Chapter 25

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Electric Potential

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Lecture 04

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Obtaining The Value Of The Electric Field From The Electric Potential

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Obtaining the Value of the Electric Field from the Electric Potential

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Recall that:

$$\Delta V = \int_{V_i}^{V_f} dV = -\int_A^B \vec{E} \cdot d\vec{s} = -\vec{E} \cdot \int_A^B d\vec{s}$$

$$dV = -\vec{E} \cdot d\vec{s}$$

Which tells us how to find ΔV if the electric field $\vec{E}$ is known.

What if the situation is reversed?

Assume, to start, that the field has only an x-component. Then:

$$E_x = -\frac{dV}{dx}$$

Obtaining the Value of E from V, cont.

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Given $V\,(x, y, z)$ you can find E_x, E_y and E_z as partial derivatives:

$$E_x = -\frac{\partial V}{\partial x} \qquad E_y = -\frac{\partial V}{\partial y} \qquad E_z = -\frac{\partial V}{\partial z}$$

Equipotential surfaces must always be perpendicular to the electric field lines passing through them. Because:

The motion through a displacement ds along an equipotential surface:

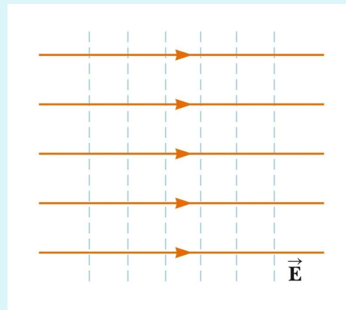
$$dV = 0$$

$$\vec{E} \cdot d\vec{s} = 0$$

$\vec{E}$ and $d\vec{s}$ (and Equipotential surface) must be perpendicular.

E and V for an Infinite Sheet of Charge

- The equipotential lines are the dashed blue lines.
- The electric field lines are the brown lines.
- The equipotential lines are everywhere perpendicular to the field lines.

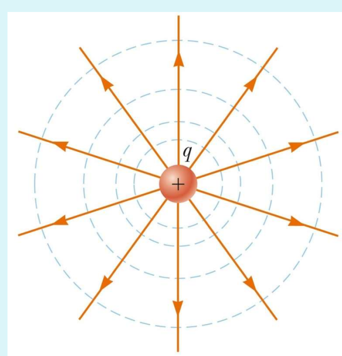


E and V for a Point Charge

- The equipotential lines are the dashed blue lines.
- The electric field lines are the brown lines.
- The electric field is radial.

$$E_r = -dV/dr$$

- The equipotential lines are everywhere perpendicular to the field lines.



Obtaining E from V

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Lecturer: Mustafa Al-Zyout, Philadelphia University, Jordan.
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In a certain region, the electric potential due to a charge distribution is given by the equation $V(x,y,z) = 3x^2y^2 + yz^3 - 2xz^3$, where x, y, and z are measured in meters and V is in volts. Calculate the electric field vector at the position $(x,y,z) = (1,1,1)$.

$$E_x = -\frac{\partial V}{\partial x} = -\frac{\partial}{\partial x}(3x^2y^2 + yz^3 - 2xz^3) = -6xy^2 + 2z^3$$

$$E_y = -\frac{\partial V}{\partial y} = -\frac{\partial}{\partial y}(3x^2y^2 + yz^3 - 2xz^3) = -6x^2y - z^3$$

$$E_z = -\frac{\partial V}{\partial z} = -\frac{\partial}{\partial z}(3x^2y^2 + yz^3 - 2xz^3) = -3yz^2 + 6xz^2$$

At $(x,y,z) = (1,1,1)$

$$E_x = -6 \times 1 \times 1^2 + 2 \times 1^3 = -4\,V/m$$

$$E_y = -6 \times 1^2 \times 1 - 1^3 = -7\,V/m$$

$$E_z = -3 \times 1 \times 1^2 + 6 \times 1 \times 1^2 = 3\,V/m$$

In unit vector notation:

$$\vec{E} = \left(-4\hat{\imath} - 7\hat{\jmath} + 3\hat{k}\right) V/m$$