Benjamin Banneker: The Surveyor

### Objective

Students learn about land surveying and the Homestead act. Students solve mathematical problems related to land surveying.

Standards

Grade 6 Common Core

math Practice—mP.3,5

math Content— 6.ee.1,2,3,5,6,7,8; 6.rP.3c;

6.G.2,4

Grade 7 Common Core

math Practice—mP.3,5 math Content—7.G.4

Grade 8 Social Studies PaLS—1.a.3,C.8

Social Studies Content— 2.2; 3.1; 6.4

Common Core math Practice—mP.3,5 math Content—math Process—1.1,3,4,5,6; 2.1,2; 4.1; 5.4, math Content—8.G.7

Resources Needed

ruler yard/meter sticks

protractor calculator

yarn/string construction stakes

hammer

10’ or 25’ measuring tool

computer access

Background

As a young man, Banneker developed a working relationship with a surveyor named Andrew Ellicott. Surveying is the technique of measuring to determine the position of points, or of marking out points and boundaries. These points may be above, beneath, or on the earth’s surface. Surveying is as old as civilization. It dates back to early Egypt. every year, after the Nile river flooded and washed out farm boundaries, new boundaries were fixed by surveying. Three of the four presidents on Mount Rushmore started as surveyors—George Washington, Thomas Jefferson, and Abraham Lincoln. It was an important task in a young country where land records needed to be made.

In 1791, Ellicott was given the task of surveying land for the new federal district that would become the capital of the United States. Ellicott hired Banneker to help him. They worked to set accurate boundaries for the District of Columbia. Banneker is credited with positioning the starting point at Jones Point in Alexandria, Virginia.

Banneker had learned surveying reading a book “Gibson’s Treatise on Practical Surveying” and had discussed the book with the Ellicotts. In 1791 when Major Andrew Ellicott was chosen to survey the boundaries of the new district where the federal city was to be, he selected Banneker as part of his team. Celestial readings were key to measuring out the boundaries, and Ellicott knew Banneker’s excellent work in this area.  At that time, with no advanced equipment for measuring land, an astronomer used the parallax effect to ascertain distances; Banneker’s primary job was making astronomical observations for the starting point of the survey and maintaining a clock that was used to relate points on the ground to the positions of the stars at specified times.

By George Washington’s choice, the land for the federal city lay along the Potomac River, taking sections from Maryland and Virginia. To survey what was to become the District of Columbia meant hacking one’s way through brush and fording streams to mark off an area of 10 square miles (16 km).  Ellicott’s team placed boundary stones at every one-mile point along the border of the new district.

After spending the first several months with the team, Banneker, at 59, became concerned about his farm and returned to the family land.

Some experts denigrate Banneker’s contribution to the project, but given his knowledge and the long-term friendship he shared with the Ellicotts, there is no evidence that indicates he was anything but a full team member during the time he worked on the survey.

From colonial times and through the 1800s surveying was performed using a crude transit, or compass, and a chain. The chain was designed by Edmund Gunter in the late 1500s and is sometimes referred to as “Gunter’s chain.” The most common chain used was 66 feet long and had 100 links. each link was equal to 7.92 inches. The compass was mounted on a tripod or a single pole, called a “Jacob’s Staff.” These tools were cumbersome to carry and difficult to maneuver through thick brush. more modern methods of surveying include the Theodolite, an electronic distance measurement, GPS (Global Positioning System), and robotic surveying systems.

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Vocabulary **boundary—**anything mark- ing a limit or border **chain—**a 66 foot length in surveying made up of 100 links

**compass—**instrument for showing direction by using a magnetic needle which always points north **domain—**land or territory belonging to one govern- ment or person

**Global Positioning System (GPS)—**a system of satel- lites, computers, and receivers that is able to determine the latitude and longitude of a receiver on earth by calculating the time difference for signals from different satellites to reach the receiver **hectare—**metric measure of surface equal to 10,000 square meters or 2.471 acres

**meridian—**any of the lines of longitude running north and south on a map or globe

**robotic—**an automated device to take the place of human manual work **transit—**a surveying instrument for measuring horizontal angles

### Activities

1. read together and discuss the background information to familiarize stu-dents with surveying and its purpose.

—Students will give examples of the uses of surveying today.

—Introduce/discuss the vocabulary.

1. discuss the Homestead act of 1862.

—Were the original purposes for the Homestead act successful?

—What problems or concerns arose?

1. Hand out Worksheet a and review with students.

—discuss the terminology of measurement used in surveying.

—Compare the measurements to standard or metric units used today.

—Students complete Worksheet a using the information given.

—discuss the problems or concerns students had relating to the conver- sion of measurements.

1. Hand out Worksheet B and review with students.

—discuss the surveying terminology of townships and sections.

—divide students into groups of three or four.

—Students will work together to complete the surveying.

—Students will complete Worksheet B, using their geometric skills to physically stake out plots on the school grounds.

—Students will use protractors to accurately find the angles on their plots.

—Students will exchange work areas with another group and check the accuracy of that group’s survey work.

—discuss the problems of physically completing this activity rather than doing it on paper.

—What would have been some problems with surveying land in the early 1800s?

