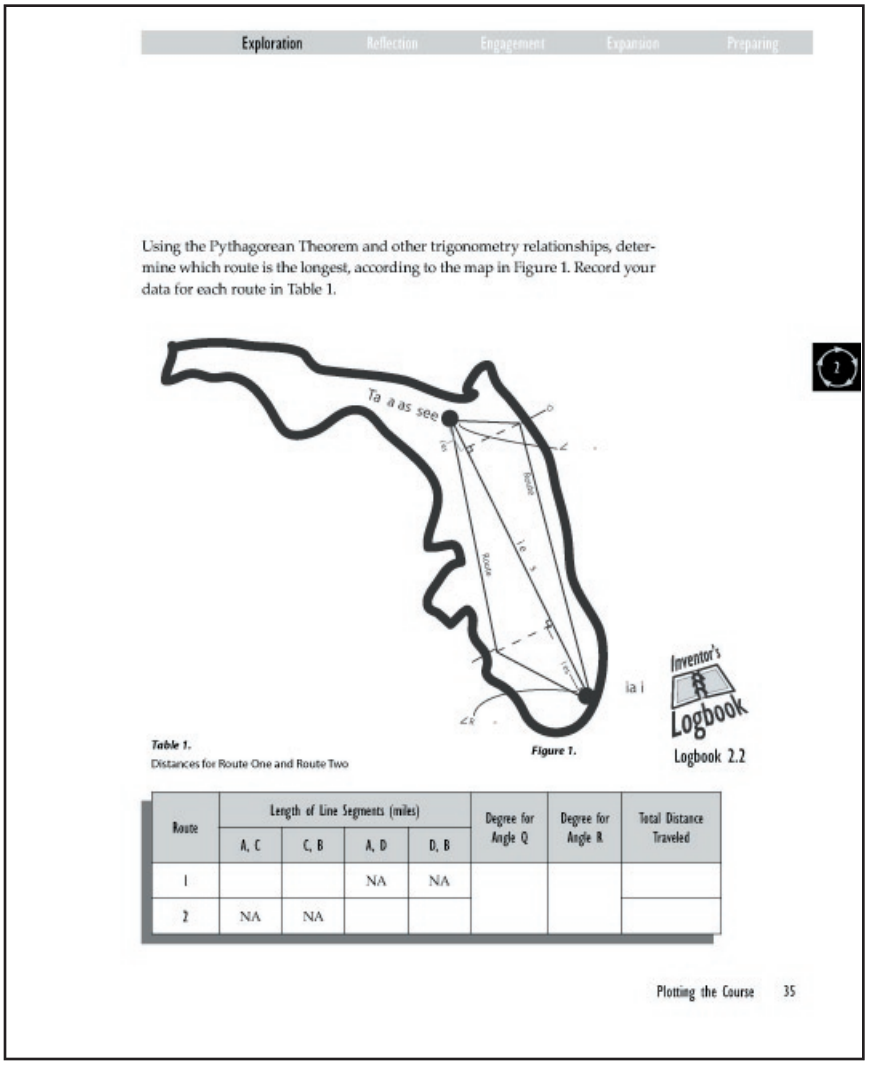
Estimated Number of 50-minute class periods: **6**

Suggested Daily Outline

Day One	Day Two	Day Three
Introduction, *Exploration I* *Reflection I*	*Exploration II*	*Exploration II* *Reflection II*
Day Four	**Day Five**	**Day Six**
Engagement	*Engagement*	*Engagement* *Preparing for the Challenge*



Logbook 2.1 entry: triangle labels



Exploration Reflection Engagement Expansion Preparing

Using the Pythagorean Theorem and other trigonometry relationships, determine which route is the longest, according to the map in Figure 1. Record your data for each route in Table 1.

Figure 1.

Inventor's Logbook

Logbook 2.2

Table 1.
Distances for Route One and Route Two

Route	Length of Line Segments (miles)				Degree for Angle Q	Degree for Angle R	Total Distance Traveled
	A, C	C, B	A, D	D, B			
1			NA	NA			
2	NA	NA					

Plotting the Course 35

Teaching Tips

Students are also required to locate the formula for determining the length of the sides of a right triangle. They need to use this information to determine the length of the opposite side of each right triangle (this is the dashed line on the map). Knowing two sides allows the students to use the Pythagorean Theorem to determine the actual distance traveled (hypotenuse).

Depending on the students' knowledge of trigonometry, they may choose other methods to solve this problem. However, one of the most efficient ways to approach this problem is described on the following two pages. The correct answers are also provided.

Teaching Tips

You may want to collaborate with a mathematics teacher for this activity. Students will be more successful if they understand the parts of a right triangle. Students are asked to draw a right triangle in the Inventor's Logbook space provided in their text and label the adjacent, opposite, and hypotenuse sides.

