Connecting Industry to Mathematics Instruction
NSF ATE Award # 1954291

Host Site Overview Student Activity Sheet

In partnership with

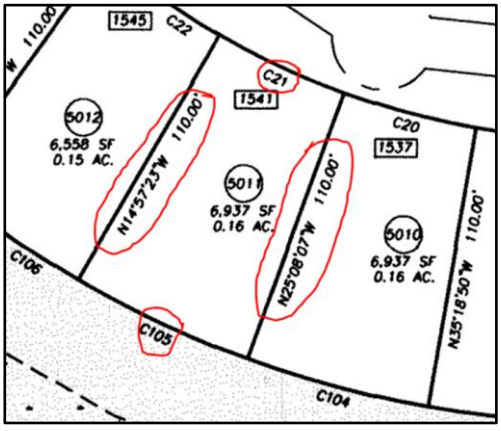
WAKE TECH

WAKE COUNTY PUBLIC SCHOOL SYSTEM

WakeEd PARTNERSHIP

A homeowner is looking into building a fence around their property. Before they start construction on the fence, they first want to confirm where their property lines are, so they don't accidentally build on their neighbor's land. Once the fence is built, they don't want to have to move the fence.

The homeowner decides to call Canoy Surveying to come and mark their property lines. In the image below, we have a map showing us the distance and bearing angles used to originally monument the property. This should help guide us to the property corners.



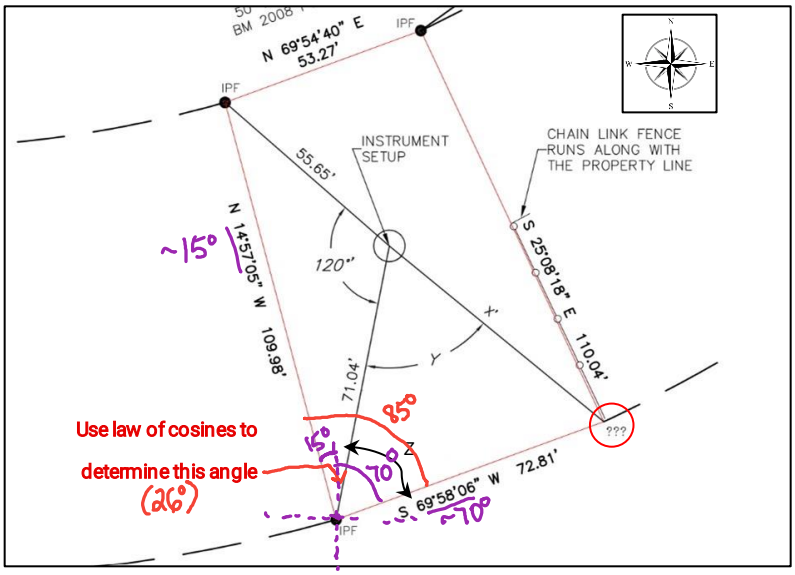
C21	53.30'	300.00'	S69°57'15"W	53.23'
C105	72.84'	410.00'	S69°57'15"W	72.74'

When a property is monumented, it is marked by burying a stake. Most stakes are made of iron or some other metal, but there are some older properties where the stakes are made of wood or other nonmetal materials. This property has metal stakes monumenting the property.

Why do you think it is useful to have metal stakes monumenting a property vs. a nonmetal one?

Won't degrade and can be found using a metal detector. Students may think of others as well.

TASK #1 Find the Missing Corner of the Property



Using a metal detector, we have been able to find and measure/locate 3 of the points relatively easily. We are having trouble finding the final corner due to the chain link fence that follows the property line. The metal detector has been less effective since there is so much metal in the area.

We set up the Robotic Total Station within the property. This piece of equipment calculates distances and internal angles turned between two points very accurately. With that we can use trigonometric equations to calculate positions of points and additional angles needed. The equipment was able to give us some information to get us started.

