Coordinate Systems

CS.1. *Worksheet*: The teacher places a small 'X' on the floor of the classroom with tape.

INDIVIDUAL WORK: Explain how you could describe the location of the 'X' using only words and numbers so that you can put the 'X' back in the same place tomorrow. (Your method should include the measurements that you need to make, but do not make the measurements now.)

GROUP WORK: Each student shares their method with the group and the group discusses the advantages and disadvantages of each method. Then the group decides on one method to use.		
Method	Advantages	Disadvantages

GROUP Activity: Each group makes the measurements it needs and writes out their description of the location of the 'X'. The group descriptions are posted on the wall.

Before the next class period the teacher removes the 'X'. In the next class period:

GROUP Activity: Each group uses their description to locate the position of the 'X'.

CLASS DISCUSSION: What did you notice?

Teachers page:
Introduce the following dictionary terms when you think it will be helpful.

Dictionary terms: A *coordinate system* is a system of assigning to *each* point in a certain region a collection of (2 or more) numbers and letters (or words) that determines its position. (That is, if you know the numbers and letters, then, by following a certain procedure that will include making some measurements, you can mark where the point is.) The collection of numbers and letters assigned to a point is called the *coordinates* (dictionary term) of that point.

Coordinate systems that the students might come up with (the teacher should make sure that 1 and 2 below come up; but only 1 will be covered now in detail). The students' own descriptions will likely be better than the descriptions here. What is important is to discuss the questions above for each system that the students come up with.

1. Rectangular Coordinates: Pick an origin (benchmark) and two straight lines thru the origin each of which has one direction called "positive" (and the other "negative"). The lines are called *axes* (dictionary term) and are usually perpendicular to each other. The coordinates (a,b) denote the point arrived at by measuring a distance a along the first axis and then starting at that point measuring a distance b along a line parallel to the second axis. When drawn on a piece of paper, traditionally (but not always), the first axis is horizontal with the positive direction being to the right and the second axis is vertical with the positive direction being up.

Coordinate systems on a football field (or basketball court) will likely be interesting examples of this.

2. Polar Coordinates: Pick an origin and a base direction from that origin. The coordinates (θ,r) denote the point arrived at by starting at the origin facing the base direction and turning thru an angle θ and then measuring in that direction the distance r. Need measurement of one length and one angle.

This may be suggested by activities with angles. This is a natural system for a baseball field or a circular disk or for air traffic controllers in a control tower.

3. Distance from two reference points on an edge of the region. Coordinates of a point are the distances from the point to each of the reference points. Need to measure only two lengths and no angles.

4. Angles from two reference points, A, B, on an edge of the region. Coordinates of a point, P, are the angles $\angle ABP$ and $\angle BAP$. The points do not need to be on the edge if you use positive and negative angles.

Exercises **CS.2:** The teacher can mark on the "Coordinate Test Sheet" Rectangular and Polar coordinate systems and ask the students to determine the coordinates of the points A-F. For Rectangular coordinates draw two perpendicular axes marking the positive direction. For Polar coordinates mark an origin and a ray from that origin. Do as many such exercises as your students need.

.A

.D

.C

.F

.E

.B

Coordinate Test Sheet

***Activity* CS.3**: **Guess our coordinate system.**

a. Each group takes the Coordinate Test Sheet and decides on a coordinate system for that sheet. Mark the origin, axes, or base direction, as appropriate for the system you choose. Do not pick any of the labeled points as your origin. Have available rulers, drawing compasses, and protractors for making measurements and drawing. Do not let the other groups know what your coordinate system is. Each group makes a list of their coordinates for each of the labeled points, A-F.

b. Now, one group goes up to the front of the class and writes on the board their coordinates of A and B. The other groups now try to determine the unknown coordinate system. (This means determining where the origin and axes or base direction are.) If no group knows the coordinate system, then the group up front gives the coordinates of point C and waits to see if any group can determine what its coordinate system is. The group that first determines the coordinate system wins and then explains to the class how it determined the unknown coordinate system. The class then discusses why it works.

c. This is now repeated with each group in turn going up front.

d. If there is time the whole process can be repeated with each group trying to make their coordinate system harder to discover by choosing axes or base direction not parallel to the edges of the paper.

{Teachers: Use and arrange in ways that will suit your class.}

CS.4 Why are coordinates important? Read the following transcript of an NPR radio segment about the use of coordinates to rescue people in an emergency (such as the Katrina Emergency).

Discussion Questions:

1. What coordinate systems are mentioned in this transcript? What are the advantages and disadvantages of each?

2. What are the coordinates of your school and house in each of these coordinate systems? Use the internet as needed.

3. Give examples that you know of different ways to give an address (consider city and rural areas). What is used by the post office? What is used when giving directions?

4. On a globe locate approximately the longitude and latitude of your city. What does this mean? What do numbers and letters (N, W, E, S) indicate? Where is the point with coordinates, 0N, 0E?

5. Using GOOGLE on the web, investigate the Military Grid Reference System.

National Public Radio Weekend Edition, February 25, 2006

New Kind of Map Could Help Emergency Response: SCOTT SIMON, host:

SIMON: How would you tell a stranger right now exactly where you are in the world? What if your life or somebody's life depends on the directions you give? When Hurricane Katrina hit the Gulf Coast, search and rescue teams discovered that they lacked a common language for explaining where they were or where people needed help. There are area mapping systems that can make rescue and response easier if Americans are willing to use them.

NPR's Dan Charles reports.

DAN CHARLES reporting:

One morning about two and a half years ago, Tom Terry parked his car in this empty five-acre parking lot in Arlington, Virginia, just across from Washington, D.C. He got out and then he heard a crash.