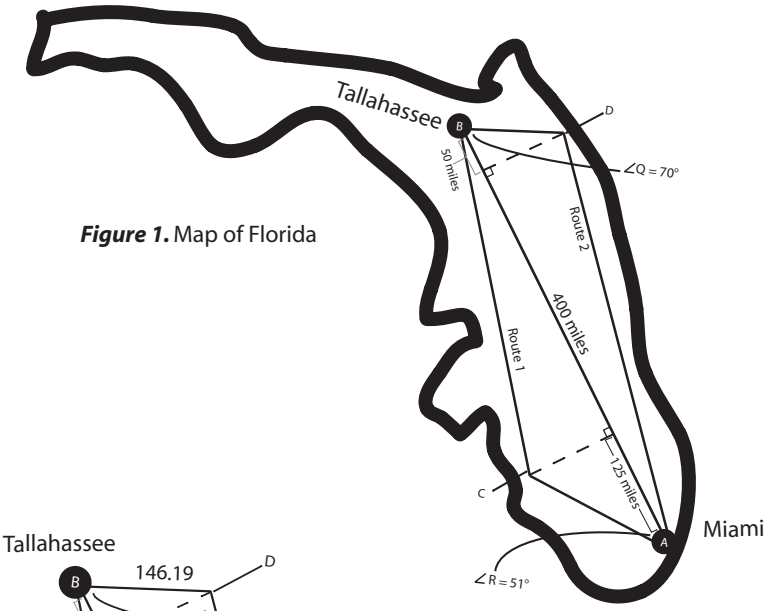


Figure 1. Map of Florida

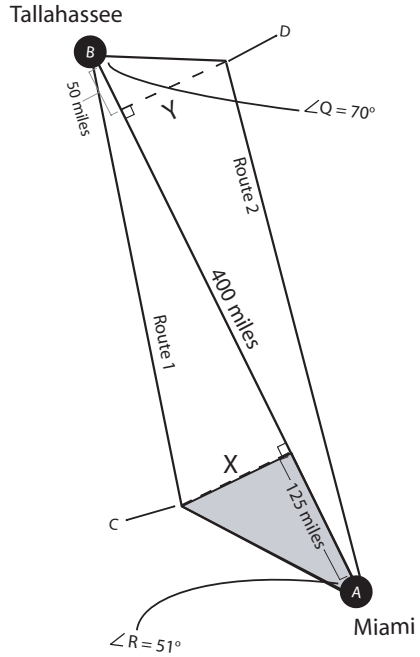


Figure 1a. Tangent of angle R

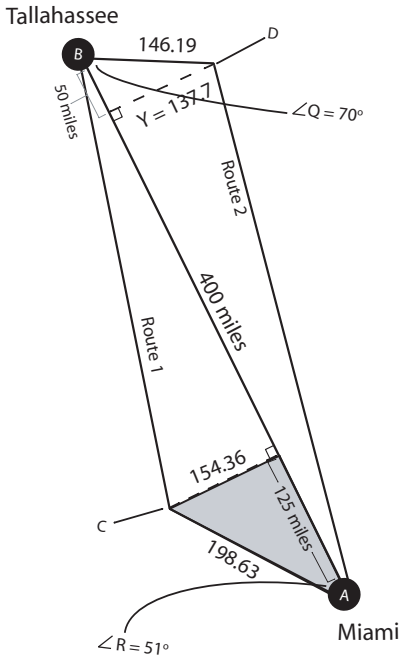


Figure 1b. Length of segment AC

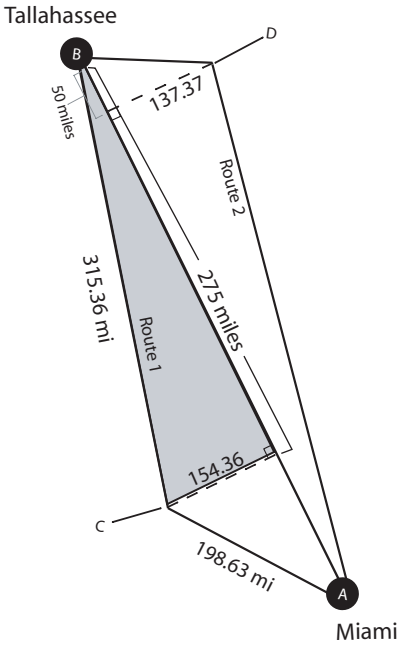


Figure 1c. Length of segment CB

Table 2.

Distances for Route One and Route Two

Route	Length of Line Segments (miles)				Degree for Angle Q	Degree for Angle R	Total Distance Traveled
	A, C	C, B	A, D	D, B			
1	198.63	315.36	NA	NA	70	51	513.99
2	NA	NA	375.99	146.19			434.24

tan(of angle R or Q) =
length of the opposite side / length of the adjacent side

Solving for Route 1

(use Figure 1a)

Adjacent side = 125 miles

Angle R = 51^0

tan (51^0) = 1.2349

Therefore: 1.2349 = opposite side (X) / 125

1.2349 x 125 = X

154.36 = X

(use Figure 1b)

Now that we know the length of the opposite and adjacent sides we can use the Pythagorean Theorem ($a^2 + b^2 = c^2$) to find the length of line segment AC.

$125^2 + 154.36^2 = c^2$

$15625 + 23827.01 = c^2$

$39452.67 = c^2$

$\sqrt{\ }$ = 198.63 miles = c (segment AC)

(use Figure 1c)

A similar process is followed to determine the length of line segment C, B. To find the length of the adjacent side one must subtract 125 miles from 400 miles. 275 miles is the length of the adjacent side used in the Pythagorean Theorem to solve the hypotenuse C, B.

($a^2 + b^2 = c^2$)

$275^2 + 154.36^2 = c^2$

$75625 + 23827.01 = c^2$

$9945.01 = c^2$

$\sqrt{\ }$ = 315.36 miles = c (segment CB)

The final step is to add the length of both line segments together to find the total distance of Route 1.

198.63 + 315.36 = **513.99 miles**

Solving for Route 2

(use the Figures 1a-c, but solve for Route 2)

Students should find the distance of Route 2 using a similar process as finding that for Route 1.

Adjacent side = 50 miles

Angle Q = 70^0

tan (70^0) = 2.7475

Therefore: 2.7475 =
opposite side (Y) / 50

Y = 137.37 miles

The length of line segment BD

($a^2 + b^2 = c^2$)

$137.37^2 + 50^2 = c^2$

$\sqrt{\ }$ = 146.19 miles = c (segment BD)

The length of line segment DA

($a^2 + b^2 = c^2$)

$137.37^2 + 350^2 = c^2$

$18870.52 + 122500 = c^2$

$141370.52 = c^2$

$\sqrt{\ }$ = 375.99 miles = c (segment DA)

The total distance of Route 2 =
(146.19 + 375.99)= **522.18 miles**

Therefore, the shortest route between Tallahassee and Miami is Route 1 @ 513.99 miles.

A black line master of the map can be found in the Appendix.

