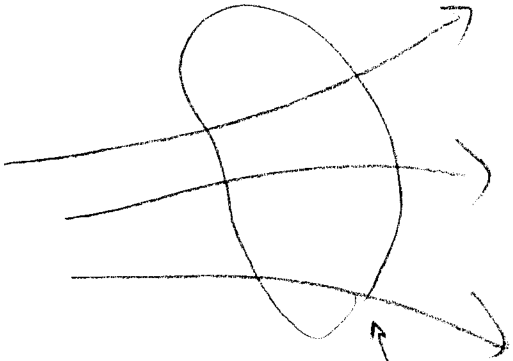
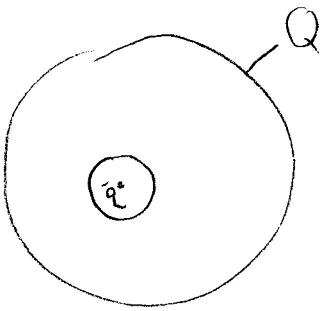
# Homework 3

## Q1 (22-1)



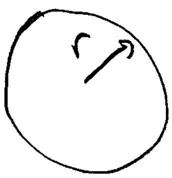
the electric field is not necessarily zero at certain points. It is the total flux going in and out that is zero.

## Q12 (22-12)




a charge of $+q$ will be attracted to the charge inside, leaving a charge of $Q-q$ on the outside surface.

## P22-1



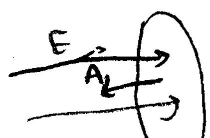

$r = 13\,cm = 0.13\,m$

$\vec{E} = 5.8 \times 10^2\,N/c$

$A = \pi r^2$

$$\Phi = \vec{E} \cdot \vec{A} = |E||A| \cos\theta$$

a)



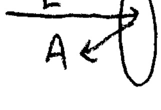

$\theta = 0$ so $\cos\theta = 1$

therefore

$\Phi = (5.8 \times 10^2\,N/c)(\pi)(0.13\,m)^2$

$\boxed{\Phi = 30.8\,\frac{N}{C}m^2}$

b)




$\theta = 45^\circ$ so $\cos 45 = \frac{1}{\sqrt{2}}$

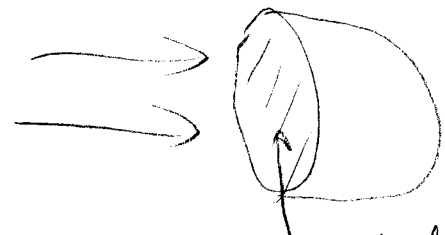
$\Phi = (580\,N/c)(\pi)(0.13\,m)^2(1/\sqrt{2})$

$\boxed{\Phi = 21.8\,\frac{N}{C}m^2}$

## Problem 22-4

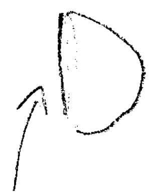
a) Since $\vec{E}$ is $\parallel$ to the axis, the area is simply a circle

So $\Phi_E = \vec{E} \cdot \vec{A} = E \pi r^2$



circle of radius r

b) The area 'seen' from the field coming in $\perp$ is a half circle. However, there are <u>two</u> surfaces, with $\vec{A}$ pointing in opposite directions, so



the <u>net</u> flux is <u>zero</u>

## Problem 22-5

$$\Phi = \vec{E} \cdot \vec{A} = \frac{Q}{\epsilon_0}$$

$\epsilon_0 = 8.85 \times 10^{-12} \, C^2/Nm^2$

$$\left(1.84 \times 10^3 \, \frac{N \cdot m^2}{C}\right) = \frac{Q}{\epsilon_0}$$

