

Gauss' law

Reading assignment

Ulaby, 4-4

Connor and Salon, I-24 → I-29 and II-1 → II-10

Problem 1 - Coulomb and Gauss' law

Show that the electric field of a point charge satisfies Gauss' law by evaluating

 $\oint \mathbf{E} \cdot d\mathbf{s}$ over the surface of a sphere of radius a .**Problem 2 - Symmetry**

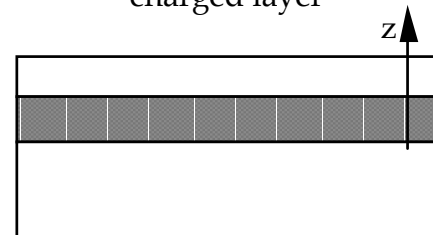
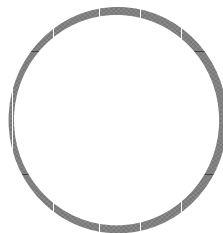
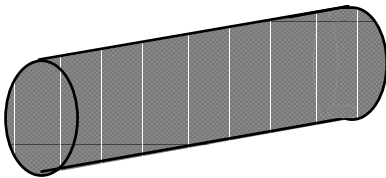
Three charge distributions are pictured below. In 1) and 3), assume that the system is very long and ignore fringe effects. For each of the charge distributions, answer the following:

- Determine the direction in which \mathbf{E} points.
- Determine surfaces over which $\int \mathbf{E} \cdot d\mathbf{s}$ is constant and non-zero.
- Sketch a surface that can be used with Gauss' law to find \mathbf{E} .

1) cylinder with uniform volume charge density

2) spherical shell of charge

3) semiconductor with charged layer

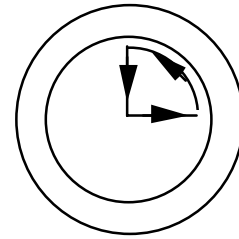
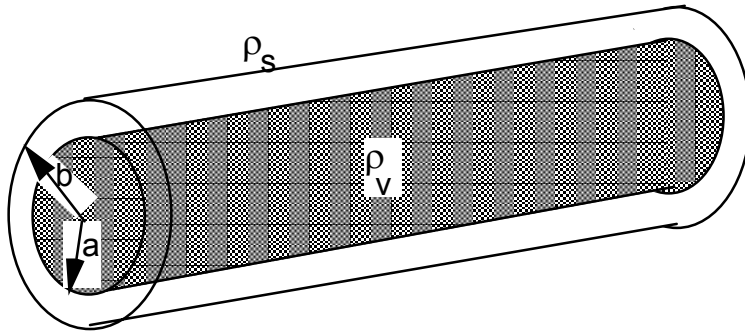
**Problem 3 - Use Gauss' law to evaluate \mathbf{E}**

A charge distribution with *cylindrical* symmetry is shown below. The inner cylinder has a uniform charge density $\rho_v \text{ C/m}^3$. The outer shell has a surface charge density $\rho_s \text{ C/m}^2$ such that the total charge on the outer shell is the negative of the total charge in the inner cylinder. Ignore end effects.

- Find \mathbf{E} for $r < a$.
- Find \mathbf{E} for $a < r < b$ and for $b < r$.
- Check your answer for \mathbf{E} by evaluating $\nabla \cdot \mathbf{E}$ and $\nabla \times \mathbf{E}$.
- What is $\oint \mathbf{E} \cdot d\mathbf{l}$ around the contour shown on the right?

Gauss' law

e. Express ρ_s in terms of the geometry and ρ_v .



integration contour for
part c.