National University

of Computer & Emerging Sciences

Applied Physics (NS-1001) **Quiz # 4A** **Fall 2025**

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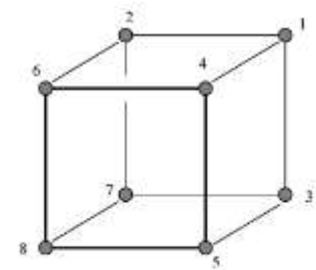
Section: BCS-B **CLO5** **Date: 19-11-2025**

Q.1: A cube of edge a carries a point charge q at each corner. Show that resultant electric force on charge q1 is given by $F = 0.262q^2/\varepsilon_o a^2$. (7M)



Solution: On any corner charge there are seven forces; one from each of the other seven charges. The net force will be the sum. Since all eight charges are the same all of the forces will be repulsive. We need to sketch a diagram to show how the charges are labeled.

The magnitude of the force of charge 2 on charge 1 is,

$$F_{12} = \frac{1}{4\pi\epsilon_0}\frac{q^2}{r_{12}^2},$$

where $r_{12} = a$, the length of a side. Since both charges are the same we wrote q_2. By symmetry we expect that the magnitudes of F_{12}, F_{13}, and F_{14} will all be the same and they will all be at right angles to each other directed along the edges of the cube. Written in terms of vectors the forces would be,

$$
\begin{aligned}
\vec{\mathbf{F}}_{12} &= \frac{1}{4\pi\epsilon_0}\frac{q^2}{a^2}\hat{\mathbf{i}}, \\
\vec{\mathbf{F}}_{13} &= \frac{1}{4\pi\epsilon_0}\frac{q^2}{a^2}\hat{\mathbf{j}}, \\
\vec{\mathbf{F}}_{14} &= \frac{1}{4\pi\epsilon_0}\frac{q^2}{a^2}\hat{\mathbf{k}}.
\end{aligned}
$$

The force from charge 5 is

$$F_{15} = \frac{1}{4\pi\epsilon_0}\frac{q^2}{r_{15}^2},$$

and is directed along the side diagonal away from charge 5. The distance r15 is also the side diagonal distance, and can be found from

$$r_{15}^2 = a^2 + a^2 = 2a^2,$$

Then,

$$F_{15} = \frac{1}{4\pi\epsilon_0}\frac{q^2}{2a^2}.$$

By symmetry we expect that the magnitudes of F_{15}, F_{16}, and F_{17} will all be the same and they will all be directed along the diagonals of the faces of the cube. In terms of components we would have

$$
\begin{aligned}
\vec{\mathbf{F}}_{15} &= \frac{1}{4\pi\epsilon_0}\frac{q^2}{2a^2}\left(\hat{\mathbf{j}}/\sqrt{2} + \hat{\mathbf{k}}/\sqrt{2}\right), \\
\vec{\mathbf{F}}_{16} &= \frac{1}{4\pi\epsilon_0}\frac{q^2}{2a^2}\left(\hat{\mathbf{i}}/\sqrt{2} + \hat{\mathbf{k}}/\sqrt{2}\right), \\
\vec{\mathbf{F}}_{17} &= \frac{1}{4\pi\epsilon_0}\frac{q^2}{2a^2}\left(\hat{\mathbf{i}}/\sqrt{2} + \hat{\mathbf{j}}/\sqrt{2}\right).
\end{aligned}
$$

The last force is the force from charge 8 on charge 1, and is given by

$$F_{18} = \frac{1}{4\pi\epsilon_0}\frac{q^2}{r_{18}^2},$$

and is directed along the cube diagonal away from charge 8. The distance r18 is also the cube diagonal distance, and can be found from

$$r_{18}^2 = a^2 + a^2 + a^2 = 3a^2,$$

then in term of components

$$\vec{\mathbf{F}}_{18} = \frac{1}{4\pi\epsilon_0}\frac{q^2}{3a^2}\left(\hat{\mathbf{i}}/\sqrt{3} + \hat{\mathbf{j}}/\sqrt{3} + \hat{\mathbf{k}}/\sqrt{3}\right).$$

We can add the components together. By symmetry we expect the same answer for each components, so we'll just do one. How about ˆi. This component has contributions from charge 2, 6, 7, and 8:

$$\frac{1}{4\pi\epsilon_0}\frac{q^2}{a^2}\left(\frac{1}{1} + \frac{2}{2\sqrt{2}} + \frac{1}{3\sqrt{3}}\right),$$

$$\frac{1}{4\pi\epsilon_0}\frac{q^2}{a^2}(1.90)$$

The three components add according to Pythagoras to pick up a final factor of √3, so

$$F_{\text{net}} = (0.262)\frac{q^2}{\epsilon_0 a^2}.$$