Chapter E3: Fields and Currents

E3.2 Field of a Charged Disk

The field due to a disk of radius R, charge density σ, a distance z above the disk along its central axis is given by:

$$E_z = 2\pi k\sigma\left[1 - \frac{1}{\sqrt{1 + (\frac{R}{z})^2}}\right] \tag{1}$$

Important limiting case: in the infinite disk limit. If the disk is infinitely wide, the field above the disk is constant.

E3.3 Field of a Charged Spherical Shell

Field due to a spherical shell with charge Q:

$$E_z = \frac{kQ}{r^2} \tag{2}$$

Note that this doesn't depend on the size of the shell.

E3.4 Introduction to Current

Current is defined as the amount of charge flowing per unit time:

$$I \equiv \left|\frac{\Delta Q}{\Delta t}\right| . \tag{3}$$

The direction of conventional current assumes that the charge carriers are positive.

The SI unit of current is the Amp:

$$1\text{A} \equiv 1\text{C/s} . \tag{4}$$

E3.5 A Microscopic Model

Fields cause electrons to move in a metal. The conduction electrons undergo lots of collisions with the underlying lattice. The average speed at which electrons drift is given by:

$$v_d = neAv_d \ . \tag{5}$$

I think the key to understanding this equation is Fig. E3.7.

E3.6 Current Density

The current density is defined as the current per unit area:

$$\vec{J} \equiv \lim_{A \to 0} \frac{\vec{I}}{A} = nq\vec{v}_d \ . \tag{6}$$

The current density is proportional to the applied electric field:

$$\vec{J} = \sigma \vec{E} \ . \tag{7}$$

Where σ is the *conductivity*, a constant (like density or "hardness") that varies from material to material.

Practice:

1. In class we found that the field due to the a wire of charge Q and length L, a distance from the wire along its axis is given by:

$$\frac{kQ}{D(D+L)}$$

   (a) What is the behavior of the field in the limit that $D \gg L$? Does this make sense?

   (b) What is the behavior of the field in the limit that $L \gg D$? Does this make sense?

   (c) Let $L = 1$ meter and $Q = 1nC$. If I put a charge of $-3nC$ at a point a distance $D = .5meters$ from the wire's end, what is the direction and magnitude of the force on the charge?

2. Do problems E3T.3 – E3T.7.