Equipotential Lines & Maps

Unit: Electric Force, Field & Potential

NGSS Standards/MA Curriculum Frameworks (2016): N/A

AP® Physics 2 Learning Objectives/Essential Knowledge (2024): 10.5.B, 10.5.B. 1, 10.5.B.2, 10.5.B.2.i, 10.5.B.2.ii, 10.5.B.2.iii, 10.5.B.2.iv

Mastery Objective(s): (Students will be able to…)

- Sketch & interpret equipotential ("isoline") maps.

Success Criteria:

- Isolines are perpendicular to electric field lines.
- Isolines connect regions of equal electric potential.

Language Objectives:

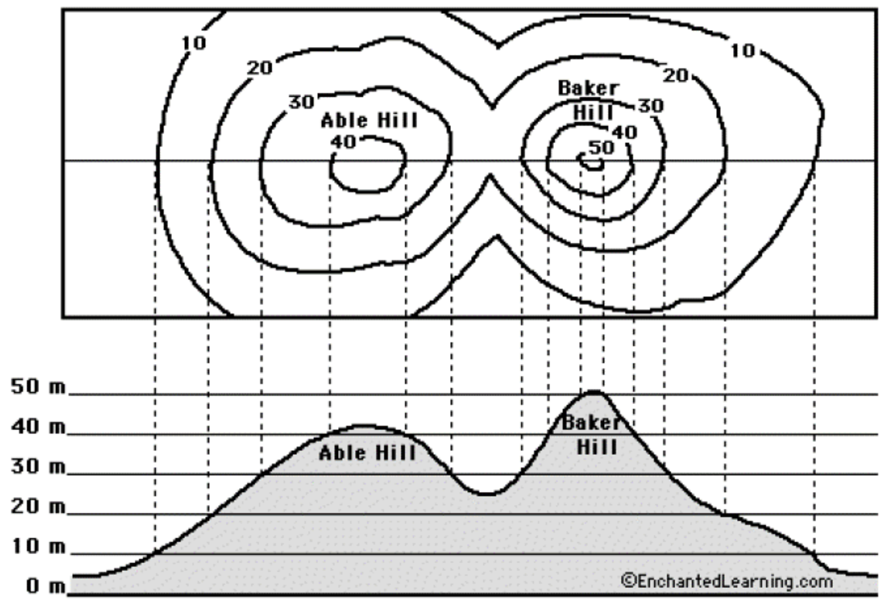
- Explain how isolines are like geographical contour maps.

Tier 2 Vocabulary: isoline, field, map

Notes:

<u>isoline or equipotential line</u>: a line on a map that connects regions of equal electric potential.

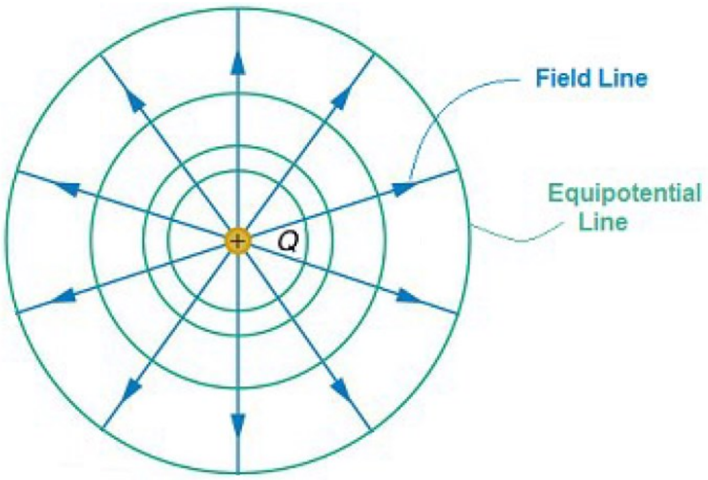
Isolines are the equivalent of elevation lines on a contour map. Below is a contour map (top) and side view of the same landscape (bottom):



The contour map (top) is a view from above. Each contour line connects points that have the same elevation.

