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Electric potential due to a dipole and system of two point charges

CLASS-XII

SUBJECT : PHYSICS
CHAPTER NUMBER: 02
CHAPTER NAME : ELECTROSTATIC POTENTIAL AND CAPACITANCE

LEARNING OUTCOME

- To use potential and potential difference to find the direction of flow of charges between two bodies in contact.
- To find the potential due to a dipole.
- Students use concept of potential for spherical shell.

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REVIEW

- How charge flows when two bodies are in contact?
- How electric potential is applied commonly used for separating large molecules, such as DNA, by size and charge?
- How external work is done in moving a charge from one point to another?

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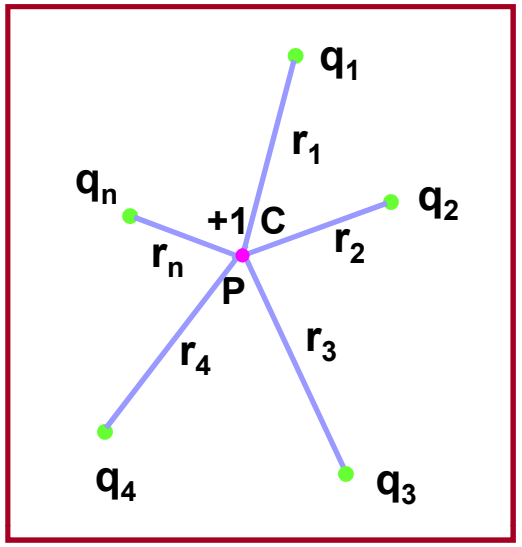
Electric Potential due to a Group of Point Charges:

$$V_P = V_1 + V_2 + V_3 + V_4 + \ldots\ldots\ldots\ldots + V_n$$

$$V = \frac{1}{4\pi\varepsilon_0} \sum_{i=1}^{n} \frac{q_i}{r_i}$$

$$V = \frac{1}{4\pi\varepsilon_0} \sum_{i=1}^{n} \frac{q_i}{|\vec{r} - \vec{r_i}|}$$

(in terms of position vector)



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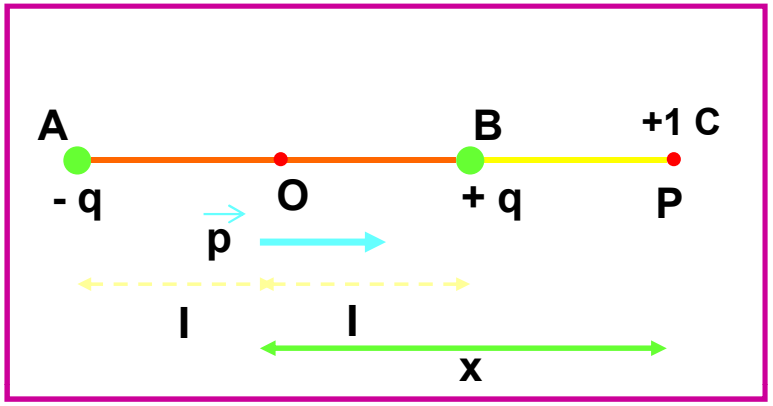
Electric Potential due to an Electric Dipole:

i) At a point on the axial line:

$$V_P = V_{P\,q+} + V_{P\,q-}$$

$$V_P = \frac{1}{4\pi\varepsilon_0} \frac{p}{(x^2 - l^2)}$$



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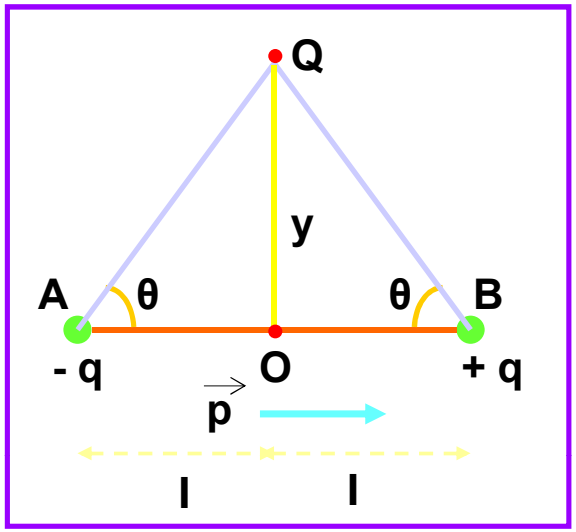
ii) At a point on the equatorial line:

