Lecture 8: Energy, Work, and Potential

ECE221: Electric and Magnetic Fields

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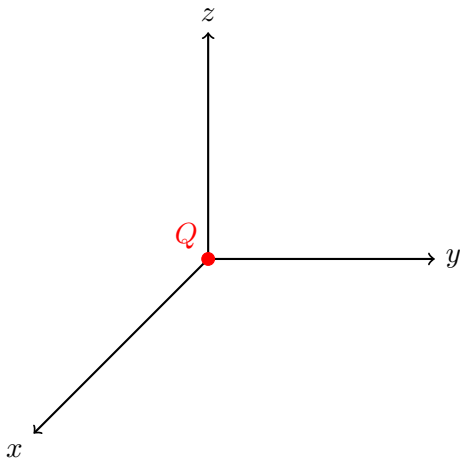
Conservative Property of the Electrostatic Field

Potential Gradient

- We have seen how to go from $\boldsymbol{E}$ to V; we now wish to do the reverse.
- Consider the E-field between two opposite point charges:

Equipotential Surfaces

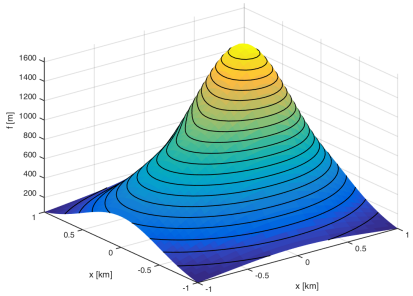


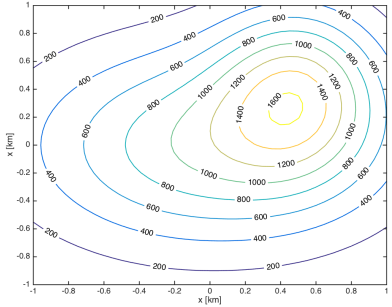
Draw the *equipotential surfaces* associated with a point charge.

$$V = \frac{Q}{4\pi\epsilon_0 R}$$

Contour Plots

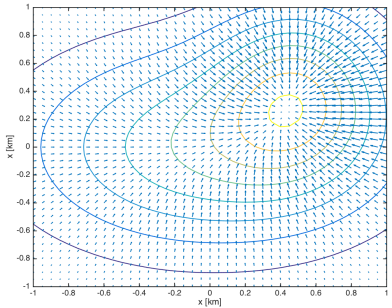
- Recall our plot of $f(x, y)$ in 2D, using *contours* to denote points where f is constant
- If f represents elevation, this is equivalent to a *topographic (topo) map*, where contours show lines of *constant elevation*





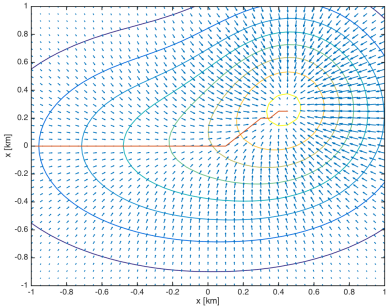
Gradient Example

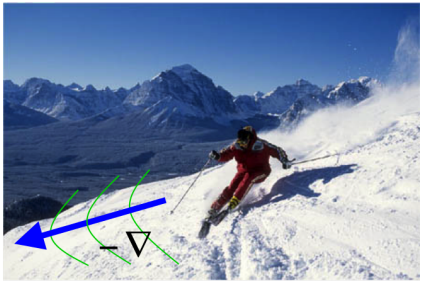
- ∇f evaluated along a grid of points is superimposed on the contour plot of f
- Vectors illustrate direction and magnitude of the gradient vector (by arrow length)



Steepest Descent

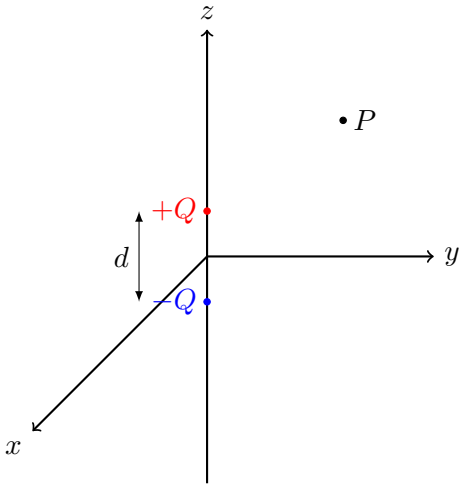
- Follow the longest arrows down $-\nabla f$
- Notice ∇f always points perpendicular to contour lines!
- The steepest ways up/down is to follow a line perpendicular to the contours when they are closest together





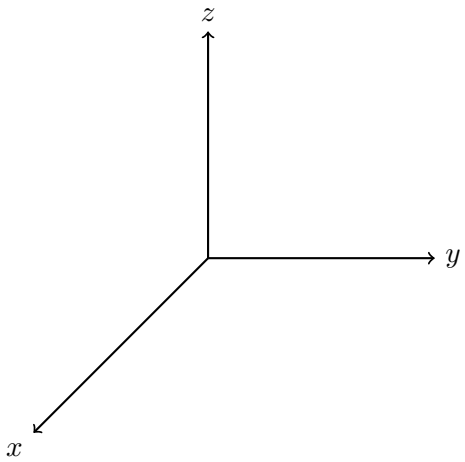
Electric Dipole

Let's revisit the example of two opposite charges separated by a distance. What is $\boldsymbol{E}$ and V at P?



Electric Dipole E-field and Equipotential Surfaces

Total Work in Positioning Discrete Charges



Total Energy Associated with Continuous Charge Densities