In order to find the final corner point for the property, we need to find several missing pieces of information, so we can use our equipment to help us locate that final point. From the bottom left corner point to the bottom right, we are given a distance of 72.81 feet. But, we don't actually know the location of that corner point since that is what we are trying to find. Can we use that value to help us calculate the other unknowns? Why or why not?

We can assume that the original property map should be accurate within a couple inches, so we can use that value.

1. Let's talk about a bearing angle. What makes a bearing angle different from a standard position angle?

   A bearing angle (in the surveying world) is a quadrantal angle and either starts due north or due south and then the angle is measured by how far to the east or west you travel.

   a. How can we use the bearing angles given to help us find angle Z?

   Since we are given the bearing angle for each corner point given, when we get can an idea of the measurements of internal angles.

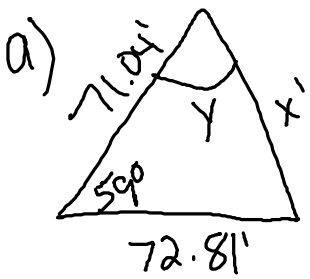
   b. Determine the measure of angle Z. Make sure you show all of your work.

   The measure of angle Z should be 59 degrees. See the diagram above on how we determine this.

2. Now, let's find side X' and angle Y
   a. Determine the values for both X' and Y. Make sure you are showing all of your work.

   b. Why is it important to know the value of angle Y? How does this help us find the corner point?

a)



$x^2 = (72.81)^2 + (71.04)^2 - 2(71.04)(72.81)\cos 59$

$x^2 = 5019.99$

$X = 70.85'$

$\frac{\sin 59}{70.85} = \frac{\sin Y}{72.81}$

$\sin Y = 0.88$ $Y = 62°$

It is important to know Y because this allows us an angle measure to use for the Robotic Total Station. Once we know Y and X', we can use that information along with the Robotic Total Station to give us a more narrowed in focus for finding the 4th corner point.

TASK #2 (Possible Extension for Precalculus/Math 121) Confirming the Area of the Property

The original property document shows the original square footage and acreage for the lot. The plot was measured to be 6,937 square feet and 0.16 acres.

Now that you have calculated or been given the various angles and side lengths of the property, calculate the area of the plot, and then convert that and determine the acreage.

Total Area = 6946 SF

Acreage = 0.16 AC

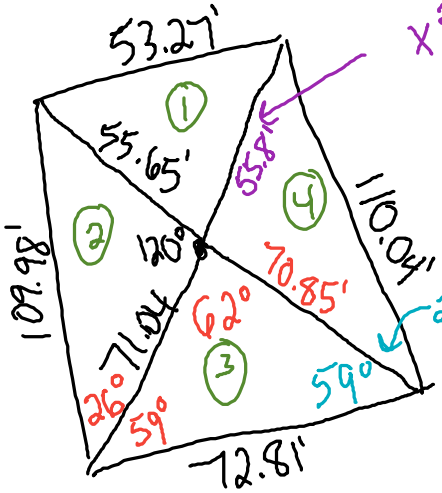
Some important formulas and conversion factors are:

$$A = \frac{1}{2}absinC \quad and \quad A = \sqrt{s(s-a)(s-b)(s-c)}, where\ s = \frac{a+b+c}{2}$$

1 acre = 43560 square feet

Based on the acreage you found, do the surveying results do a good job at measuring the property?

Based on the acreage results, the surveying results seem accurate. The square footage is slightly more than the original mapping, but slight differences are to be expected due to human error in measuring.



$x^2 = (70.85)^2 + (110.04)^2 - 2(70.85)(110.04)\cos 26°$

$x = 55.8'$

26° (Found using the bearing angles)