### Extra Reading

Harlan, James D., and James M. Denny, *Atlas of Lewis and Clark in Missouri,* University of Missouri, 2003.

Lasky, Kathryn, *The Journal of Augustus Pelletier: The Lewis and Clark Expedition (My Name is America)*, Scholastic, 2000.

Laurence, Edward, *The Young Surveyor’s Guide: Or, a New Introduction to the Whole Art of Surveying Land: Both by the Chain and all Instruments Now in Use*, Nabu, 2010.

MacLauchlan, Patricia, *Caleb’s Story*, Harper Trophy, 2002.

Panchyk, Richard, *Keys* *to* *American* *History:* *Understanding* *Our* *Most* *Important* *Historic* *Documents,* Chicago review, 2009.

Petersen, Christine, *Colonial People: The Surveyor,* Benchmark, 2010

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name

# Surveying: 19 Chains and 50 Links A

Surveying units:

Chain = 66ft. or 20 meters (100 links) Furlong/furrow long = 660 ft.

Link = 7.92 inches mile = 5280 ft. or 1760 yds.

rod/perch/Jacob’s pole = 16.5 feet Township = square of land 6 miles by 6 miles

80 chains = 1 mile Township = 36 sections

100 square chains = 10 acres square Section = 640 acres or 1 mile square 1 chain = the width of many rural roads

Use the above information to complete the activities below. Please show your computations.

1. draw a township, including the 36 sections. (.25 inches = 1 mile)
2. most early settlers could only farm 80 acres. How many 80-acre plots are included in a township?
3. a Jacob’s pole is 3 fathoms or 16.5 feet long.
   1. How many poles would equal 1 chain?
   2. How many links would equal one pole?
4. Surveyors used stakes to mark the end of each chain. If they were surveying a square plot of 10 acres per side, how many stakes would they need?
5. How many chain lengths would be needed to survey a township? (perimeter measurement)
6. How many chains and links would be needed to plot a distance of 8000 feet?

## Surveying: 19 Chains and 50 Links (answers) A

Surveying units:

Chain = 66ft. or 20 meters (100 links) Furlong/furrowlong = 660 ft.

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Use the above information to complete the activities below. Please show your computations.

1. draw a township, including the 36 sections. (.25 inches = 1 mile) answer: each side of the township should measure 1 1/2 inches.
2. most early settlers could only farm 80 acres. How many 80-acre plots are included in a township? answer: each section = 640 acres ÷80 acres = 8 farm plots

36 sections (1 township) x 8 farms = 288 plots

1. a Jacob’s pole is 3 fathoms or 16.5 feet long.
   1. How many poles would equal 1 chain? answer: 1 chain = 66 ft.

66 ft. ÷ 16.5 ft. = 4 poles

* 1. How many links would equal one pole?

answer: 1 link = 7.92 in 1 pole = 16.5 ft. or 198 in.

198 in. ÷ 7.92 in. = 25 links

1. Surveyors used stakes to mark the end of each chain. If they were surveying a square plot of 10 acres per side, how many stakes would they need?

answer: 10 chains per side

4 corner stakes + 9 stakes per side

9 stakes x 4 sides + 4 corners = 40 stakes

1. How many chain lengths would be needed to survey a township? (perimeter measurement) answer: 80 chains per mile 6 miles x 4 sides = 24 miles perimeter

24 miles x 80 chains = 1920 chain lengths

1. How many chains and links would be needed to plot a distance of 8000 feet? answer: 1 chain = 66 ft. 8000 ft. ÷ 66 ft = 7986 ft. (121 chains)

8000 – 7986 = 14 ft. or 168 inches

168 in ÷ 7.92 in = 21.21 links

Final answer: 121 chains and 21.21 link

# Surveying: 19 Chains and 50 Links B

as a surveyor, you will be marking out sections of land. all angles and measurements need to be exact.

1. Survey a square plot of land with sides of 25 links. (a link equals 7.92 inches.) draw and label your plot when finished surveying.
2. Survey a triangular plot of land. The plot forms a right triangle whose base is 3 ft. long and contains a 60- degree angle. draw and label your plot when finished with the measurements of all three sides and angles.
3. Your choice! Complete the survey of a plot which is a geometric polygon and has 6 or fewer sides. Be sure to draw and label a diagram of your plot with angles and sides.

## Surveying: 19 Chains and 50 Links (answers) B

as a surveyor, you will be marking out sections of land. all angles and measurements need to be exact.

1. Survey a square plot of land with sides of 25 links. (a link equals 7.92 inches.) draw and label your plot when finished surveying.

answer: 25 links x 7.92 in = 198 inches or 16.5 ft. or 5.5 yds drawing: a square with 90 degree angles

1. Survey a triangular plot of land. The plot forms a right triangle whose base is 3 ft. long and contains a 60 degree angle. draw and label your plot when finished with the measurements of all 3 sides and angles.

answer: The angles of the right triangle should be 30, 60, and 90 degrees respectively.

The sides of the triangle should follow the formula 3 squared + “b” squared = “c” squared with “c” being the hypotenuse of the triangle.

1. Your choice! Complete the survey of a plot which is a geometric polygon and has 6 or fewer sides. Be sure to draw and label a diagram of your plot with angles and sides.

answers: each group will vary depending on the choice of design.