25.3 Electric Potential and electric energy due to a point charge:

Remember!

1. Electric Potential (V)

- **Definition**: The amount of **electric potential energy per unit charge** at a point in an electric field.
- **Formula**: $V = \frac{U}{q}$; where V is the electric potential (volts), U is the electric potential energy (joules), and q is the charge (coulombs).
- **Key Idea**: It describes how much energy a unit charge would have at a certain point due to the electric field.
- **Units**: Volts (V) = Joules per Coulomb (J/C).

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2. Electric Potential Energy (U)

- **Definition**: The **energy stored** in a system of charges due to their positions in an electric field.
- **Formula**: $U = qV$;where U is the potential energy, q is the charge, and V is the electric potential at that point.
- **Key Idea**: It depends on both the charge q and the electric potential V. It tells us how much work is needed to move a charge within an electric field.
- **Units**: Joules (J).

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3. Electric Potential Difference (ΔV) (Voltage)

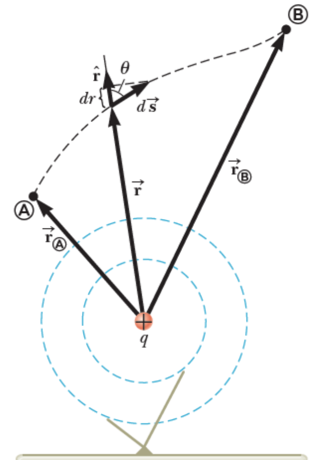
- **Definition**: The difference in electric potential between two points in an electric field, representing the work required to move a unit charge from one point to another.
- **Formula**: $\Delta V = V_B - V_A = \frac{W}{q}$; where W is the work done to move the charge from point A to point B.
- **Key Idea**: This is what drives current in a circuit—it’s often referred to as "voltage."
- **Units**: Volts (V).

- The potential difference is also give as:

$$V_{AB} = V_B - V_A = -\int_A^B E ds \cos\theta = -K\int_{r_A}^{r_B} \frac{q}{r^2} dr \cos\theta = K\frac{q}{r}|_{r_A}^{r_B} = Kq[\frac{1}{r_B} - \frac{1}{r_A}]$$

- The electric potential created by a point charge at any distance r is given by:

$$V = K\frac{q}{r}$$

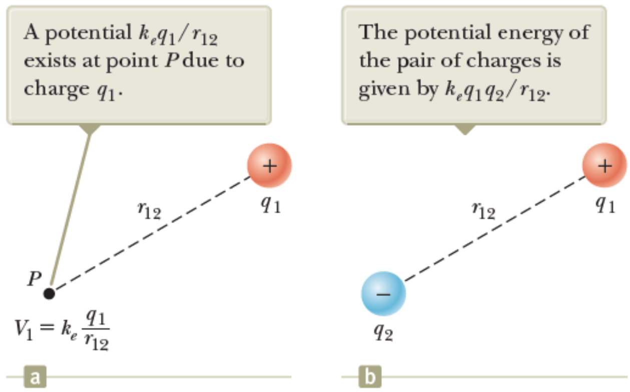


The two dashed circles represent intersections of spherical equi-potential surfaces with the page.

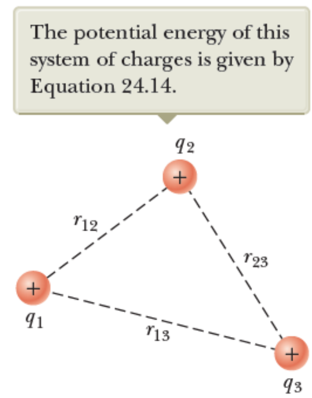
This is can be derived if we assume that choose the reference of electric potential for a point charge to be $V_A = 0$ at $r_A = \infty$.

- For a group of point charges, we can write the potential energy as follows:

$$V = k\frac{q_1}{r_1} + k\frac{q_2}{r_2} + \ldots = K\sum\frac{q_n}{r_n}$$



Potential energy is also given by:



$$U = K\frac{q_1\, q_2}{r_{12}}$$

Or, $$U = K\left[\frac{q_1\, q_2}{r_{12}} + \frac{q_1\, q_3}{r_{13}} + \frac{q_2\, q_3}{r_{23}} + \cdots\right]$$

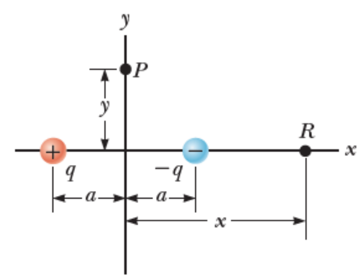
Example-1

An electric dipole consists of two charges of equal magnitude and opposite signs separated by a distance of 2a, as shown in Figure 24.13. The dipole is along the x axis and is centered at the origin.

(A) Calculate the electric potential at point P on the y axis.

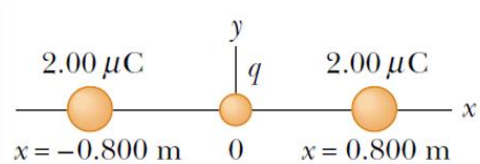
(B) Calculate the electric potential at point R on the positive x-axis.

(C) Calculate V and Ex at a point on the x-axis far from the dipole.



Exampl-2

Given two 2.00 μC charges, as shown in the figure, and a positive test charge $q = 1.28 \times 10{-}18$ C at the origin, (a) what is the net force exerted by the two 2.00 μC charges on the test charge q? (b) What is the electric field at the origin due to the two 2.00 μC charges? (c) What is the electric potential at the origin due to the two 2.00 μC charges?



Example-3

A charge q_1 = 2.00μC is located at the origin, and a charge q_2 = −6.00 μC is located at due to these charges at the point *P*, whose coordinates are 0, 3.00 m, as shown in Fig. (a). (a) Find the total electric potential 4.00, 0 m. (b) Find the change in potential energy of the system of two charges plus a charge q_3 =3.00μCas the latter charge moves from infinity to point *P* (Fig. (b)).