(3) $A = \frac{1}{2}(71.04)(70.85)\sin 62$

$A = 2222.02\ ft^2$

(4) $A = \frac{1}{2}(70.85)(110.04)\sin 26$

$A = 1708.84\ ft^2$

(2) $A = \frac{1}{2}(55.65)(71.04)\sin(60)$

$A = 1711.86\ ft^2$

(1) $\frac{55.65 + 53.27 + 55.8}{3} = 82.36$

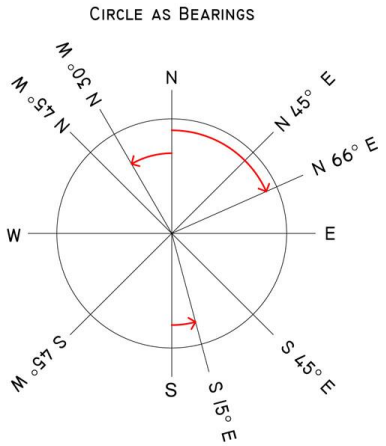
$A = \sqrt{82.36(82.36-55.65)(82.36-53.27)(82.36-55.8)}$

$A = 1303.71\ ft^2$

Total Area = $6946.43\ ft^2$, acreage = 0.16

GLOSSARY of TERMS

Bearing Angle in Surveying - surveying rarely uses degrees. They usually use a system of bearings based on deviation from north or deviation from south. For example: N 70° E means 70° to the east of North. See some examples below.

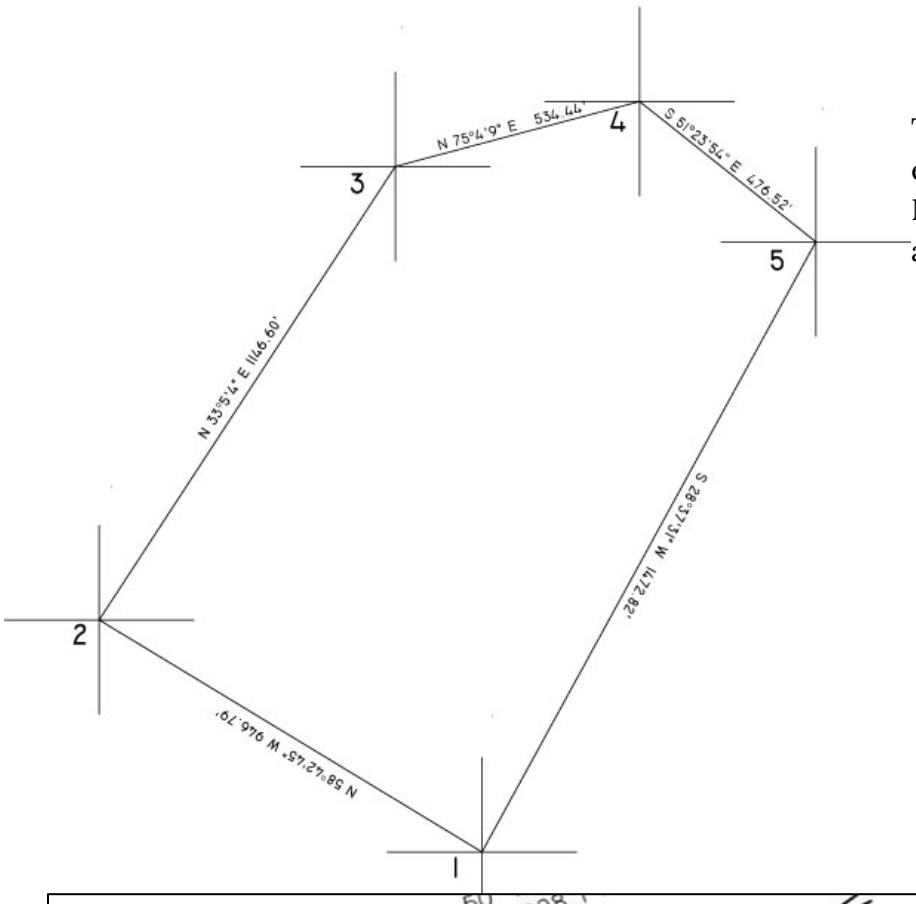


Surveying - or land surveying is the technique of determining two-dimensional or three-dimensional positions of points and the distances and angles between them.

