Negative electric charge $-Q$ is distributed uniformly around a quarter of a circle of radius $R$.

What are the components of the electric field $\mathbf{E}$ at point $P$ in terms of $Q$, $\varepsilon_0$, and $R$.

\[
\mathbf{E} = \frac{Q}{2 \pi \varepsilon_0 R^2} (1 \hat{r} + \hat{\theta})
\]
Negative electric charge \(-Q\) is distributed uniformly around a 120 degree circular arc of radius \(R\). What are the components of the electric field \(E\) at point \(P\) in terms of \(Q\), \(R\), and \(\varepsilon_0\)?

\[
\phi = \frac{Q}{2\pi R^2} = \frac{3Q}{2\pi R^2}
\]

\[
E_\phi = 0 \quad \text{due to the symmetry}
\]

\[
dE_x = d\varepsilon \cos \theta, \quad dE_y = \cos \theta \frac{1}{4\pi \varepsilon_0} \frac{2Rd\theta}{R^2}
\]

\[
E_x = \int_{\theta_1}^{\theta_2} \frac{1}{4\pi \varepsilon_0} \cos \theta d\theta = \frac{3\sqrt{3}Q}{8\pi R^2 \varepsilon_0}
\]

\[
E = \frac{3\sqrt{3}Q}{8\pi R^2 \varepsilon_0}
\]
A wire of length $L$ extends from $x=d$ to $x=d+L$. The wire has uniform charge density $\lambda$ per unit length. Determine the sign and the magnitude of a point charge that must be placed at $x=-d$ such that the electric field at the origin is zero. Determine the magnitude of the point charge when the rod has infinite length in the $+x$ direction. Put $\frac{1}{4\pi\varepsilon_0} = k$ in your calculations for simplicity.

\[ \frac{d}{dx} = \frac{1}{\varepsilon_0} \frac{\lambda}{x^2} \Rightarrow E = \frac{\lambda}{4\pi\varepsilon_0} \int d\frac{dx}{x^2} = \frac{\lambda}{4\pi\varepsilon_0} \left( \frac{1}{d} - \frac{1}{d+L} \right) \]

Find $E$ of the rod at the origin:

\[ E = \frac{\lambda}{4\pi\varepsilon_0} \left( \frac{1}{d} - \frac{1}{d+L} \right) \]

Due to a point charge at $x=-d$, $E_q = \frac{1}{\varepsilon_0} \frac{q}{d^2}$.

Point charge must be positive.

\[ \frac{1}{\varepsilon_0} \left( \frac{q}{d^2} - \frac{1}{d} + \frac{1}{d+L} \right) = 0 \Rightarrow q = \pm d \left[ \frac{1}{d} - \frac{1}{d+L} \right] \]

If rod has infinite length, $E_{rod} = \frac{1}{\varepsilon_0} \int \frac{dx}{x^2} = \frac{1}{\varepsilon_0} \left( -\hat{i} \right)$. $E_{rod} + E_q = 0$
Negative electric charge \(-Q\) is distributed uniformly around a semicircle of radius \(r\). Find the magnitude and direction of the electric field \(E\) at point \(P\) in terms of \(Q\), \(\varepsilon_0\) and \(r\).

\[ E_x = \int_{0}^{\pi} \frac{1}{\varepsilon_0} \sin \theta \, d\theta = \frac{\theta}{\varepsilon_0} \]

\[ E_y = 0 \]

\[ E = \frac{Q}{\varepsilon_0} \]
A positive charge $Q$ is uniformly distributed over a quarter circle of radius $R$. The charged quarter circle is located symmetrically relative to the $x$ axis, as shown in the figure. The point $P$ is at the origin and is the center of the quarter circle.

What are the components of the electric field at point $P$ in terms of $Q$, $\varepsilon_0$, $R$.

$$\sin 45^\circ = \cos 45^\circ = \frac{\sqrt{2}}{2}$$

$$\mathbf{E}_x = \frac{\mathbf{E} \cos \theta}{n} = \frac{1}{{2\pi}} \frac{R^2 \sin \theta}{n^2} \cos \theta$$

$$\mathbf{E}_y = \frac{1}{{2\pi}} \int_{\theta = 0}^{\pi / 4} \cos \theta d\theta = \frac{\sqrt{2}}{2\pi} \frac{Q}{R^2}$$

$$\mathbf{E}_z = \frac{\mathbf{E} \sin \theta}{n} = \frac{1}{{2\pi}} \frac{R^2 \cos \theta}{n^2}$$

We are integrating the electric field vector, not the arc of the quarter circle. The $\mathbf{E}$ should be divided by $n$, not $n^2$.