Exploring Meteorite Mysteries

Lesson 2 — Follow the Falling Meteorite

Objectives

Students will:

- apply geometric properties and relationships to meteorite hunting.
- demonstrate and experience the way remote objects or sites can be accurately located by triangulation.
- use triangulation on a map, both in a directed activity and in a group-challenge activity.

Background

Triangulation is a basic geometric technique for locating distant objects or events by measuring the directions to an object from two known locations. The basic premise behind triangulation is that many of our senses can accurately determine the direction to an object but cannot always accurately determine its distance. However, two observers in different locations will see the object in different directions. The two known locations of the observers form the base of a triangle. The angles to the distant object define where that object is located, as seen in Figure 2-1.

Triangulation is used extensively in astronomy to determine distances or sizes of objects we cannot visit (like stars and planets). Triangulation is a useful map and survival skill often taught in scouting and orienteering. This technique is used in surveying and in determining the epicenter of an earthquake. It is also a good introduction to the geometry and mathematics of triangles.

"Where do they come from?"

About This Lesson

In the activities in this lesson students use sound to easily demonstrate basic triangulation techniques. They also triangulate using a meteor's path to predict where meteorites might be found. Extended math applications may be added. Students also develop a treasure hunt map in the final activity.

Vocabulary

meteor, meteorite, triangulation

Activity A: Demonstration of Triangulation

About This Activity

Students will demonstrate how to locate distant objects or sites by triangulation. They will use sound to show the basic principles of triangulation. This activity can be done indoors or outside.

Materials for Activity A

- ❑ blindfolds for two *(optional)*
- ❑ noise maker *(anything that makes a noise)*
- ❑ yarn *(enough to "trace" the triangle in Activity A-Step 2, or ~50 m)*

Procedure

Advanced Preparation

1. Gather materials.

Classroom Procedure

1. Choose a student to be the listener (not hearing-impaired in either ear), and another to make noise (bell, buzzer, pencil tapping etc.). Make sure that the listener cannot (or will not) see during the procedure, as by blindfolding. Have the noise maker go to a far point in the room, moving quietly or masked by noises made by the other students. When the room is quiet again, have the noise maker make a sound. Repeat if necessary until the listener points at the noise maker. Almost all students will be able to point very close to the direction of the noise maker. [Many students have probably played the swimming pool game "Marco Polo," which is this same idea.] Ask blindfolded listener to determine distance to the noise maker. Show the students that a single listener can tell the direction to the noise, but not always the accurate distance.
2. Chose two students to be listeners and repeat as in step 1, keeping as much distance between them as possible. Both listeners should be pointing fairly close to the noise maker. Show how the location accuracy is improved. To make it easier for students to see the triangle, try using yarn to trace the visual lines of sight.
3. Repeat with more than two listeners if desired. A small "target area" will usually be formed.