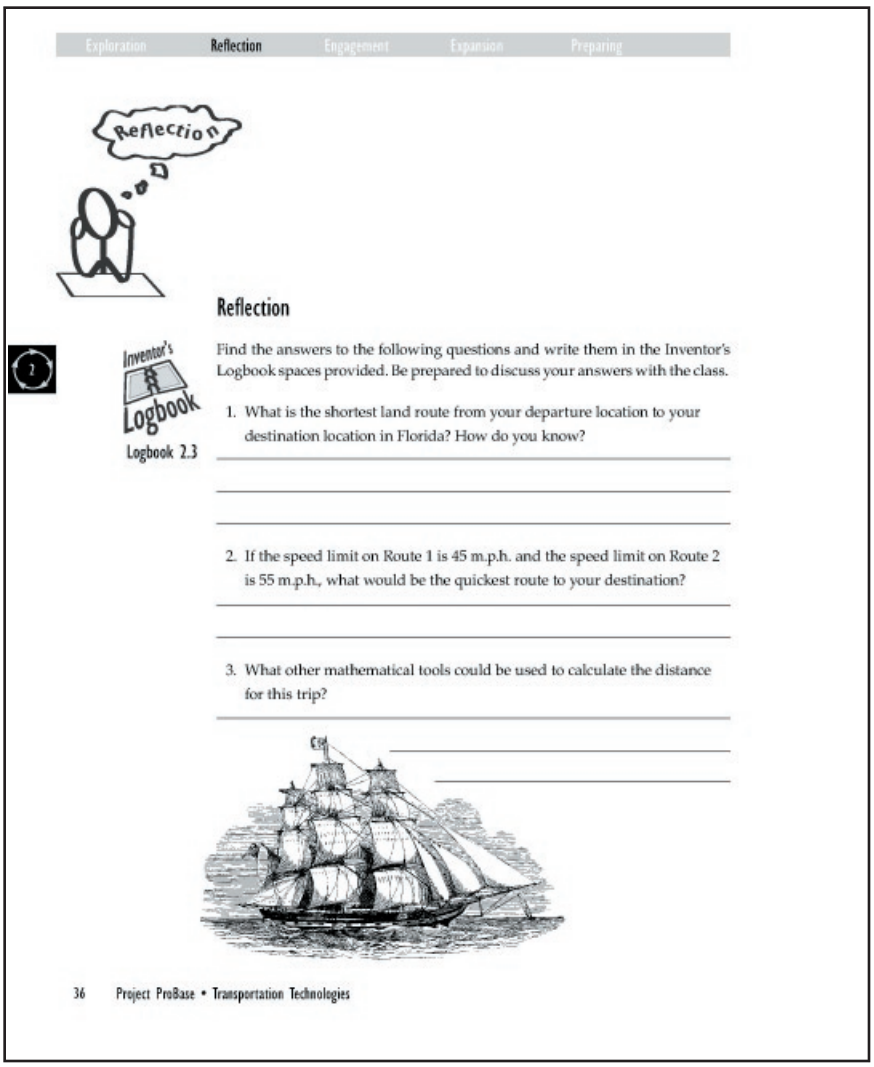
Reflection

Students should record the answers to the following questions in the Inventor's Logbook spaces provided.

1. What is the shortest land route from your departure location to your destination location in Florida? How do you know?
   The shortest route between Tallahassee and Miami is Route 1 @ 513.99 miles.

2. If the speed limit on Route 1 is 45 mph and the speed limit on Route 2 is 55 mph, what would be the quickest route?
   Route 1 =
   513.99 miles / 45 mph =
   11.42 hrs
   Route 2 =
   522.18 miles / 55 mph =
   9.49 hrs

3. What other mathematical methods can you use to calculate the distance?
   Using the longitude and latitude coordinates, you can also measure distance.



Exploration Reflection Engagement Expansion Preparing

Reflection

Inventor's Logbook

Logbook 2.3

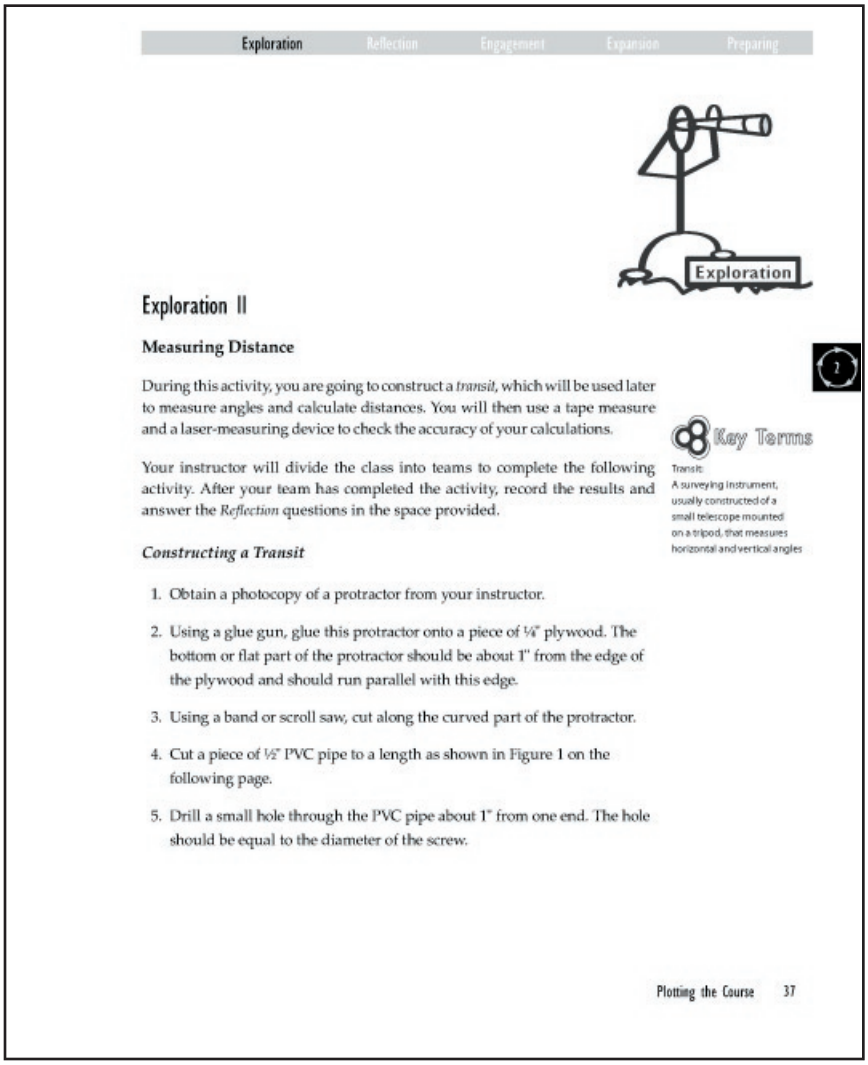
Find the answers to the following questions and write them in the Inventor's Logbook spaces provided. Be prepared to discuss your answers with the class.

