Calculating the Potential from the Field

→ To calculate potential

Consider Electric Field = E

Test charge = q_o

Electric force $F = q_o E$

Differential displacement = ds

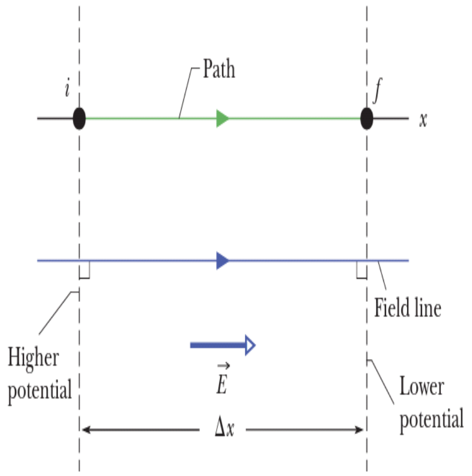
Differential work = dW

→ A positive test charge q_o moves from point i to f. The work done on charge is

$$dW = F.ds$$

$$dW = -q_o E.ds$$

$$(\therefore F = q_o E)$$



(negative sign is needed because F must be applied opposite to $q_o E$ so as to keep it in equilibrium).

→ To find total work done, take integration

$$\int_i^f dW = -q_o \int_i^f E.ds$$

$$\frac{W}{qo} = -\int_i^f E.ds$$

$$\Delta V = \int_i^f E.ds \qquad (\therefore \Delta V = \frac{W}{qo})$$

$$\Delta V = -E \int_i^f ds$$

Result $\boxed{\boldsymbol{\Delta V = -E\Delta x}}$ $(\therefore$ for uniform field $\int_i^f ds = \Delta x)$

If we move in direction of field potential decreases and in opposite direction it increases.

Related Problems

1. A particle carrying a charge of 2e falls through a potential difference of 3 V. Calculate energy acquired by it.
2. A particle having a charge of 20e on it falls through a potential difference of 100 V. Calculate energy acquired by it in eV.
3. A proton placed in an electric field of 500 N/C directed to right is allowed to go a distance of 10 cm from A to B. Calculate potential difference.
4. Determine the amount by which a point charge of 4×10^{-8} C alters the electric potential at point 1.2 cm away when a) charge is positive b) charge is negative.
5. What is the electric potential at the surface of gold nucleus? The radius is 7×10^{-5} m and atomic number is 79. (Hint: q = e×atomic number)

V = W/q

V = –Ed

$V = q/4\pi\varepsilon_0 r$

$e = 1.6\times10^{-19}$ J

$\varepsilon_0 = 8.85\times10^{-12}\ C^2/Nm^2$

Calculate the Field from the Potential

Suppose that a positive test charge q_0 moves through a displacement from one equipotential surface to the adjacent surface. From dW = qE.ds, we see that the work the electric field does on the test charge during the move is $-q_0\, dV$. We see that the work done by the electric field may also be written as the scalar product $(q_0E).ds$ or $q_0E(\cos\theta)\, ds$. Equating these two expressions for the work yields

$$-q_0\, dV = q_0 E(\cos\theta)\, ds,$$

$$E\cos\theta = -\frac{dV}{ds}.$$

Since E cos θ is the component of in the direction of above equation becomes

$$E_s = -\frac{\partial V}{\partial s}.$$

We have added a subscript to E and switched to the partial derivative symbols to emphasize that above equation involves only the variation of V along a specified axis (here called the s axis) and only the component of E along that axis. In words, above equation states:

The component of $\bar{E}$ in any direction is the negative of the rate at which the electric potential changes with distance in that direction.

For the simple situation in which the electric field is uniform, above equation becomes

$$E = -\frac{\Delta V}{\Delta s},$$

where *s* is perpendicular to the equipotential surfaces. The component of the electric field is zero in any direction parallel to the equipotential surfaces because there is no change in potential along the surfaces.