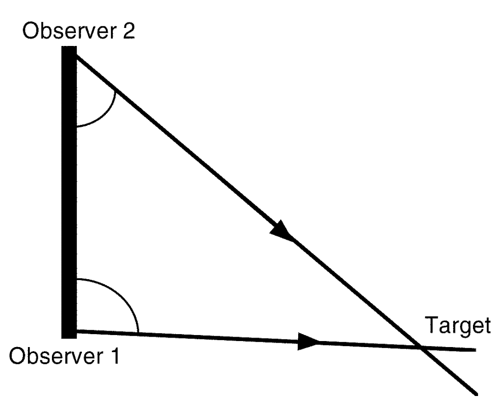


Figure 2-1

Lesson 2 — Follow the Falling Meteorite

Activity B: Path and Speed of a Meteor

Procedure

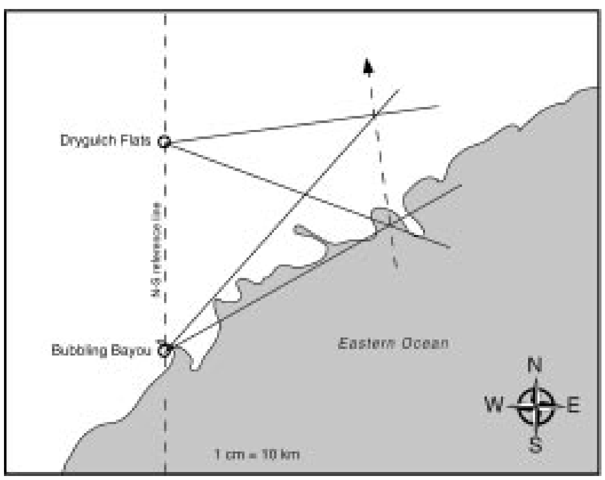
Advanced Preparation

1. Review student procedure.
2. Assemble materials.

Classroom Procedure

1. Review use of protractors, map coordinates, map scale and units.
2. Practice several protractor readings (see example below).
3. Distribute "Student Procedure: Activity B."
4. If desired, work the first observation measurement as a class or on the overhead.
5. Allow students to continue working on the worksheet.
6. Discuss.

Map Teacher Key



Question Key

Section 1

Where do the two lines cross?

40-43 km East-Northeast of Drygulch Flats.

Where did the meteor explode?

In the air near where the lines crossed, or same answer as first question.

Section 2

Where was the meteor when the spark flew?

50-52 km northeast of Bubbling Bayou, or near the coastline by the peninsula.

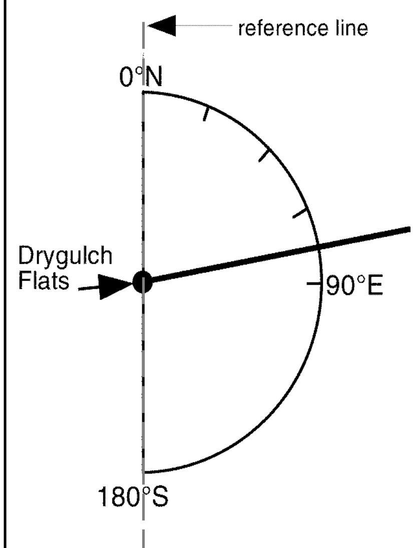
About This Activity

Students will track a meteor's path using triangulation and predict where its meteorites might be found. The exercise can be extended to calculating the velocity of a meteor and understanding how scientists can determine a meteor's original orbit in space.

Materials for Activity B

- ❑ protractors
- ❑ rulers
- ❑ Student Procedure *(pgs. 2.5-2.6, one per student)*
- ❑ colored pencils
- ❑ pencils

Example



Using the positions of the spark and the explosion, which direction was the meteorite traveling?

