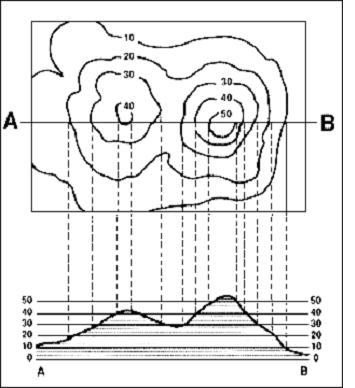
**Geo-Electric Field Science: Using Topographic Maps and Clay Models to Teach Electric Field and Potential**

Student Worksheet

Note to teacher: *Italicized commentary* are notes for teachers. Red statements show sample correct student responses. Highlighted yellow items are areas where students are likely to get “stumped.”

**Purpose:** Draw, build, and interpret electric fields using topographic maps.



Credit: USGS

**Background:** Electric fields can be visualized by thinking about a gravitational field on a topographical map. In this activity, you will first make sense of a **topographical map**, then make a physical model to draw. Topographic maps give a sense of the three-dimensional shape of a landscape, such as in the image shown to the right. Contour lines give information about elevation. Visualizing a topographical map by looking at a **profile** can also be helpful. In the image to the right, a profile for the line drawn from points A to B is show immediately beneath it.

**Guiding questions:**

Look closely at the topographical map of a Hawaiian island **on the following page**. Answer the following questions in regard to the geographical information it presents.

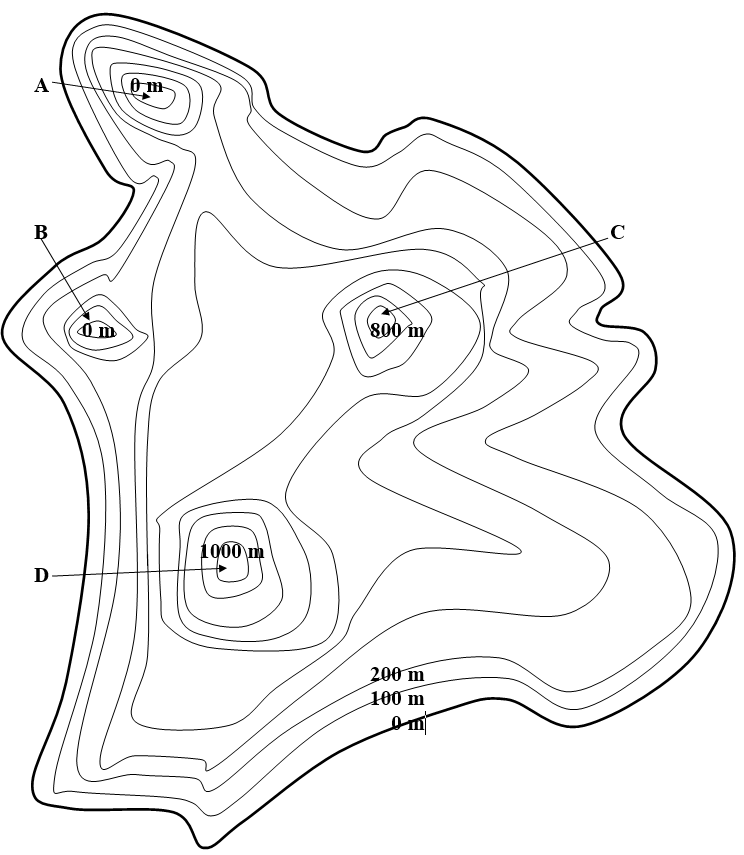
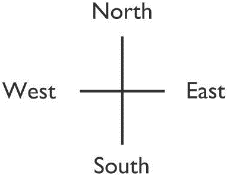
* 1. What is constant along the contour lines?
  2. What is indicated by a region where the lines close on themselves, such as around points A, B, C, or D?
  3. In the space below, draw a **profile** view for a line that cuts directly West-East and through point D.
  4. Imagine you allowed a ball to roll down from point D. How would the motion of the ball be different if it rolled eastward versus westward? Why?

Using clay, make a three-dimensional model of the island to the best of your ability. Using a sharp pencil, engrave at least 10 contour lines.

