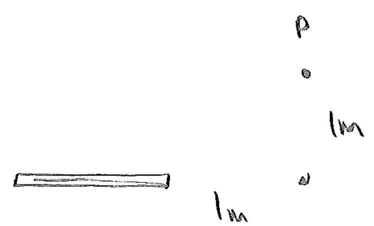
Physics 161 Fall 2010 Exam 3
Numbers and positions will be changed on the real exam. Closed book closed notes calculators OK. Enter 0,0 for 0. $\frac{1}{4\pi\varepsilon_0} = 9\times10^9$ Nm^2/C^2

A thin rod of length L=1 m has charge 0.1 C uniformly distributed.

1&2] What is the x-component of the electric field at point P, in N/C?

3&4] What is the y-component of the electric field at point P, in N/C?

Note: in the real exam, the position of point P will be different.

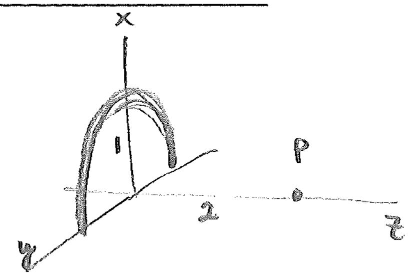


A half ring of radius 1 m has 0.6C of charge uniformly distributed.

5&6] What is the x component of the E field at a point z=2?

7&8] What is the y component of the E field at this point?

9&10] What is the z component of the E field at this point?
In the real exam, the object to be integrated over may be different.

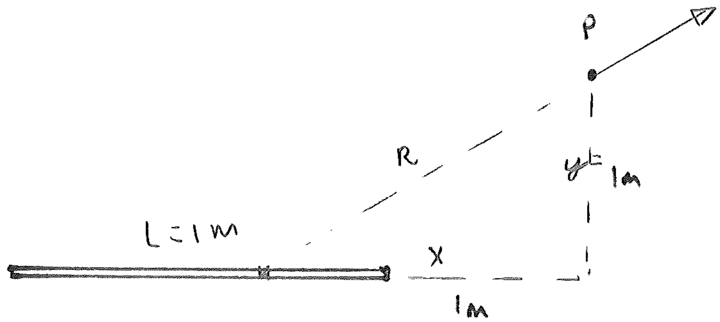


Applications of Gauss' Law
11&12] An infinite plane of charge has a uniform charge density of 0.02 C/m^2. What is the magnitude of the electric field at a distance of 1 m above the surface?
This may be changed to a sphere or an infinite rod.

13] A hollow conducting shell has a total net charge of 4C on it. The outer radius of the shell is 1m. In the hollow, off center, there is a point charge of 2C. What is the sign of the charge on the surface of the shell? outer surface
a) + b) - c) There is no surface charge

14] What is the magnitude of the surface charge, to the nearest coulomb? (0-9).

A brief table of integrals will be provided.



$dq = \lambda\, dx$

$dE = \dfrac{k\, dq}{R^2}$

$\dfrac{dE_x}{dE} = \dfrac{-x}{R}$

$\dfrac{dE_y}{dE} = \dfrac{y}{R}$

$\boxed{1\&2}$ $E_x = \int dE_x = -\int \dfrac{k\, dq\, x}{R^3} = -k\lambda \displaystyle\int_{x=1}^{x=2} \dfrac{x\, dx}{(x^2+y^2)^{3/2}}$

$= k\lambda \left.\dfrac{1}{(x^2+y^2)^{1/2}}\right|_1^2$

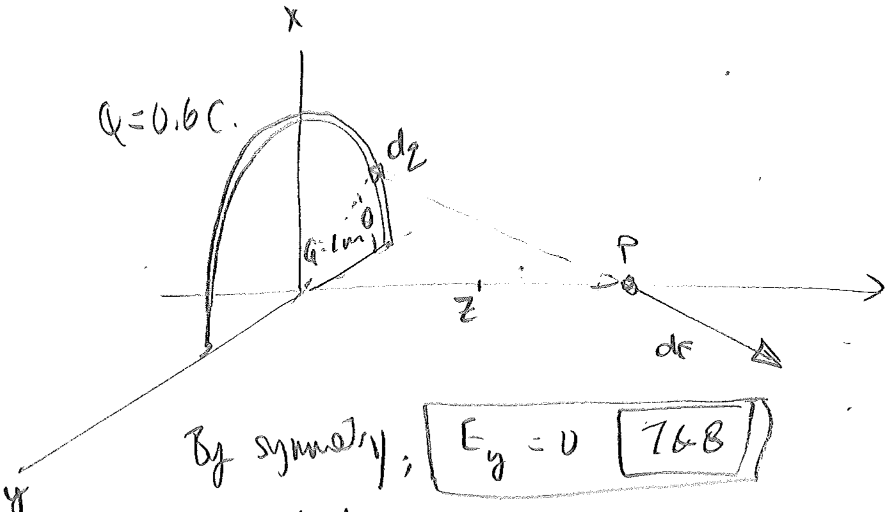
$= k\lambda\left(\dfrac{1}{\sqrt{4+1}} - \dfrac{1}{\sqrt{2}}\right) = -0.26\, k\lambda$

$= -2.3 \times 10^8$ N/C.

$\boxed{3\&4}$ $E_y = \int dE_y = k\lambda y \displaystyle\int \dfrac{dx}{R^3} = \dfrac{k\lambda}{y}\left[\dfrac{x}{\sqrt{x^2+y^2}}\right]_{x=1}^{x=2}$

$= \dfrac{k\lambda}{1m}\left(\dfrac{2}{\sqrt{5}} - \dfrac{1}{\sqrt{2}}\right)$

$= 0.187\, k\lambda = 1.7 \times 10^8$ N/C



By symmetry; $\boxed{E_y = 0}$ $\boxed{7\&8}$

$dE = \frac{k\,dq}{R^2}$ $dq = \lambda\,d\ell = \lambda a\,d\theta$

$\frac{dE_z}{dE} = \frac{z}{R}$ $\int dE_z = E_z = \int \frac{kz\,dq}{R^3} = \frac{kzQ}{R^3}$

$R = \sqrt{z^2 + a^2} = \sqrt{4+1}$ so $E_z = 9.6 \times 10^8$ N/m.

$\frac{dE_x}{dE} = -\frac{x}{R}$ $\boxed{9\&10}$

$\int dE_x = E_x = -\int \frac{kx\lambda a\,d\theta}{R^3}$ but $x = a\sin\theta$

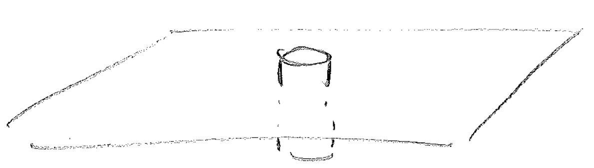
$E_x = -\int_0^{\pi} \frac{k\lambda a^2}{R^3}\sin\theta\,d\theta = -\frac{2k\lambda a^2}{R^3}$

Now $\pi a \lambda = Q$ so $E_x = -\frac{2kQa}{\pi R^3}$

$= 3.1 \times 10^8$ N/C $\boxed{5\&6}$

$\boxed{11\&12}$

$\oint \vec{E}\cdot d\vec{A} = \frac{q}{\epsilon_0} = \frac{\sigma A}{\epsilon_0} = 2EA$



$E = \frac{\sigma}{2\epsilon_0} = \left(\frac{1}{4\pi\epsilon_0}\right) 2\pi\sigma = 1.1\times10^9$ N/C.

$\boxed{14}$ Inner surface → −2C. Total = 4C. so outer surf. → 6C.