# Mapping Inside a Cave

Imagine yourself deep inside a cave. There is little to no light and few reference points. It's no wonder that people have gotten lost while caving. Professional cavers, spelunkers or speleologists (http://www.umsl.edu/~joellaws/ozark_caving/mss/spelunk.htm) carefully document their movements in caves so that they can produce maps. Spelunkers use a compass, tape measure and inclinometer to orient themselves and map the cave (http://www.exploratorium.edu/math_explorer/howHigh_makeInclino.html).

When you are in a dark cave it is similar to being in Space. Because space is 3 dimensional, mathematicians use 3 Cartesian coordinates to define a location or position. One coordinate can be located along the X axis. A second coordinate can be located along the Y axis. The third position is what takes you out into "space" and can be located along the Z axis. In this activity, you will map your cave along 3 coordinates.

In this activity, students will map the limestone cave that they created using clay and sugar cubes (http://teacher.scholastic.com/lessonrepro/lessonplans/theme/caves01.htm) using Cartesian coordinates as a guide to help them recreate a blueprint of the interior of their cave.

Materials:

- Cave made from clay and sugar cubes (long, tubular shapes up to 8 inches long work best for this activity)
- ~12 inches of thin dental floss or wire
- Overhead transparency of with graphing grid cut into 3-4 inch squares that can be superimposed on each other (grids align)
- Vis-à-Vis marker (2 colors)
- Thin nail and large needle
- Bamboo skewers (at least 8 to 10 inches long)

Procedure:

- Place your cave on a flat surface so that it is stable and doesn't roll or move. Orient it so that one end (entrance) is perpendicular and next to the edge of the surface.
- Make a mark along the exterior floor of the cave at its center point. You will use this as a reference point to align your transparency grids. This will serve as the 0 point on your X axis and Y axis.
- Measure the cave's exterior length and gently make marks along the top surface every centimeter (the length will represent the Z axis).
- Make a mark at the center of the bottom edge of each transparency grid to use as a reference point. Label each grid (one per section = number of centimeter marks).
- Position a square of the transparency grid in front of the cave using the reference point to align it with the entrance to your cave.
- Trace the exterior perimeter of the cave in one color. Trace the entrance to the cave in a different color. Measure the height of the interior opening of the cave along the Y axis and make a mark at the mid-point of the opening.
- Remove the grid and lay it where it won't get smeared.

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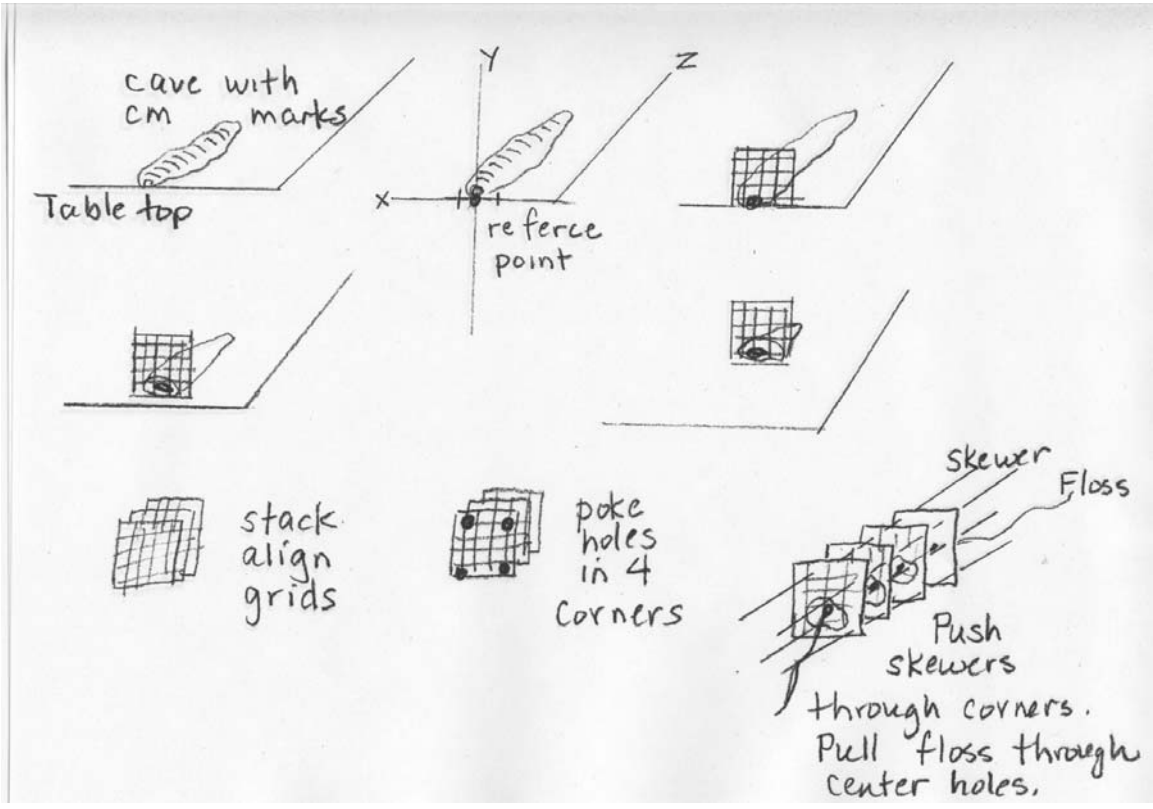
Using the dental floss or wire, carefully cut straight down through your cave at the first centimeter mark.
Position the corresponding transparency grid in front of the cave and align the reference points.
Trace the exterior perimeter of the cave in one color and the perimeter of the interior opening of the cave in a different color. Measure and mark the mid-point of the interior opening.
Repeat this sectioning and tracing procedure for each centimeter section.