Similar to contour lines, equipotential lines connect regions of the same electric potential.

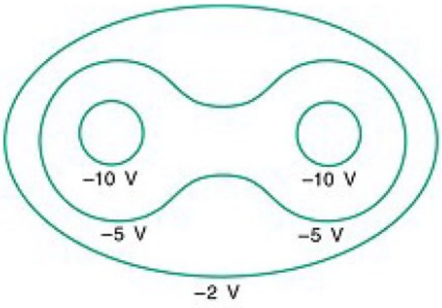
For example, the electric field direction is away from a positive point charge. The electric field strength decreases as you get farther away from the point charge. The equipotential lines (isolines) are therefore circles around the point charge; circles closer to the charge have higher electric potential, and circles farther away have lower electric potential.



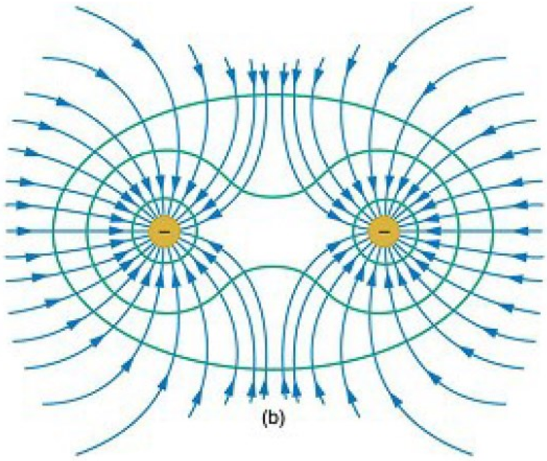
Notice that the equipotential lines are perpendicular to the field lines. As you travel along a field line, the electric potential becomes continuously less positive or more negative. The equipotential lines are the mileposts that show what the electric potential is at that point.

If you were given only the equipotential lines, you could determine what the resulting field lines looked like. For example, in the illustration below, if you were given the isolines in diagram (a), you would infer that the regions inside each of the smaller isolines must be negative point charges, and that the electric field becomes more and more negative as you approach those points.

Because the electric field lines go from positive to negative, the field lines must therefore point into the points, resulting in diagram (b). Notice again that the field lines are always perpendicular to the isolines.

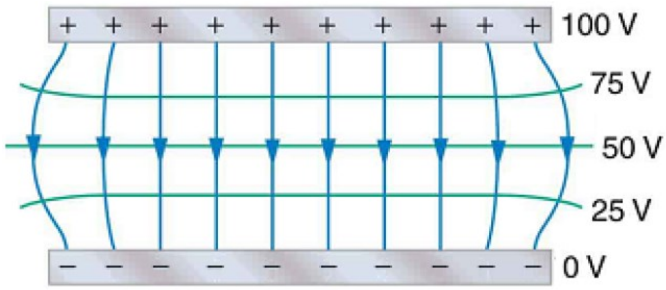


(a)



(b)