$$V_Q = V_{P\,q+} + V_{P\,q-}$$

$$V_Q = 0$$



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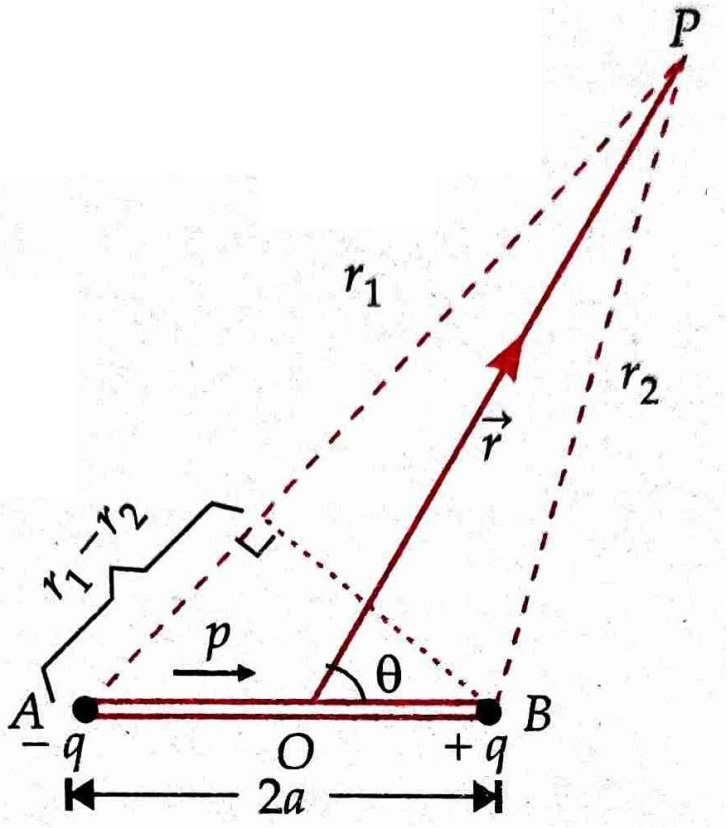
ELECTROSTATIC POTENTIAL AT A POINT DUE TO AN ELECTRIC DIPOLE

$$V = \frac{1}{4\pi\varepsilon_0} \cdot \frac{p\cos\theta}{r^2}$$

In vector notation

$$V = \frac{\vec{P} \cdot \hat{r}}{4\pi \in_0 r^2} \qquad \{P\cos\theta = \vec{P} \cdot \hat{r}\}V$$