$(Q = \Phi \epsilon_0)$

$$\boxed{Q = 1.63 \times 10^{-8} \, C}$$

## Problem 22-33

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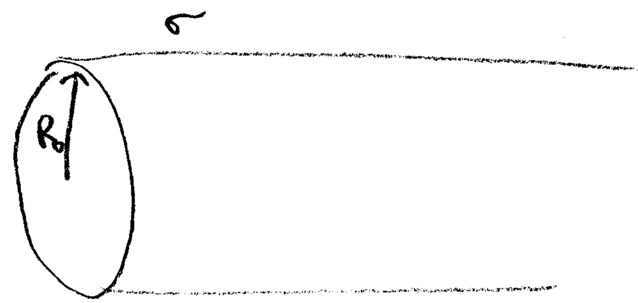
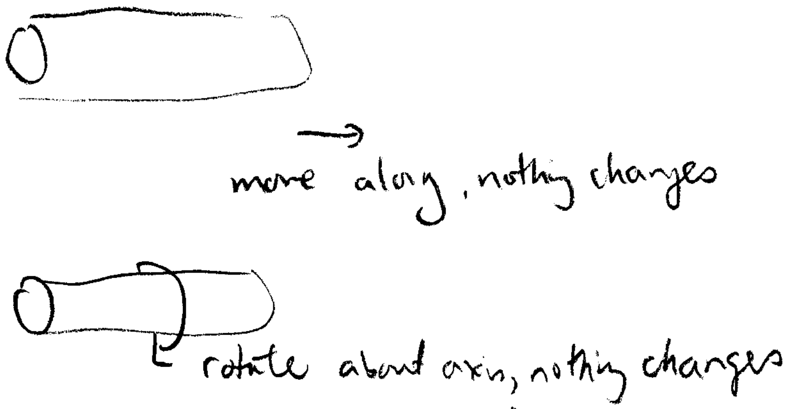
Problem 22-33




$R_0 << l$, and looking at pts far from ends, so assume infinite length.

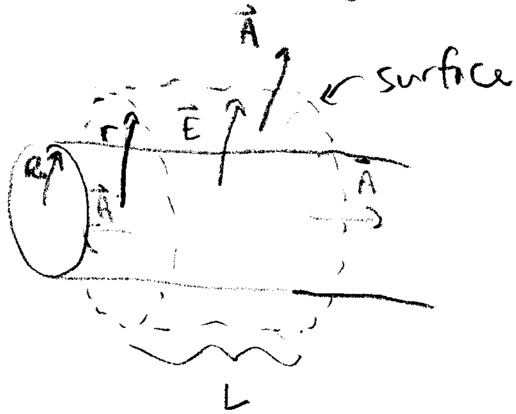
The geometry has cylindrical symmetry, so I will pick cylindrical Gaussian surfaces.

Symmetry:




therefore field must point radially in or out. I know it points out because $q$ is $+$.

a) $R > R_0$




$\vec{E} \parallel \vec{A}$ on curved surface

$\vec{E} \perp \vec{A}$ on sides

Apply Gauss' law:

$$\int \vec{E} \cdot d\vec{A} = \frac{Q}{\epsilon_0}$$

22-33 contd:

$Q = \sigma A$, A being the surface of the cylinder enclosed by the gaussian shape.

