1. An electroscope for the detection and measurement of electric charge consists of a fixed cork ball and a suspended cork ball (see Fig. 1). The mass of the suspended ball is $1.5 \times 10^{-4}$ kg, and the length of the suspension thread is 10 cm. The fixed ball is located 10 cm directly below the point of suspension of the suspended ball. Assume that when equal electric charges are placed on the two balls, the electric repulsive force pushes the suspended ball up so its thread makes an angle of 45° with the vertical. What is the magnitude of the electric charge? [10]

![Figure 1: A charge suspended by a thread and a fixed charge.](image-url)
2. Four point charges of $\pm Q$ are arranged on the corners of a square of side $L$ as illustrated in below Figure. What is the net electric force that these charges exert on a point charge $q$ placed at the center of the square? \[10\]

\[
\begin{array}{c}
+Q \\
\hline
\hline
-\ Q
\end{array}
\]

3. A spherical shell has net charge only on its inner and outer surfaces. The total charge on the entire shell is $Q_{\text{total}} = -1.0 \times 10^{-8}$ C. The charge on the inner surface of the shell is $Q_{\text{inner}} = +2.0 \times 10^{-8}$ C. What charge is on the outer surface of the shell? \[05\]

4. Find out the expression for the electric field of a quadrupole and verify that it varies with $1/r^4$. \[10\]

5. Four closed surfaces, $S_1$ through $S_4$, together with the charges $-2Q$, $Q$, and $-Q$ are sketched in following figure:

(i) Find the electric flux through each surface.
(ii) Also sketch the electric flux corresponding to each surface. \[10+5\]

6. A particle with charge $Q$ is located immediately above the center of the flat face of a hemisphere of radius $R$ as shown in below figure. What is the electric flux through

1. the curved surface?
2. the flat face? \[5+5\]