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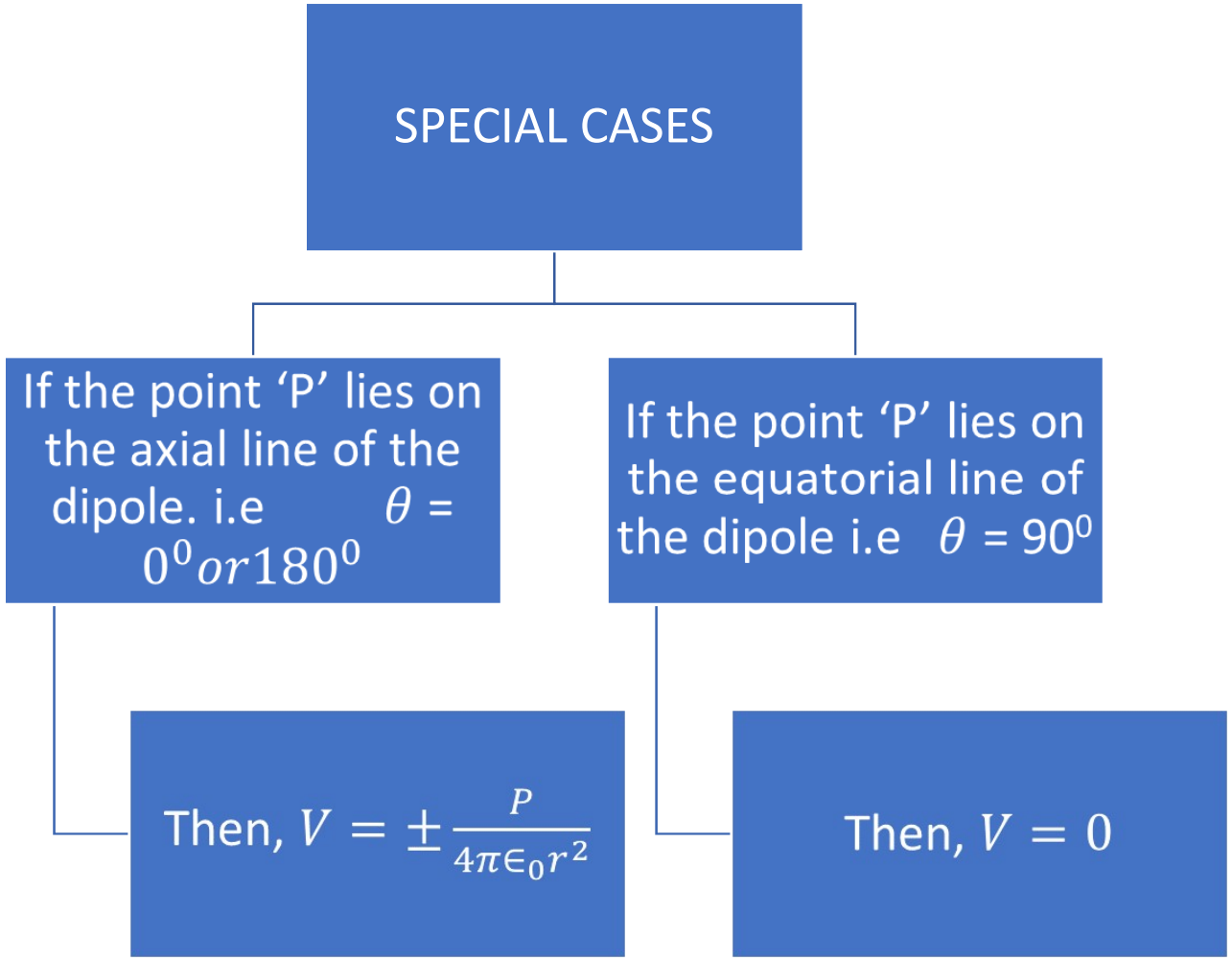
ELECTROSTATIC POTENTIAL AT A POINT DUE TO AN ELECTRIC DIPOLE



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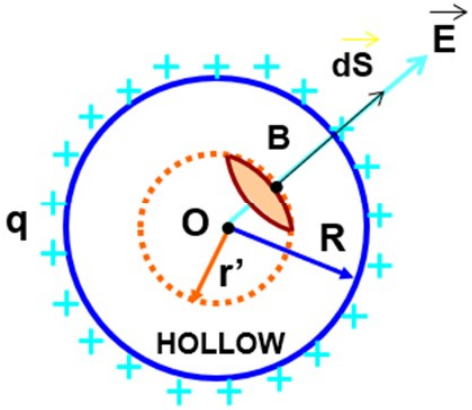
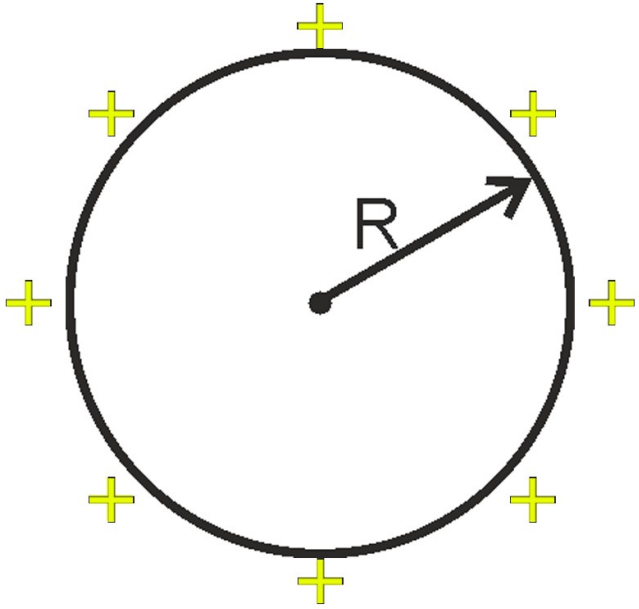
ELECTRIC POTENTIAL DUE TO UNIFORMLY CHARGED THIN SPHERICAL SHELL