1. What is the shortest land route from your departure location to your destination location in Florida? How do you know?

2. If the speed limit on Route 1 is 45 m.p.h. and the speed limit on Route 2 is 55 m.p.h., what would be the quickest route to your destination?

3. What other mathematical tools could be used to calculate the distance for this trip?

36 Project ProBase • Transportation Technologies



Exploration Reflection Engagement Expansion Preparing

Exploration

Exploration II

Measuring Distance

During this activity, you are going to construct a *transit*, which will be used later to measure angles and calculate distances. You will then use a tape measure and a laser-measuring device to check the accuracy of your calculations.

Your instructor will divide the class into teams to complete the following activity. After your team has completed the activity, record the results and answer the *Reflection* questions in the space provided.

Constructing a Transit

1. Obtain a photocopy of a protractor from your instructor.
2. Using a glue gun, glue this protractor onto a piece of ¼" plywood. The bottom or flat part of the protractor should be about 1" from the edge of the plywood and should run parallel with this edge.
3. Using a band or scroll saw, cut along the curved part of the protractor.
4. Cut a piece of ½" PVC pipe to a length as shown in Figure 1 on the following page.
5. Drill a small hole through the PVC pipe about 1" from one end. The hole should be equal to the diameter of the screw.

Key Terms

Transit: A surveying instrument, usually constructed of a small telescope mounted on a tripod, that measures horizontal and vertical angles

Plotting the Course 37

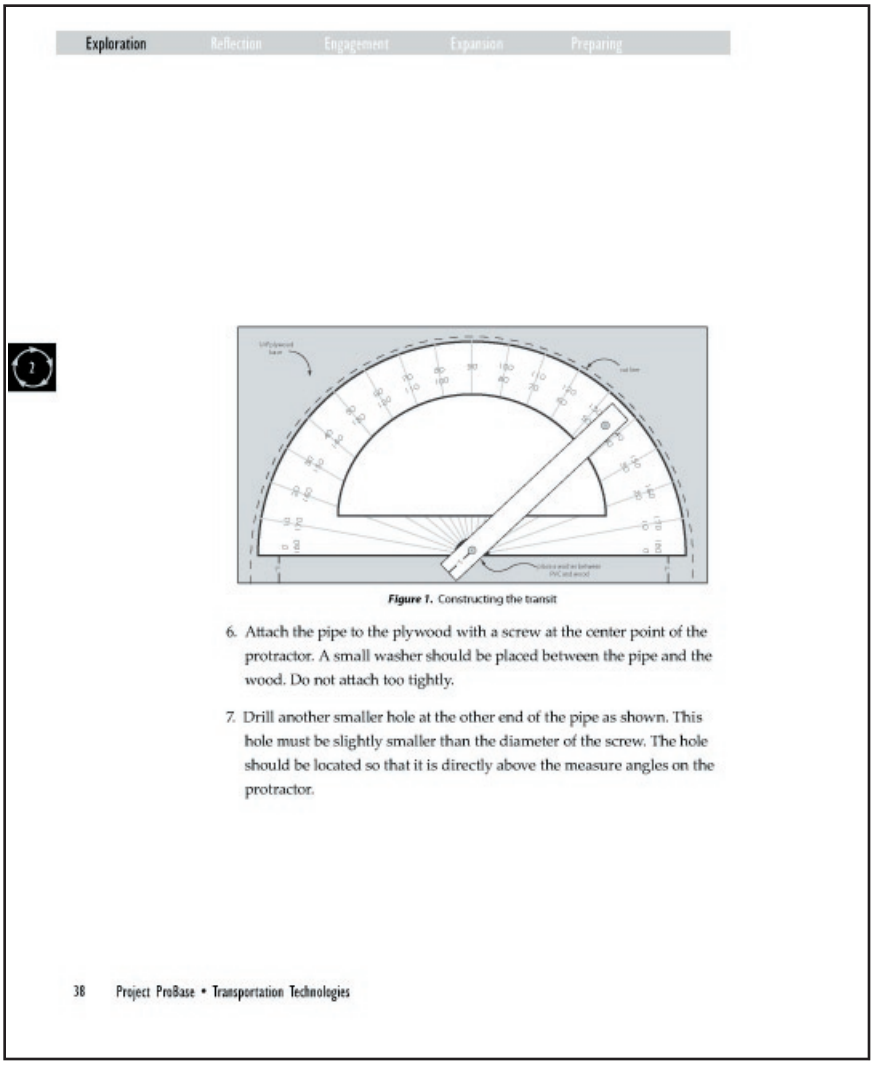
Teaching Tips

You should encourage the students to first research transits so they understand how they work before they begin constructing their devices. If they do not construct their devices correctly, the measurements they take during the *Engagement* activity will be incorrect.

Exploration II

The purpose for this *Exploration* is for students to construct a measuring device that will be used during the *Engagement* activity. A transit is a device that uses the mathematical concepts explored on paper (during the first *Exploration*) and applies them to real situations.

Place your students in teams of three or four to construct their devices. These same teams will complete the *Engagement* activity.



Exploration Reflection Engagement Expansion Preparing

2

Figure 1. Constructing the transit

6. Attach the pipe to the plywood with a screw at the center point of the protractor. A small washer should be placed between the pipe and the wood. Do not attach too tightly.

7. Drill another smaller hole at the other end of the pipe as shown. This hole must be slightly smaller than the diameter of the screw. The hole should be located so that it is directly above the measure angles on the protractor.

