Topic 4: Electric Fields

Net Potential

Potential is a scalar quantity, therefore the **potential at a point due to multiple** charges or masses, is the **sum of the potential** due to the individual charges or masses.

Electrostatics—Coulomb's Law

Force:

Coulomb's law states that the force between two point charges is directly proportional to the product of the charges and inversely proportional to the separation squared.

$$F = \frac{1}{4\pi\varepsilon_o}\frac{Q_1Q_2}{r^2}$$

Where $\frac{1}{4\pi\varepsilon_o}$ is a constant ≈ 9×10^9 F m^{-1}

Electrical field strength, $\boldsymbol{E}$, is defined as the **force per unit charge** on a positive test charge at that point.

$$E = \frac{1}{4\pi\varepsilon_o}\frac{Q}{r^2}$$

Both F and E, can be repulsive (positive) or attractive (negative).

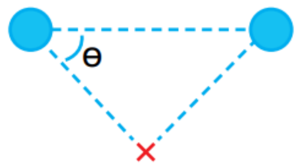
Field lines:

Can be repulsive (positive) or attractive (negative).

Net Field Strength

Field strength is a vector quantity. Therefore, when the fields of multiple masses or charges act at a point, the total field strength is the vector sum of the individual fields. This may require calculating vertical and horizontal components of E

In this example, if both charges are equal, the horizontal components will cancel, and the vertical components, each equal to E sinθ, will add



Potential

Electrical potential is defined as the **work** done **per unit charge** in bringing a **positive** charge from infinity to that point.

$$V_T = \frac{1}{4\pi\varepsilon_o}\frac{Q}{r}$$

Therefore, electrical potential energy is given by:

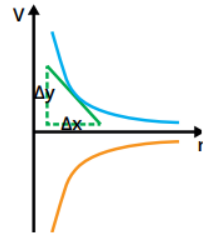
$$PE = \frac{1}{4\pi\varepsilon_o}\frac{Q_1Q_2}{r}$$

Energy

Work done: $W = q\Delta V$

As the potential at infinity must be 0, the electrical potential can be negative or positive.

In both cases, a tangent can be used to calculate the gradient at a point.



***E* = - slope of V_E - *r* graph at that point**

Conservation of energy is used to calculate the **distance of closest approach to a nucleus**.

If a charged particle is fired at a nucleus, its kinetic energy is transferred to potential energy as it gets closer to the nucleus. At the nearest point, the kinetic energy at the start = potential energy gained:

$$\frac{1}{2}mv^2 = \frac{1}{4\pi\varepsilon_o}\frac{Q_1Q_2}{r}$$

r = radial distance in m

E = electrical field strength in N C^{-1}

V = electrical potential in J C^{-1} = V

Q = charge in C