Electric Field, Potential and Energy

Electric Potential

- An electric charge creates an electric field in the space around it
- It also creates a related quantity, an electric potential

Definition

- Electric potential is the work done in moving a positive test charge from infinity (very far away) to a point P near a charge Q

$$V = \frac{W}{q}$$

- Electric potential is measured in units called volts (V)
- 1 V = 1 JC^{-1}

Recall: $W = Fs$ and $F = k\frac{q_1 q_2}{r^2}$

In our case, the displacement, s is r

So… $V = \frac{W}{q} = \frac{Fs}{q} = \frac{kq_1 q_2 r}{r^2 q}$

$$\boxed{V = \frac{kq}{r} \quad or \quad V = \frac{q}{4\pi\varepsilon_0 r}}$$

Electric Potential Energy

- If we do work to move a test charge from infinity to a point P near a charge Q, then it has gained energy (potential energy)
- The electric potential energy of the test charge is then

$$\boxed{E_p = qV}$$

Potential Difference

- In practice we would like to measure the potential difference between two charges
- In general, the work that must be done on a charge q to move it from point A, where the potential is V_A, to point B, where the potential is V_B, is given by

$$W = \Delta E_p = E_{pB} - E_{pA} = qV_B - qV_A = q(V_B - V_A)$$

$$W = q\Delta V$$

Another Look at Electric Field

- Electric field is related to electric potential energy as follows:

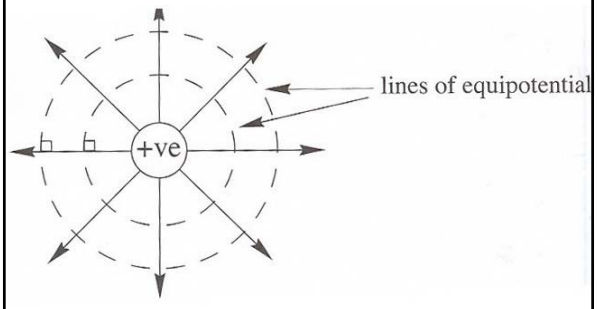
$$E = -\frac{\Delta V}{\Delta r}$$

- ΔV is the potential difference between the plates
- Δr is the separation between the plates

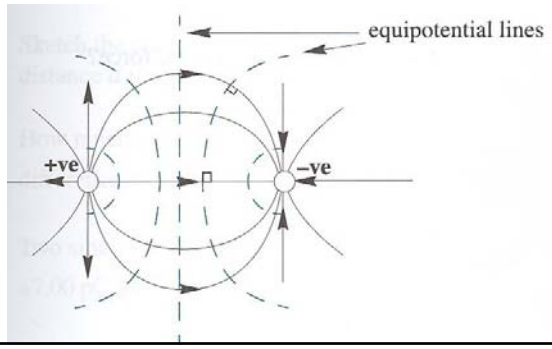
Equipotential Surfaces (Lines)

- Points in space that have the same potential are said to define equipotential surfaces
- For a single charge, the equipotential surfaces are concentric spheres centered at the charge

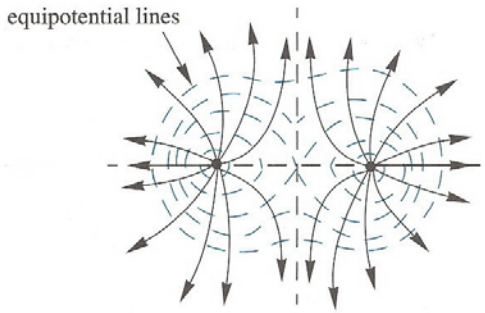
Equipotential Surfaces of a Point Charge



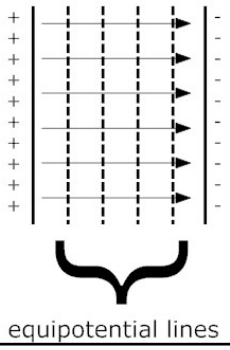
Equipotential Surfaces for Two Opposite Charges



Equipotential Surfaces for Two Equal Charges



Equipotential Surfaces for Two Parallel Plates



The Electronvolt

- A unit of energy (normally used in atomic physics)

$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$$