38 Project ProBase • Transportation Technologies

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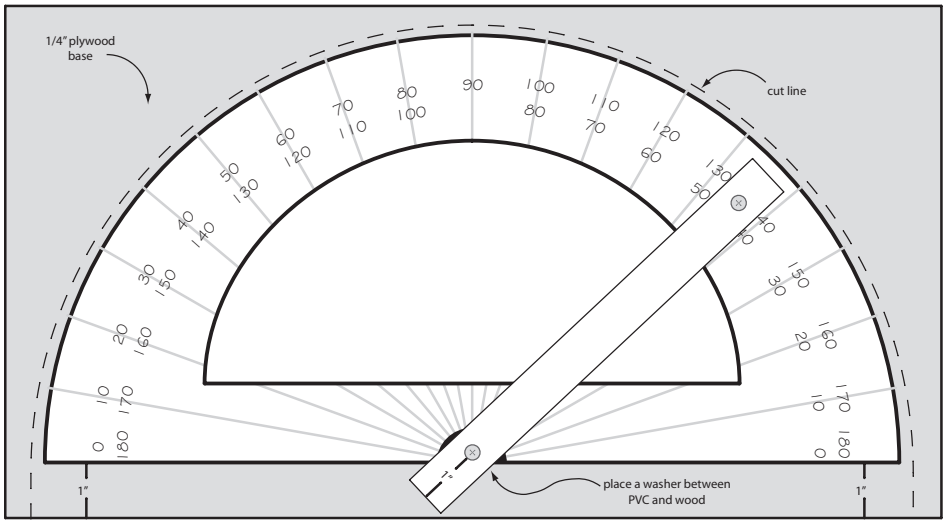
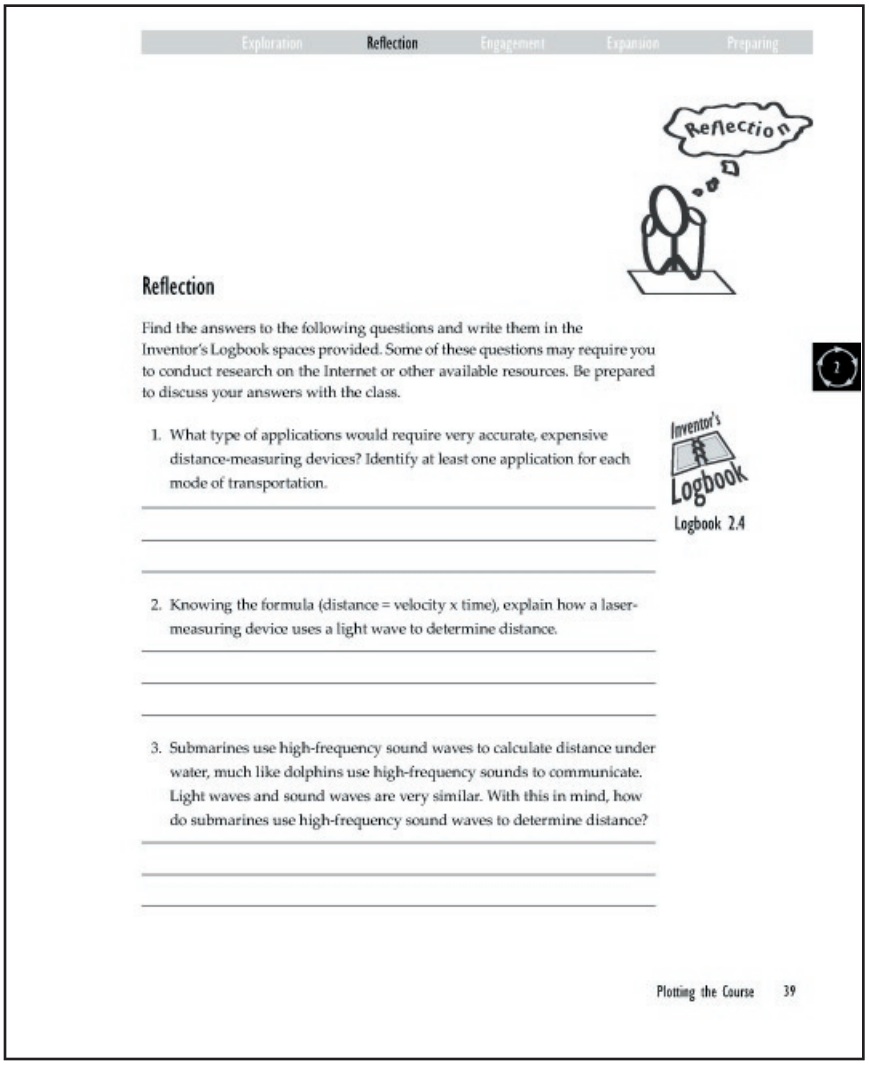


Figure 1. Constructing the transit



Exploration Reflection Engagement Expansion Preparing

Reflection

Find the answers to the following questions and write them in the Inventor's Logbook spaces provided. Some of these questions may require you to conduct research on the Internet or other available resources. Be prepared to discuss your answers with the class.

Inventor's Logbook

Logbook 2.4

1. What type of applications would require very accurate, expensive distance-measuring devices? Identify at least one application for each mode of transportation.

2. Knowing the formula (distance = velocity x time), explain how a laser-measuring device uses a light wave to determine distance.

3. Submarines use high-frequency sound waves to calculate distance under water, much like dolphins use high-frequency sounds to communicate. Light waves and sound waves are very similar. With this in mind, how do submarines use high-frequency sound waves to determine distance?

