Physics 2220
Spring 2000
George A. Williams

FIRST MIDTERM

3

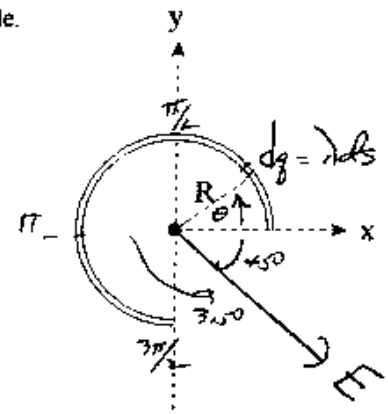
Name: KEY G. Williams

Discussion Instructor (circle): Billeter Bulson Muntean Paul Pomeroy Walker

Discussion Section # _____ Student ID #: _____

SHOW ALL WORK!!!!!
REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!
Use the conversion constants and data given on the front page.

The curved object is a thin rod bent in a circular form that goes 3/4 of the way around the circle from the positive x-axis to the negative y-axis. The origin is at the center of the circle. There is a uniform linear charge density and a total charge $Q = 4.70 \times 10^{-9}$ C. Find the electric field, magnitude and direction, at the origin. Ignore the diameter of the rod itself.



λ is not given, Therefore it must be calculated.

$$\lambda = \frac{Q}{\frac{3}{4}(2\pi R)} = \frac{2Q}{3\pi R} \quad \left[\text{Rod} = \tfrac{3}{4}\text{ of circle}\right]$$

$$ds = R\,d\theta$$

$$\therefore dq = \lambda\, ds = \lambda R\, d\theta$$

$$\vec{E} = \frac{k\,dq}{R^2}\hat{R} \qquad dE_x = \frac{k\,dq}{R^2}\cos\theta \qquad dE_y = \frac{k\,dq}{R^2}\sin\theta$$

$$E_x = \int_0^{3\pi/2} \frac{k\lambda R\,d\theta\cos\theta}{R^2} = \frac{k\lambda}{R}\int_0^{3\pi/2}\cos\theta\,d\theta = \frac{k\lambda}{R}\left[-\sin\theta\right]_0^{3\pi/2}$$

$$= \frac{k\lambda}{R}\left[-(-1) - 0\right] = \frac{k}{R}\frac{2Q}{3\pi R} = \frac{kQ}{R}$$

$$E_y = \frac{k\lambda}{R}\int_0^{3\pi/2}\sin\theta\,d\theta = \frac{k\lambda}{R}\left[0 - 1\right] = -\frac{k\lambda}{R}$$

$$|E| = \sqrt{E_x^2 + E_y^2} = \sqrt{2}\,\frac{k\lambda}{R} = \frac{\sqrt{2}\,(9\times10^9)(2)(4.7\times10^{-9})}{3\pi R}$$

$$\boxed{|E| = \frac{12.7}{R}\ \text{N/C}}$$

Direction $+315°$, $-45°$ by symmetry. $|E_y| = |E_x|$

Notes:

① GAUSS'S LAW CANNOT BE USED

② YOU CANNOT integrate $\int d\vec{E}$, you must calculate dE_x, dE_y, and integrate to get E_x, E_y

③ λ is not given; you must calculate it from data given. $\lambda = \frac{Q}{\frac{3}{4}(2\pi R)} = \frac{2Q}{3\pi R}$

④ Arc length $ds = R\,d\theta$ needed,