Fields And Gauss

I. Dipole. Generic:

\[ E = \frac{k q d}{L^3} \]

If charge \( Q \) at the observation point (black dot)

\[ \vec{F} = Q \vec{E} \]

In all problems below \( q = \pm 1 \mu C \) (small red/blue circles) or \( q = \pm 2 \mu C \) (large red/blue), and \( Q = 0.5 \mu C \) (black dot). Distances are in mm.

For all configurations:

a) find the direction of the field at the black dot; show your work to instructor
b) clearly identify \( L \) and \( d \) in each picture and calculate the magnitude of the field
c) calculate the magnitude of the force on \( Q \)
II. Zero points of field.

1. Charges $q = 1 \text{nC}$ and $Q = -2 \text{nC}$ are placed at $x = 0$ and $x = 3 \text{cm}$. Identify the point with $E = 0$.

2. The same for $Q = +2 \text{nC}$
III. Gauss.

\[ \Phi = \frac{q_{enc}}{\epsilon_0} \]

1. A square has a side of 1 cm. The field \( E = 10^5 \, N/C \) makes an angle 30° with the normal. Find \( \Delta \Phi \).

2. Find \( \Phi \) through an elliptically shaped surface

3. A metal sphere with \( R = 2 \, m \) has \( Q = 1 \, nC \).
   a) find \( E \) for \( r = 0.25 \, m \)
   b) same for \( r = 3 \, m \).
IV. Extra credit

1. For $\lambda = 1 \, \mu C/m$ find $E$ at the red dot, at a distance $D = 1 \, m$ away from an infinite line. (see lecture notes.)

2. The same, $D = 1 \, m$ away from the end of a semi-infinite line:

$$dE = \frac{k \lambda \, dx}{(D + x)^2}$$