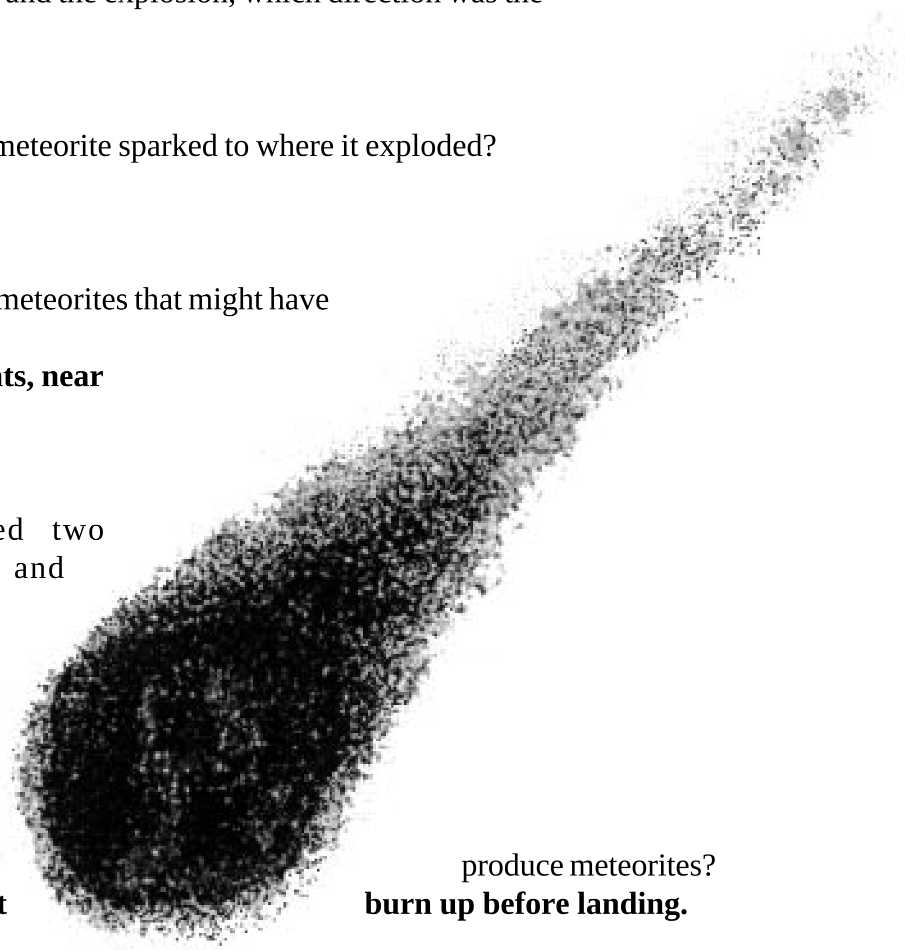
North-Northwest

How far was it from where the meteorite sparked to where it exploded? (measure with ruler)?

23-25 km

Where would you first look for meteorites that might have fallen from the explosion?

Northeast of Drygulch Flats, near where the lines cross.



<u>Section 3</u> ***(optional)***

If both observers counted two seconds between the spark and the explosion, how fast was the meteor going?

Approximately 43,200 km per hour.

<u>**Extra Thinking Questions**</u>

1. Why might a meteor not produce meteorites?

   The meteorite might burn up before landing.

2. Could a meteorite fall without anyone seeing a meteor? Explain.

   Yes. Meteors can be small enough and slow enough that they do not make big meteor streaks in the sky; no one saw a meteor when Noblesville fell. Also, it might fall at a time or remote location where no one is looking.

3. How could you determine the elevations of the meteor's sparking and its explosion?

   You can calculate the height using the determined distance and the measured observed angle above the horizon h = d Tan angle.

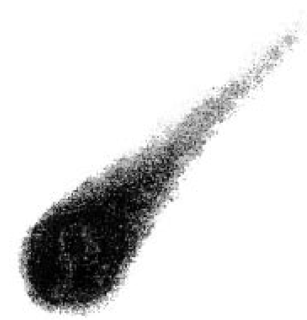
4. What information would you need to determine the orbit a meteorite was in before it hit the Earth?

   You would need several accurately located photo observations of the meteor with exact time records, and data charts of Earth's positions. (See also Lesson 4.)

<u>**Extensions**</u>

1. Try depicting this activity in 3 dimensions by providing altitude angles. Challenge students to come up with a way of representing the true meteor location.
2. For students with a background in algebra and trigonometry, the location of the meteor spark and explosion in Activity B can be determined mathematically using the cosine rule.
3. If possible have students observe and or photograph a meteor shower.