Plotting the Course 39

Reflection

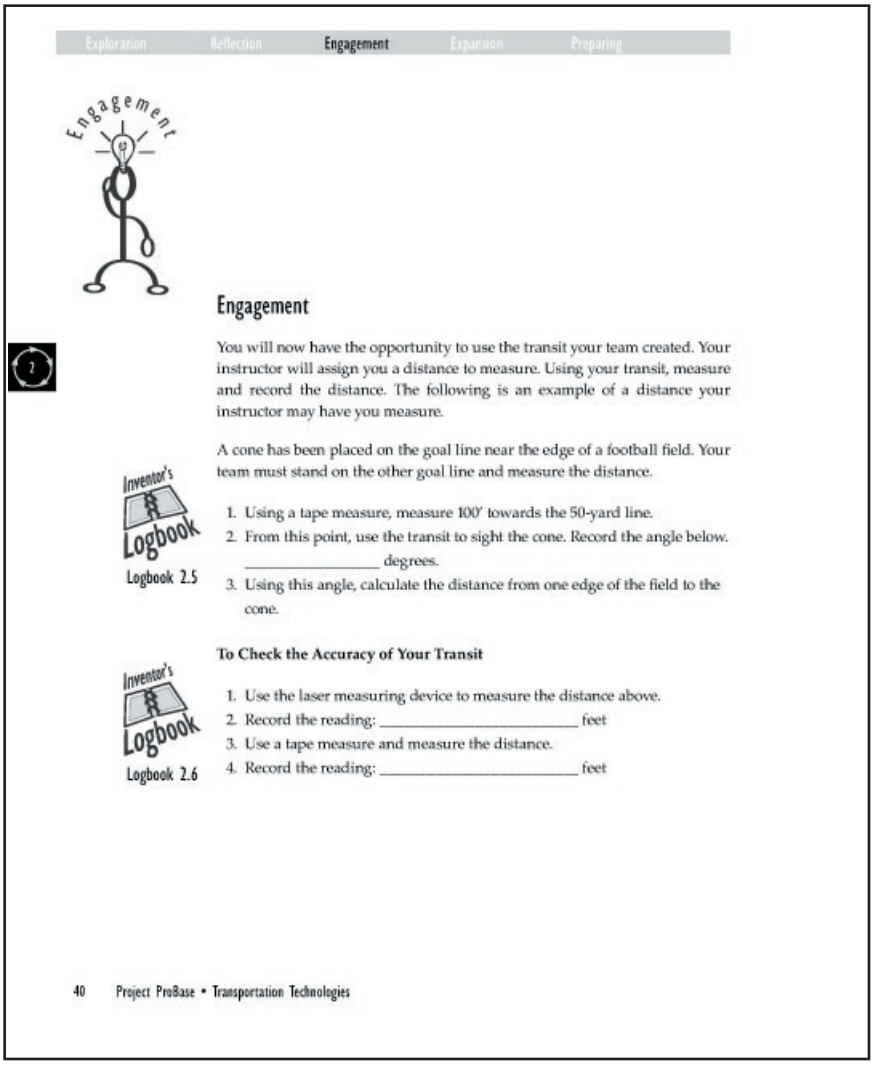
1. What type of applications would require very accurate, expensive distance-measuring devices? Identify at least one application for each mode of transportation.
   Land: Mobility of Blind and Elderly People Interacting with Computers (MoBIC) uses a route planning system. Air: Aircraft use Distance Measuring Equipment (DME), which is a transponder-based radio navigation technology that measures distance by timing the propagation delay of UHF radio signals. Water: The USS Cape St. George, a guided missile cruiser, uses Electronic Charting Display and Information System-Navy (ECDIS-N) with the National Geospatial-Intelligence Agency's Digital Nautical Chart (DNC). Space: The Hubble Space Telescope measures distance in space.

2. Knowing the formula (distance = velocity x time), explain how a laser-measuring device uses a light wave to determine distance.
   Light travels in a straight line, which makes it feasible to use different geometric methods for measuring distance. Light propagates through space at the speed of light, which is measured at 299,792,458 meters per second.

3. Submarines use high-frequency sound waves to calculate distance under water, much like dolphins use high-frequency sounds to communicate. Light waves and sound waves are very similar. With this in mind, how might a submarine use high frequency sound waves to determine distance?
   Sonar determines distance by measuring the time taken for a sound wave to travel from the transmitter, reflect from an object, and travel to the receiver.

Engagement

Working in the same teams, students will use the transits they created. This activity will need to be completed outdoors at the football field, soccer field, tennis courts, etc. You will need to provide the teams with distances to measure. An example is provided in the student guide. You may decide to use different measurements as you see fit. Students will need to measure the distances using the transit and a tape measure and record their observations. Students will then need to measure the same distance with a tape-measure and a laser measuring device to check the accuracy of their device.



Exploration Reflection **Engagement** Expansion Preparing

Engagement

Engagement

You will now have the opportunity to use the transit your team created. Your instructor will assign you a distance to measure. Using your transit, measure and record the distance. The following is an example of a distance your instructor may have you measure.

A cone has been placed on the goal line near the edge of a football field. Your team must stand on the other goal line and measure the distance.

Inventor's Logbook Logbook 2.5

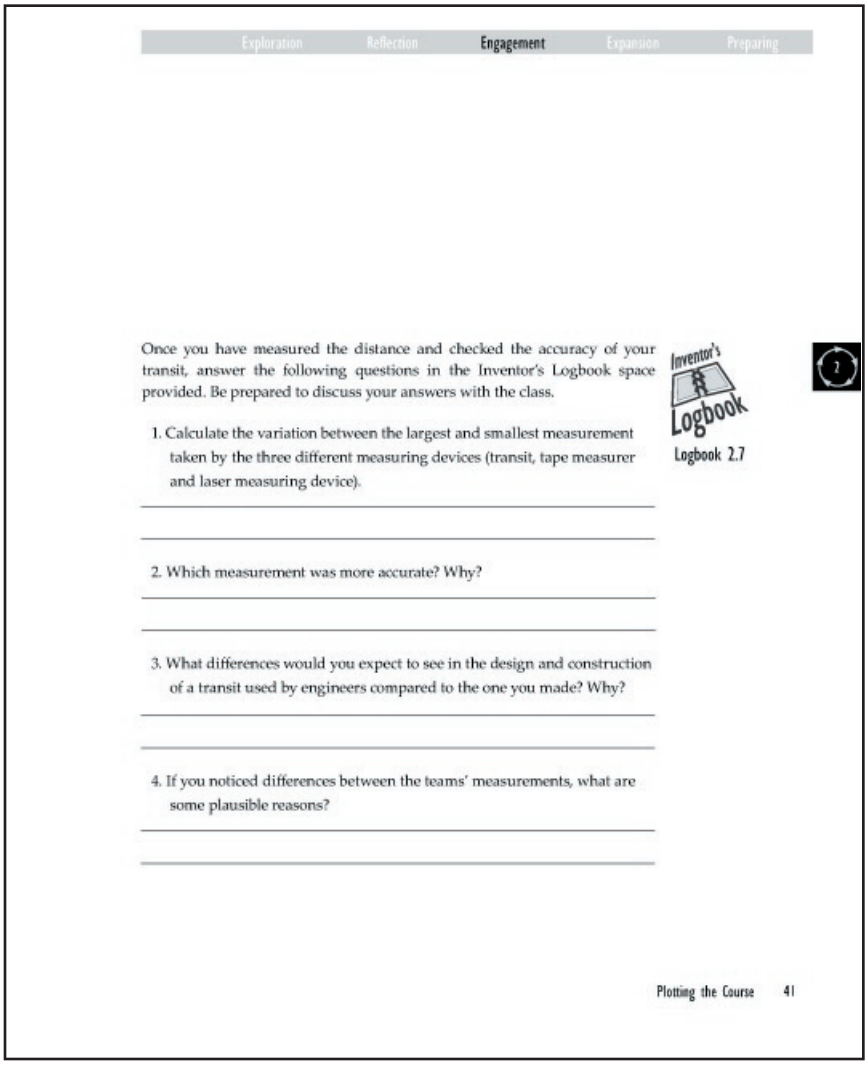
1. Using a tape measure, measure 100' towards the 50-yard line.
2. From this point, use the transit to sight the cone. Record the angle below. _____ degrees.
3. Using this angle, calculate the distance from one edge of the field to the cone.