Mr. TOM TERRY (Virginia): I turned to look and saw a motorcycle banging along the guardrail on its side.

CHARLES: Right up there?

Mr. TERRY: Right up there, about a hundred yards away. Of course, I immediately pulled out the cell phone, called 9-1-1.

CHARLES: When the 9-1-1 operator came on the line, Tom Terry had to answer that basic universal question, where. You'd think he'd be good at this; after all, he is the executive director of the Public XY Mapping Project, which promotes the use of high quality maps. But Tom Terry struggled.

Mr. TERRY: Well, I said something to the effect of it's on a freeway coming out of Washington, D.C. It's adjacent to the Pentagon. It's adjacent to Columbia Pike. It's opposite to the side of the freeway from the Pentagon City Shopping Mall. And after a moment, she comes back and says, Are you on Interstate 66?

CHARLES: But Interstate 66 is several miles from here. Terry was frustrated. But then he remembered he had a global positioning system receiver in his pocket.

Mr. TERRY: So I said, Well, ma'am, can you take a coordinate from a GPS receiver? And she goes, No, I can't use that.

CHARLES: So the operator had to wait for somebody else to call, somebody who could name the road where the crash happened. But imagine how much harder it would have been to get help to that motorcyclist if all the street signs had been blown down, and if the rescue crew was coming from out of state. What if the rescuers were in a helicopter and had never seen the area before? That was the situation for thousands of people stranded and ailing along the Gulf Coast after Katrina.

Mr. TALBERT BROOKS (Director, Center for Geo-Spatial Information Technology, Delta State University): The Coast Guard would come running in the room and say, Okay, we've got a baby with a hole in her neck. They're at this location. Give us the coordinates. We've got to go.

CHARLES: Talbert Brooks is the director at the Center for Geo-Spatial Information Technology at Delta State University in Mississippi. He was volunteering at a command center in Jackson after Katrina ripped through that city.

Mr. BROOKS: But you still can't fly a helicopter to a street address. They don't kind of stop to hover and look at street signs; instead, they need stop type of coordinate to fly to. In this case, we were providing them with latitude and longitude.

CHARLES: Brooks became a kind of geographic translator during the crisis. If someone needed to get to Memorial Hospital in Gulf Port, he'd start with the hospital's street address, 4500 13th Street. Then he'd check computer databases to locate the coordinates that the helicopter pilots needed. Gulf Port's Memorial Hospital is at 30-degrees, 22-minutes, three-seconds north, 89-degrees, six-minutes, 53-seconds west.

Then other military units showed up with yet another geographic language, the Military Grid Reference System. Memorial Hospital, according to that grid, is located at coordinates 16R-BU-9673-6136. Some civilian parts of the federal government now have adopted the military system for identifying the locations of buildings and streets. They now call it the National Grid. Brooks says the National Grid is much easier to use than longitude and latitude. For one thing, the coordinates measure actual distances on the ground. Eventually, Brooks says, emergency workers in the path of Katrina used these coordinates to find their way around. And he became a National Grid convert.

Mr. BROOKS: I'm sold hook, line and sinker. It works to put everybody on the same page now. Were this, and I hope to God it doesn't, to happen again, I would have the national grid working the first time out of the chute.

CHARLES: But you'll have trouble finding a map at the gas station with National Grid coordinates marked on it. Every one of those maps does have a grid, the letters and numbers that the map companies print along the edge of each page to help you locate obscure streets. But each map uses a different system.

Tom Terry, from the Public X-Y Mapping Project, says that's got to change. Every commercial map should also show the coordinates of the national grid.

Mr. TERRY: You wouldn't go buy maps and expect to have 35 different sets of street names on them. Well, it's the same thing. If you have the same grid on all the maps, it turns out that's a very powerful capability. It's when it's consistent, it's the same one. It's a language of location.

CHARLES: Learning new languages, though, isn't easy. Steve Marzoff, president of the National Association of State 911 Administrators, says when local police or fire trucks head out, all they really want is a street address.

Mr. STEVE MARZOFF (President, National Association of State 911 Administrators: We're very much more vehicle oriented, and cars and everything else. With a street system, you at least know you're on Massachusetts Avenue. And if I hit Massachusetts, I go one way or the other, I'll hit you eventually.

CHARLES: Few emergency responders, right now, are trained to use anything besides a local street address. So, if another disaster should occur, that's how they would have to find their way to the people who need help, eventually.

Dan Charles, NPR News, 635 Massachusetts Avenue Northwest, Washington; 77-degrees, one minute-13 seconds north, 38-degrees-6 seconds west, or 18S-UJ-2480-0780.

CS.5 Local spherical coordinates (East/West, North/South) on the globe and on state or national maps in the classroom or the map office. Pick any point as origin and determine the directions, E/W, N/S, by using a compass or other means. Then coordinates (*a* E, *b* N) means go East a distance *a* and then go North a distance *b*. Traditionally, in geography we do not use positive and negative; but traditionally in mathematics, East and North are positive and West and South are negative. The traditional origin on the globe is the point on the equator that is directly below Greenwich, England; however, we often say things like: "Go East 100 miles and then go 150 miles North" (note that this is not the same as "Go North 150 miles and East 100 miles".

Question: In spherical coordinates, going East 1000 miles and then North 1500 miles is not the same as going North 1500 miles and then East 1000 miles. Try this on a globe. However, in rectangular coordinates it appears that going right 10 and up 15 is the same as going up 15 and then to the right 10.
Describe what you see on the globe and in rectangular coordinates.
Why do you think they are different?

To fully answer this question we need to do some further investigations of parallel lines and to study rectangles.