$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{R} \text{ [For r = R]}$$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{R} \text{ [For r < R]}$$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{R} \text{ [For r < R]}$$



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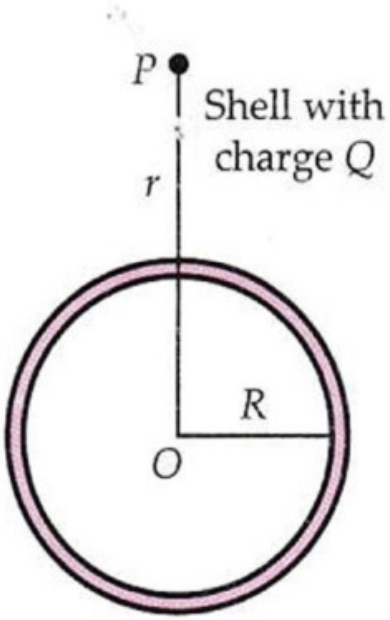
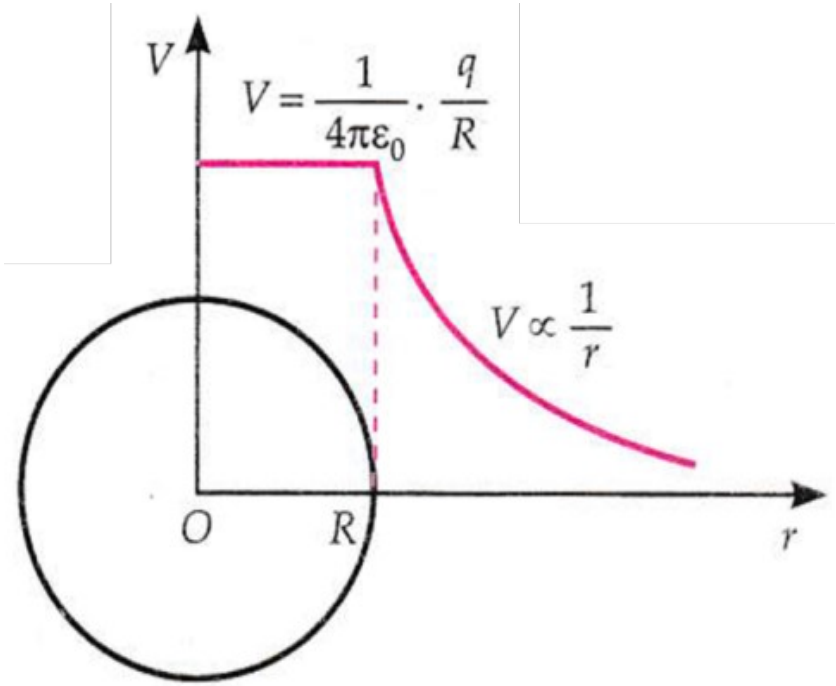
ELECTRIC POTENTIAL DUE TO UNIFORMLY CHARGED THIN SPHERICAL SHELL



Potential due to a spherical shell



Variation of potential due to charged shell with distance r from its centre.

