1. **Point charges**

In the figure below, a point charge \( q_1 = +1 \text{ nC} \) and another charge \( q_2 = -1 \text{ nC} \) are placed on the x-axis and separated by 8 cm. Let Point A in the middle be the origin. A target charge \( Q = +2 \text{ nC} \) is placed on the y-axis at \( y = +3 \text{ cm} \) (Point B). \( \varepsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{N} \cdot \text{m}^2 \).

(a) **(10 points)** Find the x- and y-components of the net Coulomb force on \( Q \) (at Point B) exerted by \( q_1 \) and \( q_2 \).

(b) **(8 points)** Find the electric potential difference, \( V_A - V_B \), produced by the electric fields of \( q_1 \) and \( q_2 \).

(c) **(8 points)** When \( Q \) is moved from Point C to Point D, what is the potential energy change for \( Q \), i.e., \( U_C(Q) - U_D(Q) \), in the electric field produced by \( q_1 \) and \( q_2 \)?

![Diagram of point charges](image)

2. **Effect of a combination of large charge sheets**

In the following figure, two infinitely large charge sheets, parallel to each other, are separated by a distance \( d \). One has a surface charge density \( \sigma \) and the other has a surface charge density twice as large. Let the x-axis be perpendicular to the sheets. Point B is in the middle between the two sheets.

![Diagram of charge sheets](image)

(a) **(12 points)** Find the electric fields at A, B, and C.

(b) **(15 points)** Find the electric potential difference between A and C.
3. **Combination of differently shaped charge distributions:**

In the figure below, a long insulating cylindrical shell with radius $R$ and negligible thickness carries a uniformly distributed charge $\lambda$ per unit length. It is placed between two infinitely large insulating charge sheets. The charge sheets and the cylindrical axis of the shell are parallel.

(a) **(10 points)** Find the electric field at B

(b) **(10 points)** Find the potential difference between the center of the cylindrical shell A and Point B, i.e., $V_A - V_B$.

(c) **(5 points)** Find the electric potential difference between Point C and D, i.e., $V_C - V_D$.

4. **Effect of two spherically symmetric charge distributions**

In the figure below, an insulating solid sphere with radius $R$ is uniformly charged throughout its volume with $+Q$. An insulating spherical shell with radius $R$ and negligible thickness is uniformly charged with $-Q$. The distance between centers of the two charge distributions is $3R$. Point A is half way between the center and the surface of the solid sphere. Point B is half way between the center and the surface of the thin shell.

(a) **(8 points)** Find the total electric field at A;

(b) **(6 points)** Find the total electric field at B;

(c) **(10 points)** Find the electric potential difference, $V_A - V_B$, produced by just the charge on the solid sphere;

(d) **(8 points)** Find the electric potential difference, $V_A - V_B$, produced by just the charge on the thin spherical shell.