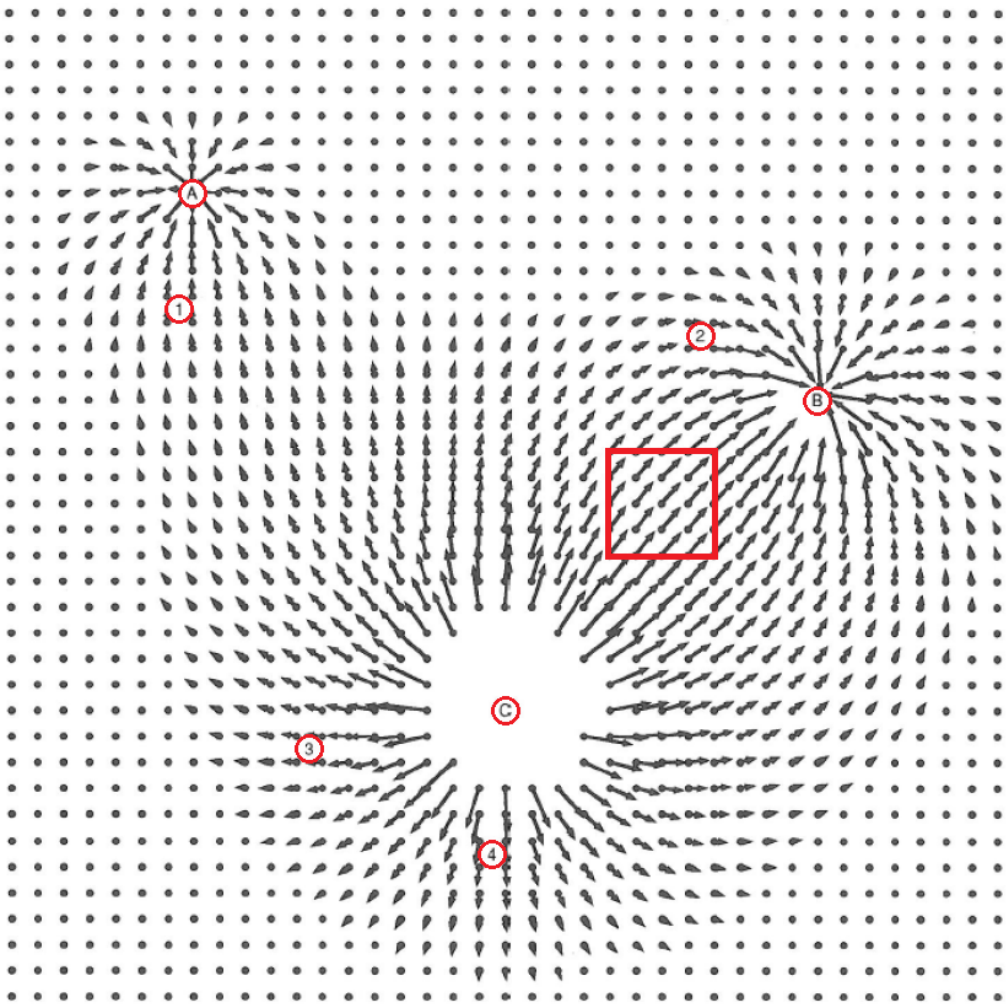
The electric field lines and isolines for the region between two parallel plates would look like the following:



Homework Problems

Consider the following electric field vector map. The length and direction of each vector arrow represents the magnitude and direction of the electric field in that location. Empty space (such as the space around point C) represents regions where the electric field is extremely strong.

There are three point charges, labeled A, B, and C. There are four numbered locations, 1, 2, 3, and 4, and a region of interest surrounded by a square box between points B and C.



1. **(M)** On the diagram on the previous page, indicate the sign (positive or negative) of charges A, B, and C.

2. **(M)** Rank the charges from strongest to weakest (regardless of sign).

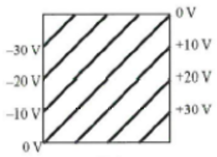
3. **(M)** Based on the lengths and directions of the field vectors, draw equipotential lines (isolines) connecting regions of the same electric potential on the diagram on the previous page.

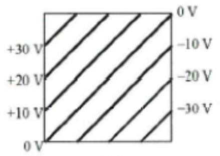
4. **(M)** Indicate the direction of the force that would act on a proton placed at point 1 and point 2.

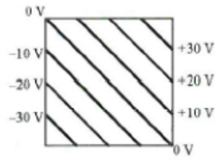
5. **(M)** Indicate the direction of the force that would act on an electron placed at point 3 and point 4.

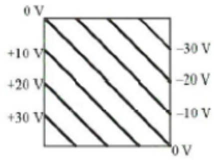
6. **(M)** At which numbered point is the electric field strongest in magnitude?

7. **(M)** Circle the diagram that could represent isolines in the boxed region between charges B and C.









Explain your rationale.