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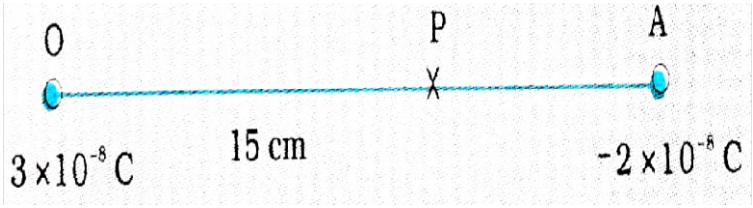
NCERT NUMERICAL

Two charges $3 \times 10^{-8} C$ and $2 \times 10^{-8} C$ are located 15 cm apart. At what point on the line joining the two charges is the electric potential 0? Take the potential at infinity to be zero.



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NUMERICAL

Two charges -q and +q are located at points A(0,0,-a) and B(0,0,+a) respectively. How much work is done in moving a test charge from point P(7,0,0) to Q(-3,0,0)

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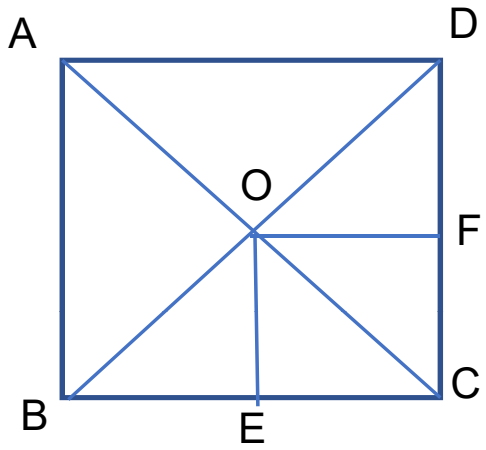
NUMERICAL

Four charges +q, +q, -q, -q are placed respectively at the corners A , B , C, D of a square of side ‘a’ arranged in the given order . Calculate the electric potential at the center O. If E and F are the midpoints of sides BC and CD respectively , what will be the work done in carrying a charge ‘e’ from O to E and from O to F?



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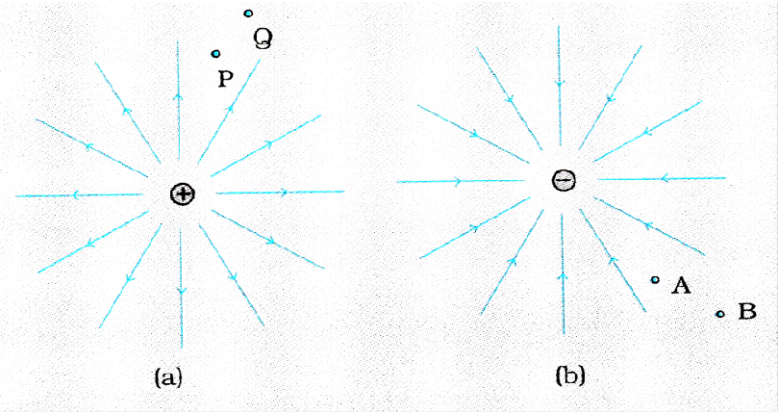
NCERT NUMERICAL

Figure (a) and (b) show the field lines of a positive and negative point charge respectively



(a) Give the signs of the potential difference $V_P - V_Q ; V_B - V_A$

(b) Give the sign of the potential energy difference of a small negative charge between the points Q and P; A and B.

(c) Give the sign of the work done by the field in moving a small positive charge from Q to P.

(d) Give the sign of the work done by the external agency in moving a small negative charge from B to A.

(e) Does the kinetic energy of a small negative charge increase or decrease in going from B to A?

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HOME ASSIGNMENT

1. A charge of 24 μC is given to a hollow metallic sphere of radius 0.2 m Find the potential

   (i) at the surface of the sphere, and

   (ii) at a distance of 0.1 cm from the centre of the sphere.

2. Two charges 5×10^{-8} C and -3×10^{-8} C are located 16 cm apart. At what point(s) on the line joining the two charges is the electric potential zero? Take the potential at infinity to be zero.

3. Give the sign of work done by an external source in slowly moving a small negative charge from A to B.

4. Two tiny spheres carrying charges 1.5 μC and 2.5 μC are located 30 cm apart. Find the potential and electric field:

(a) at the mid-point of the line joining the two charges, and

(b) at a point 10 cm from this midpoint in a plane normal to the line and passing through the mid-point.

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THANKING YOU

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