To Check the Accuracy of Your Transit

Inventor's Logbook Logbook 2.6

1. Use the laser measuring device to measure the distance above.
2. Record the reading: _____ feet
3. Use a tape measure and measure the distance.
4. Record the reading: _____ feet

40 Project ProBase • Transportation Technologies



Exploration Reflection **Engagement** Expansion Preparing

Once you have measured the distance and checked the accuracy of your transit, answer the following questions in the Inventor's Logbook space provided. Be prepared to discuss your answers with the class.

Inventor's Logbook

Logbook 2.7

1. Calculate the variation between the largest and smallest measurement taken by the three different measuring devices (transit, tape measurer and laser measuring device).

2. Which measurement was more accurate? Why?

3. What differences would you expect to see in the design and construction of a transit used by engineers compared to the one you made? Why?

4. If you noticed differences between the teams' measurements, what are some plausible reasons?

Plotting the Course 41

Once all of the teams have completed the activity, students should answer the questions below.

1. Calculate the variation between the largest and smallest measurement taken by the three different measuring devices (transit, tape measurer, and laser measuring device).
   Answers will vary.

2. Which measurement was more accurate? Why?
   Answers may vary. The most accurate measurement may depend on the type of the device and the method used to calculate the distance.

3. What differences would you expect to see in the design and construction of a transit used by engineers compared to the one you made? Why?
   Students may need to conduct research on transits used by engineers to determine the differences. Commercial transits have a high rate of accuracy because of the way they are constructed.

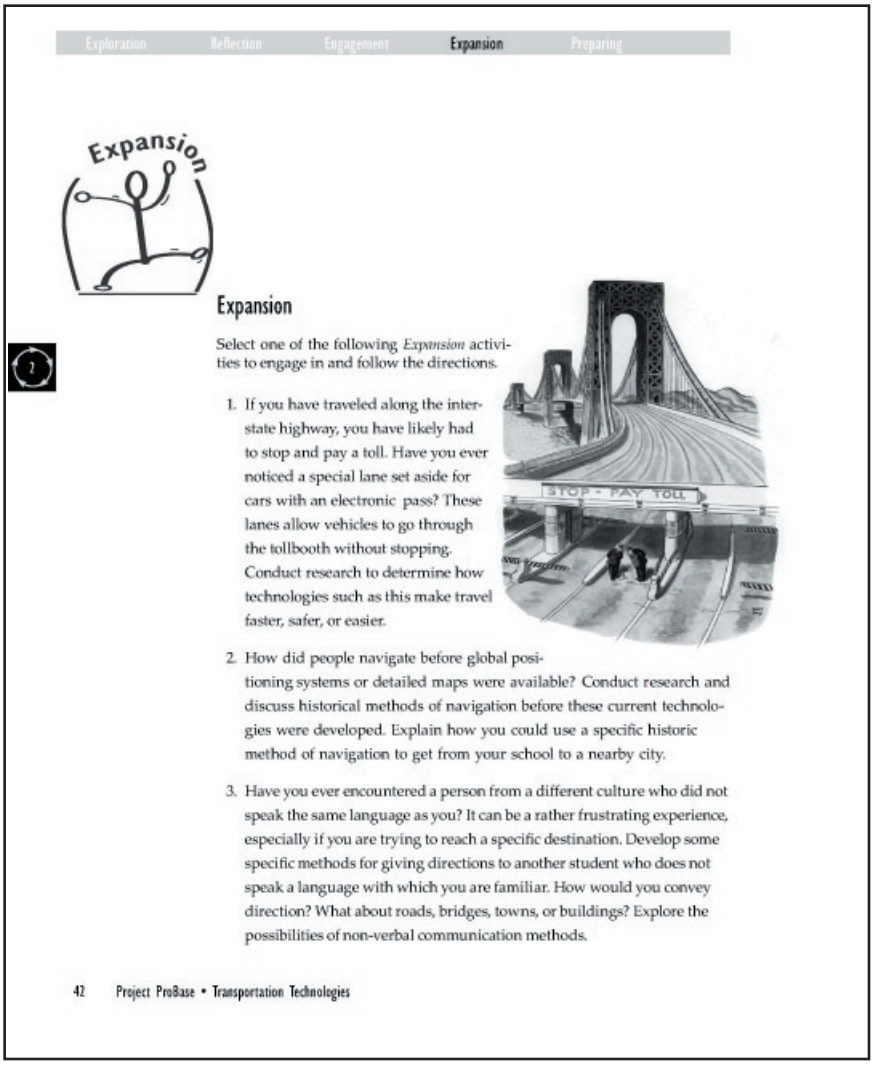
4. If you noticed differences between the teams' measurements, what are some plausible reasons for measuring errors?
   Answers may vary. Measuring errors may be attributed to faulty construction and errors in calculation.

Expansion

Although not required, these *Expansion* activities are designed to cause teams to delve deeper into concepts explored in this learning cycle.

1. If you have traveled along the interstate highway, you have likely had to stop and pay a toll. Have you ever noticed a special lane set aside for cars with an electronic pass? These lanes allow vehicles to go through the tollbooth without stopping. Conduct research to determine how technologies such as this make travel faster, safer, or easier.

2. How did people navigate before global positioning systems (GPS) or detailed maps were available? Conduct research and discuss historical methods of navigation before these current technologies were developed. Explain how you could use a specific historic method of navigation to get from your school to a nearby city.



Exploration Reflection Engagement Expansion Preparing

Expansion

Expansion

Select one of the following *Expansion* activities to engage in and follow the directions.

