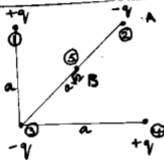
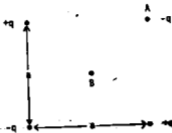


3. (a) Calculate the potential energy of the square configuration of electric charges given below.
 (b) Find the potential at A before the charge is placed at A, but after the other three charges are in place.
 (c) Find the work to bring a charge $+q$ from infinity to point B at the center of the square.



Breakdown of points as shown in red.

$$\begin{aligned}
 \text{(a) P.E.} &= U_{12} + U_{13} + U_{14} + U_{23} + U_{24} + U_{34} \quad \text{(3)} \\
 &= \frac{1}{4\pi\epsilon_0} \left[\frac{-q^2}{a} + \frac{-q^2}{a} + \frac{q^2}{a\sqrt{2}} + \frac{q^2}{a\sqrt{2}} + \frac{-q^2}{a} + \frac{-q^2}{a} \right] \quad \text{(4)} \\
 &= \frac{q^2}{4\pi\epsilon_0 a} [-4 + \sqrt{2}] \text{ Ans.} \quad \text{(2)} \quad \text{Total 9}
 \end{aligned}$$

$$\begin{aligned}
 \text{(b) } V_A &= V_1 + V_3 + V_4 = \frac{1}{4\pi\epsilon_0} \left[\frac{q}{a} + \frac{-q}{a\sqrt{2}} + \frac{q}{a} \right] \quad \text{(3)} \\
 &= \frac{q}{4\pi\epsilon_0 a} \left[2 - \frac{1}{\sqrt{2}} \right] \text{ Ans.} \quad \text{Total 8}
 \end{aligned}$$

$$\begin{aligned}
 \text{(c) } W &= U_{51} + U_{52} + U_{53} + U_{54} \quad \text{(3)} \\
 &= \frac{1}{4\pi\epsilon_0} \left[\frac{q^2}{a} + \frac{-q^2}{a\sqrt{2}} + \frac{-q^2}{a\sqrt{2}} + \frac{q^2}{a} \right] = 0 \text{ Ans} \quad \text{(2)} \quad \text{Total 8}
 \end{aligned}$$