

24. Studying Sample Problem 22-3, we see that the field evaluated at the center of curvature due to a charged distribution on a circular arc is given by

$$\vec{E} = \frac{\lambda}{4\pi\epsilon_0 r} \sin\theta \Big|_{-\theta}^{\theta}$$

along the symmetry axis, with $\lambda = q/r\theta$ with θ in radians. In this problem, each charged quarter-circle produces a field of magnitude

$$|\vec{E}| = \frac{|q|}{r\pi/2} \frac{1}{4\pi\epsilon_0 r} \sin\theta \Big|_{-\pi/4}^{\pi/4} = \frac{1}{4\pi\epsilon_0} \frac{2\sqrt{2}|q|}{\pi r^2}.$$

That produced by the positive quarter-circle points at -45° , and that of the negative quarter-circle points at $+45^\circ$.

(a) The magnitude of the net field is

$$\begin{aligned} E_{\text{net},x} &= 2 \left(\frac{1}{4\pi\epsilon_0} \frac{2\sqrt{2}|q|}{\pi r^2} \right) \cos 45^\circ = \frac{1}{4\pi\epsilon_0} \frac{4|q|}{\pi r^2} \\ &= \frac{(8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2) 4(4.50 \times 10^{-12} \text{ C})}{\pi(5.00 \times 10^{-2} \text{ m})^2} = 20.6 \text{ N/C}. \end{aligned}$$

(b) By symmetry, the net field points vertically downward in the $-\hat{j}$ direction, or -90° counterclockwise from the $+x$ axis.