Group Discussion

1. A non-uniform electric field is represented by the diagram. At which of the following points is the electric field greatest in magnitude?
   A. A  B. B  C. C  D. D  E. E

2. An electric field is created by two parallel plates. At which of the following points is the electric field the strongest?
   A. A  B. B  C. C  D. D  E. The electric field is the same at all points

Practice Problems

3. In a rectangular coordinate system a positive point charge \( q = 6.00 \times 10^{-9} \text{C} \) is placed at the point \( x = +0.0150 \text{m}, y = 0 \), and an identical point charge is placed at \( x = -0.150 \text{m}, y = 0 \). Find the \( x \) and \( y \) components, the magnitude, and the direction of the electric field at the following points:
   a) the origin; b) \( x = 3.0 \text{m}, y = 0 \); and c) \( x = 0.150 \text{m}, y = -0.400 \text{m} \).
4. A straight wire 8.50 cm long carries a charge density of +1.75 nC/m distributed uniformly along its length. a) Find the magnitude and direction of the electric field this wire produces at a point 6.00 cm directly above its midpoint. B) If the wire is now bent into a circle lying flat on the table, find the magnitude and direction of the electric field it produces at a point 6.00 cm directly above its center.

5. Sketch the electric field lines for an infinite line of charge from a parallel and perpendicular viewpoint. Explain how the magnitude of E depends on r, the radial distance from the line.

6. Three charges are at the corners of an isosceles triangle. The 5 μC and -5 μC charges form a dipole. a) find the force the -10 μC charge exerts on the dipole. b) find the torque exerted on the dipole from the -10 μC charge relative to an axis perpendicular to the line connection the +15 μC
PROBLEM 3

\[ \alpha_1 = \alpha_2 = 60^\circ \]

\[ x = -0.15 \quad x = 0.15 \quad x = 0.3 \]

\[ y = 0.4 \quad y = 0.4 \]

\[ \theta \]

\[ a) \text{ at origin } \quad E_{O1} = E_{O2} \quad E_{\text{TOTAL}} = E_{O1} - E_{O2} = 0 \]

\[ b) \quad E_{O1} = K \cdot \frac{Q_1}{r^2} \hat{r} = K \cdot \frac{6nC}{(45)^2} \hat{r} \]

\[ E_{O2} = K \cdot \frac{Q_2}{r^2} \hat{r} = K \cdot \frac{6nC}{(45)^2} \hat{r} \]

\[ \hat{r} = \hat{\theta} \]

\[ E_{\text{TOTAL}}(x) = (K \cdot \frac{6nC}{(45)^2} + K \cdot \frac{6nC}{(15)^2}) \hat{r} \]

\[ E_{\text{TOTAL}} = 2664 \text{ N/C} \]

\[ E_y = 0 \]

\[ c) \quad E_{O1} = K \cdot \frac{6nC}{(15)^2} \hat{r} = 215.8 \text{ N/C} \]

\[ \cos \theta = -\frac{3}{5} \quad \sin \theta = -\frac{4}{5} \]

\[ E_{O1x} = 215.8 \cdot \cos \theta \]

\[ E_{O1y} = 215.8 \cdot \sin \theta \]

\[ E_{O1x} = 215.8 \cdot \frac{-3}{5} = 129.5 \hat{i} \]

\[ E_{O1y} = 215.8 \cdot \frac{-4}{5} = -172.6 \hat{j} \]

\[ E_{O2} = K \cdot \frac{Q_2}{(4)^2} \hat{r} = K \cdot \frac{6nC}{(4)^2} (-\hat{j}) = -337.1 \hat{j} \quad E_{O2x} = 0 \]

\[ E_{\text{TOTAL}} x = 129.5 \hat{i} \text{ N/C} \]

\[ \hat{E} = \sqrt{129.5^2 + 509.7^2} = 525.89 \text{ N/C} \]

\[ \tan^{-1} \left( \frac{-509.7}{129.5} \right) = -75.74^\circ \]

\[ E_{\text{TOTAL}} y = -172.6 \hat{j} + -337.1 \hat{j} = -509.7 \hat{j} \text{ N/C} \]
PROBLEM 4

\[ \lambda = 1.75 \text{ nC/m} \]

\[ E = \int K \cdot \frac{L \cdot dx}{r^2} \hat{r} \]

\[ E_2 = \int K \cdot \frac{L \cdot dx}{r^2} \cos \theta \]

\[ E_2 = \int K \cdot \frac{L \cdot dx}{r^2} \cdot \frac{.06}{\sqrt{.06^2 + x^2}} \hat{z} \]

\[ E_2 = 2.425 \int K \cdot \frac{L \cdot dx}{(0.06^2 + x^2)^{3/2}} \hat{z} \]

\[ E_2 = 2 \cdot \frac{2 \cdot k \cdot 1.75 \text{nC/m}}{.06} \left[ \frac{x}{(x^2 + .06^2)^{1/2}} \right] \]

\[ E_2 = 2 \cdot k \cdot 1.75 \text{nC/m} \left( \frac{.0425}{(0.06^2 + .0425)^{1/2}} \right) = 303 \text{ nC} \]

\[ \text{perpendicular to wire} \]

b)

\[ \lambda = 1.75 \text{nC/m} \quad Q_{\text{TOTAL}} = 1.75 \text{nC} \cdot .085 = 14875 \text{nC} \]

\[ E_2 = \int K \cdot \frac{d \xi}{r^2} \cos \theta \cdot \hat{z} \]

\[ \theta = \hat{r} \cdot \cos \theta \]

\[ a = 1.35 \text{ cm} \]

\[ d = 6 \text{ cm} \]

\[ \cos \theta = \frac{\theta \text{cm}}{r} \]

\[ r = \sqrt{.06^2 + .0135^2} \]

\[ E_2 = k \cdot \frac{Q_{\text{TOTAL}} \cdot .06}{(0.06^2 + 0.0135^2)^{3/2}} \hat{z} = 345 \text{ nC} \]

\[ \text{perpendicular to ring} \]
The field lines are spaced equally around the circle so that the density of the field lines are proportional to the circumference of the circle, which increases linearly with radius. So the density will decrease linearly as $r$ increases.
PROBLEM 6

\[ a) \ \sin \theta = \frac{1.5}{2} \quad \theta = 48.6^\circ \]

\[ F_x = F_{x1} + F_{x2} = 0 \]

\[ F_{x1} = k \cdot \frac{5 \mu C \cdot (6.01 \mu C)}{(0.2)^2} \]

\[ F_{x1} = 1.24 \times 10^3 \quad \text{N} \]

\[ F_{xy} = 1.24 \times 10^3 \cdot \sin \theta = -842.6 \text{ N} \]

\[ F_{y} = - \frac{842.6}{842.6} \text{ N} \]

\[ F_{y} = -1680 \text{ N} \]

\[ b) \ \text{y component does not contribute to torque} \]

\[ F_{x2} = F_{x1} = |F_x| \cdot \cos \theta = 743.1 \text{ N} \]

\[ I = F \cdot d = (2 \cdot F_{x1}) \cdot 1.015 = 223 \text{ N} \cdot \text{m} \]

Clockwise