Summary of chapter 25

I. Objective:

1. Calculate the **electric potential V** due to a charge distribution.

2. Calculate the **electric potential difference** between two points in an electric field (uniform).

3. Calculate the electric potential energy associated with a group of point charges. Calculate the work done by an external force in moving a charge of between any two points in an electric field.

4. Electric potential for a conductor.

II. Summary of major point:

1. The electric potential at the point P due to a continuous charge distribution is given by:

$$V_p = k\int\frac{dq}{r}$$

where r is distance between the point P and the element of charge dq inside the object.

- *For a disk see example 25.5* in the textbook.
- *For a ring see example 25.4* in the textbook.
- *For a line charge example 25.6* in the textbook.
- *For a charged sphere example 25.7* in the textbook
- *For a point charge:*

$$\mathrm{V} = \frac{\mathrm{kQ}}{\mathrm{r}}$$

- The units for the potential is "Volt"

- The electric potential is **SCALAR**.

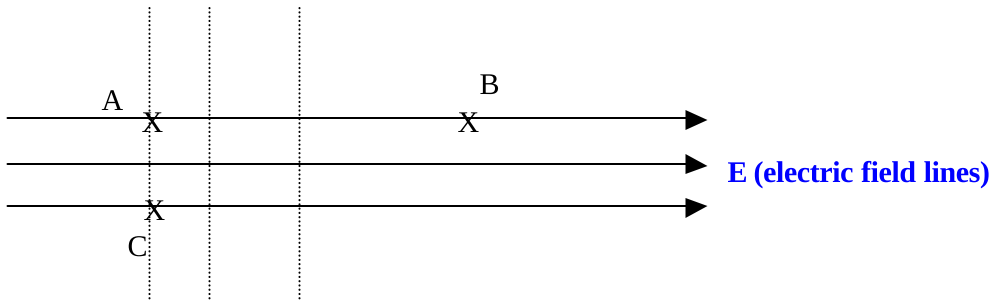
2. The potential difference between two points in an electric field is defined as:

$$\Delta V = -\int_A^B \vec{E}.d\vec{s}$$

If the electric field is **uniform**, the potential difference will be given by;

$$V_B - V_A = -Ed\cos\theta$$

where d is the distance between points A and B and θ is the angle between E and d.



✓ If $\theta = 0$, then $V_B - V_A = -E\,d$ (going from A to B)

✓ If $\theta = 180^{\circ}$, then $V_A - V_B = E\,d$ (going from B to A)

✓ If $\theta = 90^{\circ}$, then $V_A - V_C = 0$ (going from A to C)

- ***The potential at point A is greater than that at point B.***
- ***The potential at point A is the same as that at point C.***
- The dashed lines are called **equipotentials lines**.

3. The change in electric potential energy, ΔU, of a charge in moving from point A to point B in an electric field is given by;

$$\Delta U = q(V_B - V_A) = -qEd\cos\theta$$

- ***We can see from this formula that if q is positive, ΔU will be negative $\Rightarrow$ a positive charge will lose potential energy when it moves in the direction of the electric field ($\theta = 0$) and will gain kinetic energy.***

- ***On the other hand, if the charge is negative, ΔU will be positive $\Rightarrow$ a negative charge will gain potential energy when it moves in the direction of the electric field ($\theta = 0$) and will lose kinetic energy.***

The potential energy of a pair (2) of charges separated by a distance r is given by;

$$U = k\frac{q_1 q_2}{r}$$

Important: THIS ENERGY REPRESENTS THE WORK REQUIRED to assemble the charges **from infinity** to their position at r.

To assemble three charges; q_1, q_2, q_3, the potential energy (or work required) will be;

$$U = k\left(\frac{q_1 q_2}{r_{12}} + \frac{q_1 q_3}{r_{13}} + \frac{q_2 q_3}{r_{23}}\right)$$

4.

- The surface of a charged conductor is an ***equipotential surface***.

- Since the electric field inside a conductor is zero, ***the potential*** is therefore ***constant inside a charged conductor*** and equal to that at the surface.

- For a conducting sphere of radius R and charge Q, the electric potential is

  - $E = \frac{kQ}{R}$ (inside and on the surface)

  - $E = \frac{kQ}{r}$ (outside)