* 1. Before moving on, get approval of your clay model with contour lines by your teacher and get your teacher’s signature:

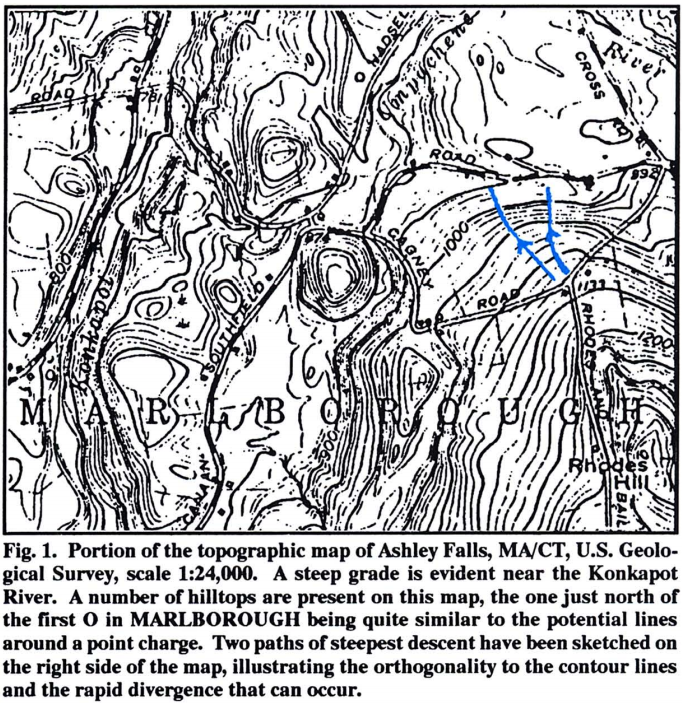
Using a dropper, drop individual droplets of water onto your clay model’s peaks, and note the direction that the droplets flow. Using a sharp pencil, draw in at least 20 small arrows showing the path of the water droplets.

* 1. Before moving on, get approval of your water droplet paths by your teacher and get your teacher’s signature:

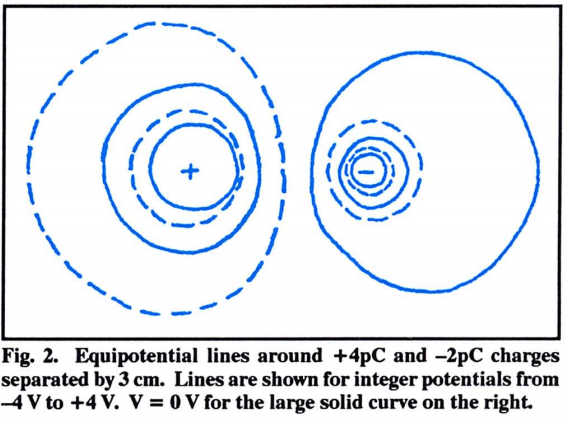


Now consider both the topographical map and the clay model of the island as if it represented an **electric field.** Note: For the purpose of this activity, assume that strong positive charges are the source of positive electric potential, represented by high altitude on a topographical map. In contrast, assume that strong negative charges are the source of “ground,” or a potential of zero.

* 1. What would be located at points A, B, C, and D? (What makes the mountains and valleys in an electric field?) Explain.
  2. What would cause points C and D to have differing heights?
  3. What is represented by the water’s path? Explain.
  4. What is represented by the contour lines? Explain.
  5. Return back to your profile view from question 3.
     + 1. On which side of point D is the electric field the strongest? How do you know? Label a corresponding area on the graph as “E.”
       2. On which side of point D is the electric field the weakest? How do you know? Label a corresponding area on the graph as “F.”
       3. Describe how the motion of a moveable charged particle might be different if it moved down either the eastward or westward side of point D. Explain how you know.
  6. Would it ever be possible for a charged particle to flow along a contour line? Why or why not? (Would it ever be possible for a water droplet to flow along a contour line?)
  7. What must be true about a clay model to have an electric field of zero? Can this only happen at “sea level”?
  8. Look closely at the geometric relationship between the contour lines and the rain lines. What is their relationship?
  9. Describe the motion for a freely-moving **positive** test charge placed at the following points:
     + A:
     + B:
     + C:
     + D:
  10. Describe the motion for a freely-moving **negative** test charge placed at the following points:
      + A:
      + B:
      + C:
      + D:
  11. Using the image on the following page of a hilly terrain and the two sample “field lines,” draw in at least 10 field lines, including arrow heads to show direction. Note: As few elevations are given on this map, you may assume that the graph displays peaks only, and no valleys.



* 1. Using the image below, describe how you would use clay to model the two point charges below. If it’s helpful, include a profile sketch of this image, or create a clay model.



* 1. Observe James Lincoln’s [*Electric Field Visualized with Crystals*](https://www.youtube.com/watch?v=63FnT0W-Hxc) YouTube video.
     + 1. For each of the following scenarios, draw in the electric field lines (using arrows to denote direction), and equipotential lines.
       2. Describe the electric field as a three-dimensional shape.
       3. Include a profile sketch (of a horizontal mid-line passing through it) of the three-dimensional shape.

Two Point Sources (Dipole)



Point Source and Bar



Point Source and Ring

Two Bars (Parallel Plate Capacitor)



* 1. Reflect back on both topographical maps and electric field maps. In paragraph form, describe the similarities and differences between them and how particles might interact differently in those fields.