Student Procedure: Activity B



Materials

❑ ruler ❑ protractor ❑ pencil ❑ colored pencils

Path and Speed of a Meteor

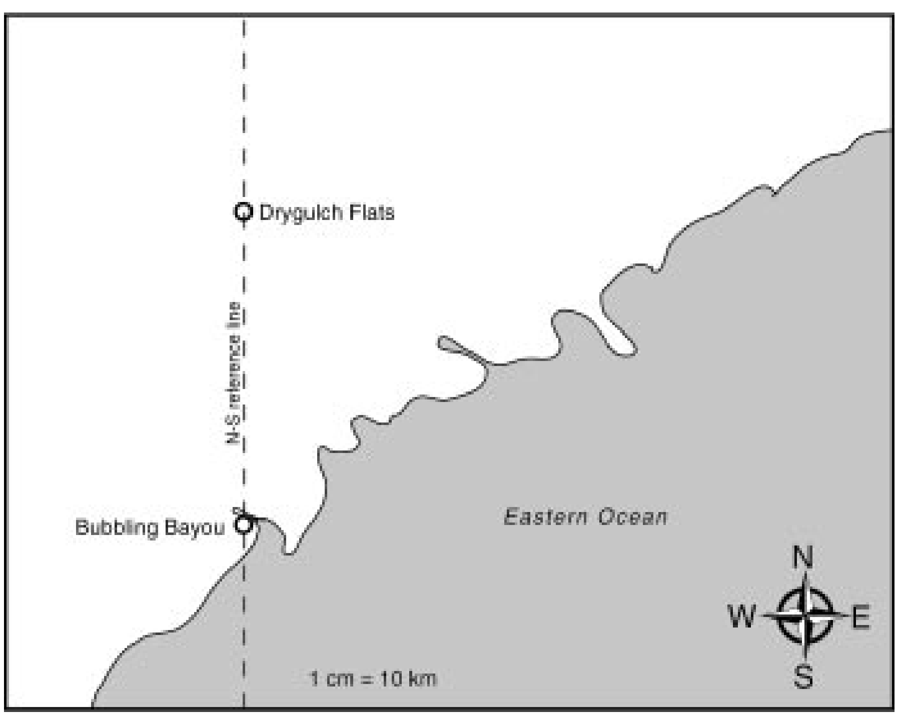
Using the map provided, you will be led through the procedures of triangulating the path and explosion of a meteor and determining a likely area to look for meteorites. Review the use of a protractor if necessary.

Section 1. The attached map shows the location of two people when they saw the meteor. The observer in Drygulch Flats was looking 80° East of North when she saw the meteor explode.

— *From Drygulch Flats, measure an angle 80° E from the dashed N-S reference line, mark the angle, and with a colored pencil draw a long line from Drygulch Flats through the mark you made.*

The observer in Bubbling Bayou was looking in a direction 40° East of North when he saw the meteor explode.

— *From Bubbling Bayou measure an angle 40° E from the dashed N-S reference line, mark the angle. Using the same color pencils draw a long line from Bubbling Bayou through the mark you made.*



Questions

Where do the two lines cross?

Where did the meteor explode?

Section 2. Both observers also saw the meteor shed a spark some time before it exploded (assume the meteor's path was horizontal). The observer in Drygulch Flats was looking in a direction 110° East of North when she saw the spark fly.

— *Using the same technique as in step 1 and a different color pencil, draw a long line from Drygulch Flats in that direction.*

The observer in Bubbling Bayou was looking in a direction 60° East of North when he saw the spark fly.

— *Draw a long line from Bubbling Bayou in that direction.*

Questions

Where was the meteor when the spark flew?

Using the positions of the spark and the explosion, which direction was the meteorite traveling?

How far was it from where the meteor sparked to where it exploded? (measure with ruler)

Where would you first look for meteorites that might have fallen from the explosion?

Section 3. Determine how fast the meteor was going. If both observers counted 2 seconds between the spark and the explosion, how fast was the meteor going (in km/hr)?

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Activity C: Meteorite Treasure Hunt

Procedure

Advanced Preparation

1. Have copies of local or regional maps for each team.

Classroom Procedure

1. Decide where on the map the two observers would be. Divide the class into teams and give each team two copies of the map.

2. Each team chooses a meteorite fall spot, and marks it with a dot on one map. Determine what direction the observers would have had to look to see the meteorite fall point. Draw lines from the fall point to where each observer is stationed. Measure the angle those lines make with North. At the bottom of the second map or a piece of paper, record these angles for use by another team.

3. Each team passes their list of angles to another team so that they have “look directions” for a new meteorite fall. Then use triangulation as in Activity B to determine where the meteorite fell. This could be done as a race or as an accuracy contest. After teams are finished, they can compare their fall location with the original maps.

Extensions

1. Outside, set up treasure hunt so that students learn to use a magnetic compass.

2. Place a ball bearing in a field to represent a meteorite. Provide a map of the field and triangulation observation angles. Have students attempt to find the “meteorite.”

About This Activity

This triangulation activity can be done as a treasure hunt game using a map of your local community, county, or state. Each team creates directions that allow another team to determine the fall site.

Materials for Activity C

- ❑ copies of local or regional map *(two per team)*
- ❑ colored pencils
- ❑ paper
- ❑ protractor *(per team)*