$$E \int dA = \frac{Q}{\epsilon_0}$$

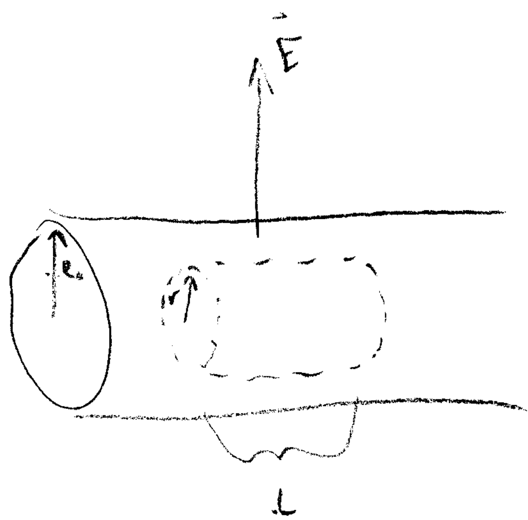
radius of surface chosen

radius of cylinder

$$E\, 2\pi r L = \frac{\sigma 2\pi R_0 L}{\epsilon_0}$$

$$\boxed{\vec{E} = \sigma \frac{R_0}{r \epsilon_0} \hat{r}}$$

b) $0 < r < R_0$




Apply Gauss' law

$$\oint \vec{E} \cdot d\vec{A} = \frac{Q_{enc}}{\epsilon_0}$$

$$E\, 2\pi r L = 0$$

$$E = 0$$

c) for a long line of charge, $E = \frac{1}{2\pi\epsilon_0} \frac{\lambda}{R}$

In this problem, we have a surface distribution instead of a line charge. The total charge along a length $L$ is given by:

cylinder $Q = 2\pi R_0 L \sigma$

wire: $Q = L\lambda$

set equal: $2\pi R_0 \cancel{L} \sigma = \cancel{L} \lambda$

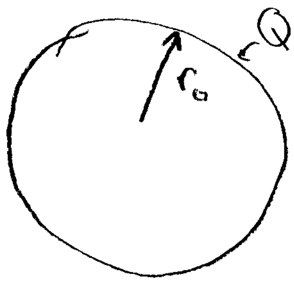
$\lambda = 2\pi R_0 \sigma$, if I put this into here

$$E = \frac{1}{2\pi\epsilon_0} \frac{(2\pi R_0 \sigma)}{R} = \frac{\sigma}{\epsilon_0} \frac{R_0}{R}$$

, which is the same as found in part (a).

22-54

$\rho_E = br$




a) $Q = \int dq$

$= \int \rho \, dV$

$= \int (br)(\underbrace{4\pi r^2 dr}_{dV})$ ← take small shells of volume dV and radius r and sum by integrating. Density depends on r, so it stays inside the integral.

$= b4\pi \int_0^{r_0} r^3 dr$

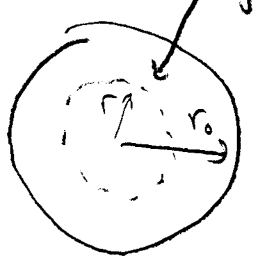
$= b\cancel{4}\pi \frac{r_0^4}{\cancel{4}}$

$Q = b\pi r_0^4$

so $\boxed{b = \frac{Q}{\pi r_0^4}}$

b) inside $r < r_0$

Gaussian surface of radius r




Apply Gauss' law:

$\int \vec{E} \cdot d\vec{A} = \frac{Q_{enc}}{\epsilon_0}$

$E \underbrace{4\pi r^2}_{\text{Area of gaussian surface}} = \frac{1}{\epsilon_0} \int dq$

22–54 cont'd

$$E\,4\pi r^2 = \frac{1}{\epsilon_0}\int \rho\, dV$$

$$= \frac{1}{\epsilon_0}\int_0^r br(4\pi r^2\,dr)$$

$$= \frac{b4\pi}{\epsilon_0}\int_0^r r^3\,dr$$

$$= \frac{b\cancel{4}\pi}{\epsilon_0}\frac{r^4}{\cancel{4}} \quad \text{sub in } b$$

$$= \frac{Q}{\cancel{\pi} r_0^4}\frac{\cancel{\pi}}{\epsilon_0} r^4$$

$$E\,4\pi r^2 = \frac{Q}{\epsilon_0}\frac{r^4}{r_0^4}$$

$$\boxed{\vec{E} = \frac{Q}{4\pi\epsilon_0}\frac{r^2}{r_0^4}\,\hat{r}}$$

c) $r > r_0$ Outside, $Q_{encl} = Q$

$$E\,4\pi r^2 = \frac{Q}{\epsilon_0}$$

$$\boxed{\vec{E} = \frac{Q}{4\pi\epsilon_0 r^2}\,\hat{r}}$$