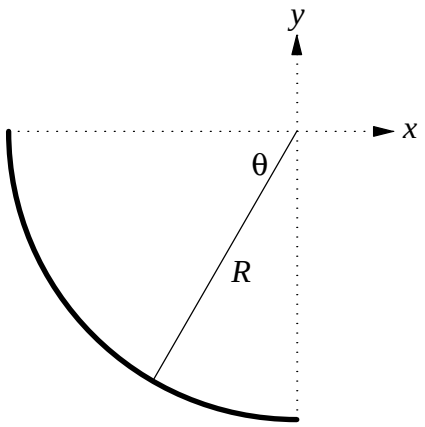
3. (20 pts.) A thin rod with linear charge density λ is bent into a quarter circle of radius R as shown in the figure. What is the electric field **vector** at the origin at the center of the circle? Show your work carefully. Remember that a small piece of the rod of arc length Δs spans a small angle $\Delta\theta = \Delta s/R$.



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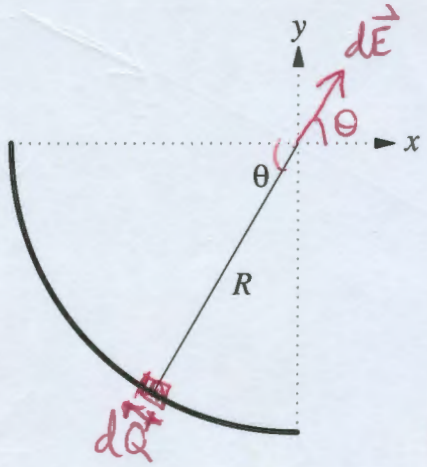

$dQ = \lambda ds = \lambda R d\theta$

$dE = \frac{1}{4\pi\epsilon_0}\frac{dQ}{R^2}$

x-components

$dE_x = dE\cos\theta = \frac{1}{4\pi\epsilon_0}\frac{\lambda R d\theta}{R^2}\cos\theta$

$E_x = \int_0^{\pi/2} \frac{1}{4\pi\epsilon_0}\frac{\lambda}{R}\cos\theta\, d\theta$

$= \frac{1}{4\pi\epsilon_0}\frac{\lambda}{R}\sin\theta\Big|_0^{\pi/2} = \boxed{\frac{1}{4\pi\epsilon_0}\frac{\lambda}{R} = E_x}$

By symmetry $E_y = E_x$

$E = \sqrt{E_x^2 + E_y^2} = \sqrt{2}\,E_x = \frac{\sqrt{2}\,\lambda}{4\pi\epsilon_0 R}$

$\boxed{\vec{E} = \frac{\sqrt{2}\,\lambda}{4\pi\epsilon_0 R} \text{ @ } 45^\circ}$