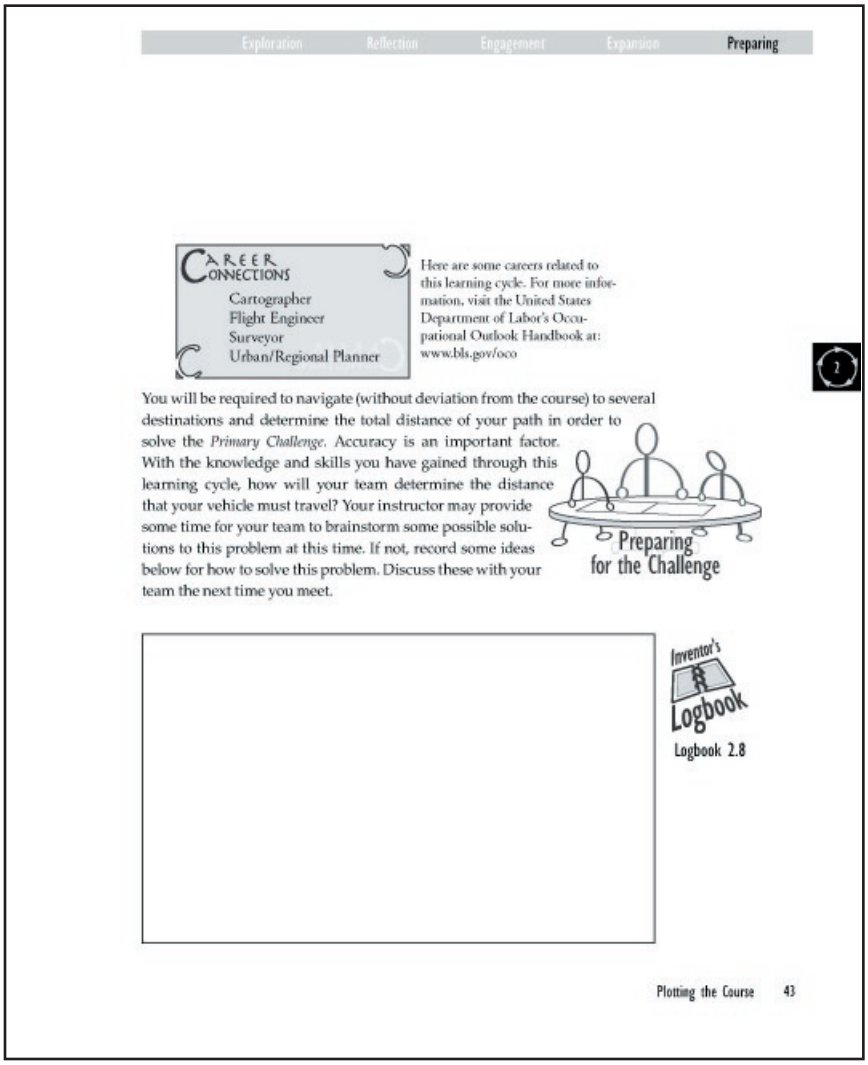
1. If you have traveled along the interstate highway, you have likely had to stop and pay a toll. Have you ever noticed a special lane set aside for cars with an electronic pass? These lanes allow vehicles to go through the tollbooth without stopping. Conduct research to determine how technologies such as this make travel faster, safer, or easier.

2. How did people navigate before global positioning systems or detailed maps were available? Conduct research and discuss historical methods of navigation before these current technologies were developed. Explain how you could use a specific historic method of navigation to get from your school to a nearby city.

3. Have you ever encountered a person from a different culture who did not speak the same language as you? It can be a rather frustrating experience, especially if you are trying to reach a specific destination. Develop some specific methods for giving directions to another student who does not speak a language with which you are familiar. How would you convey direction? What about roads, bridges, towns, or buildings? Explore the possibilities of non-verbal communication methods.

42 Project ProBase • Transportation Technologies

3. Have you ever encountered a person from a different culture who did not speak the same language as you? It can be a rather frustrating experience, especially if you are trying to reach a specific destination. Develop some specific methods for giving directions to another student who does not speak a language with which you are familiar. How would you convey the idea of direction? What about roads, bridges, towns, or buildings? Explore the possibilities of nonverbal communication methods.



Exploration Reflection Engagement Expansion **Preparing**

Career Connections

Cartographer
Flight Engineer
Surveyor
Urban/Regional Planner

Here are some careers related to this learning cycle. For more information, visit the United States Department of Labor's Occupational Outlook Handbook at: www.bls.gov/oco

You will be required to navigate (without deviation from the course) to several destinations and determine the total distance of your path in order to solve the *Primary Challenge*. Accuracy is an important factor. With the knowledge and skills you have gained through this learning cycle, how will your team determine the distance that your vehicle must travel? Your instructor may provide some time for your team to brainstorm some possible solutions to this problem at this time. If not, record some ideas below for how to solve this problem. Discuss these with your team the next time you meet.

Preparing for the Challenge

Inventor's Logbook

Logbook 2.8

Plotting the Course 43

Preparing for the Challenge

Students should develop a navigation system from these activities that can be incorporated into their solution of the *Primary Challenge* to help ensure navigation of the course without deviation. Time spent brainstorming plausible solutions in their *Primary Challenge* teams is optional here.

Student Assessment

An assessment rubric has been developed for the *Exploration* and *Engagement* activities. Feel free to change this rubric to better suit your particular needs.

Plotting the Course

Name: Date:

Element	Criteria				Points
	4	3	2	1	
Measuring devices	Demonstrated a complete understanding of the proper use of measuring devices.	Demonstrated a considerable understanding of the proper use of measuring devices.	Demonstrated a basic understanding of the proper use of measuring devices.	Demonstrated limited or no understanding of the proper use of measuring devices.	
Mathematical computation	Demonstrated a complete understanding of the proper mathematical formulas.	Demonstrated a considerable understanding of the proper mathematical formulas.	Demonstrated a basic understanding of the proper mathematical formulas.	Demonstrated limited or no understanding of the mathematical formulas.	
Inventor's Logbook Trade-offs	Fully identifies and comprehends the trade-offs considered while designing.	Identifies and comprehends most trade-offs considered while designing.	Identifies and comprehends some trade-offs considered while designing.	Does not identify or comprehend trade-offs considered while designing.	
				Total Points	