Use the needle to poke a small hole through the mid-point of each transparency.
Being careful not to smear the tracings, align the transparency grids in the correct order from front to back of the cave.
Using a sharp thin object like a small nail, poke a hole through each of the four corners (heating the nail might make it easier to pierce the stacked transparencies)
Push a bamboo skewer through each corner of the aligned transparency grids.
Spread the transparency grids along the skewers in 1 cm intervals.
Use the needle to pull the dental floss (or thread) through each of the mid-points.
Look through the end of your cave and you will see a 3D representation of its interior.

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Reference Materials:

http://en.wikipedia.org/wiki/Cartesian_coordinate_system
Explanation of graphing a point in 3D space
http://www.infoplease.com/ce6/sci/A0810636.html
Cartesian coordinates

**Cartesian coordinates** [for René Descartes] - a system for representing the relative positions of points in a plane or in space. In a plane, the point *P* is specified by the pair of numbers (*x,y*) representing the distances of the point from two intersecting straight lines, referred to as the *x*-axis and the *y*-axis. The point of intersection of these axes, which are called the coordinate axes, is known as the origin. In rectangular coordinates, the type most often used, the axes are taken to be perpendicular, with the *x*-axis horizontal and the *y*-axis vertical, so that the *x*-coordinate, or abscissa, of *P* is measured along the horizontal perpendicular from *P* to the *y*-axis (i.e., parallel to the *x*-axis) and the *y*-coordinate, or ordinate, is measured along the vertical perpendicular from *P* to the *x*-axis (parallel to the *y*-axis). In oblique coordinates the axes are not perpendicular; the abscissa of *P* is measured along a parallel to the *x*-axis, and the ordinate is measured along a parallel to the *y*-axis, but neither of these parallels is perpendicular to the other coordinate axis as in rectangular coordinates. Similarly, a point in space may be specified by the triple of numbers (*x,y,z*) representing the distances from three planes determined by three intersecting straight lines not all in the same plane; i.e., the *x*-coordinate represents the distance from the *yz*-plane measured along a parallel to the *x*-axis, the *y*-coordinate represents the distance from the *xz*-plane measured along a parallel to the *y*-axis, and the *z*-coordinate represents the distance from the *xy*-plane measured along a parallel to the *z*-axis (the axes are usually taken to be mutually perpendicular). Analogous systems may be defined for describing points in abstract spaces of four or more dimensions. Many of the curves studied in classical geometry can be described as the set of points (*x,y*) that satisfy some equation *f(x,y)*=0. In this way certain questions in geometry can be transformed into questions about numbers and resolved by means of analytic geometry.

For more background information on the technology behind cave mapping:
http://www.geoconnexion.com/magazine/article.asp?ID=753

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