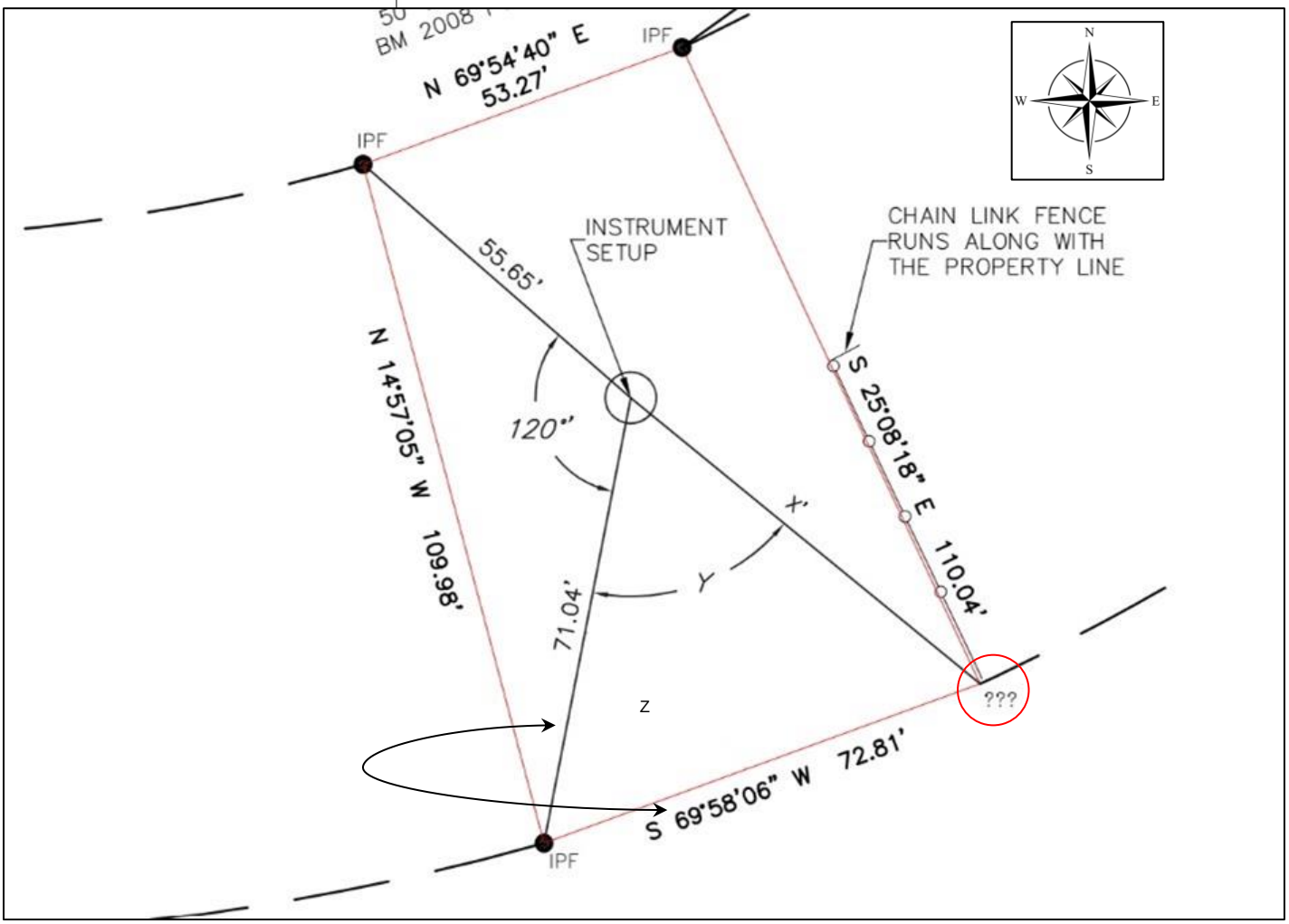
Monument - a physical structure which marks the location of a corner or other survey points.

Robotic Total Station - can measure angles and distances electronically. It uses trigonometry to give us the position of coordinates in space or the viewing plane.

Helpful Image for understanding bearing angles in context



This image shows how we can orient each property corner relative to due North in order to help us find the various angle measurements within a property.



Enlarged image for student use