

Electricity and Magnetism I (PHY 321)

Charge and Current

Problem 1 Electrons are traveling down a wire at 5 m/s, and 10^{16} electrons pass a fixed spot on the wire in each second.

- (a) Find the current in the wire.
- (b) Assuming the electrons are spread uniformly along the wire, what is the distance between neighboring electrons?
- (c) What is the number density of electrons in the wire (number density is number per unit length)?
- (d) Find the linear charge density of the electrons.

Problem 2 At time $t = 0$, the charge density is $\rho(0) = 0$. Now suppose we have some current density

$$\mathbf{J} = Az\hat{\mathbf{z}}$$

for some constant A . Find the charge $Q(t)$ in a sphere of radius R centered at the origin as a function of time.

Problem 3 Consider the current density

$$\mathbf{J} = Ax^2z\hat{\mathbf{x}} + Axy^2\hat{\mathbf{y}} + Axyz\hat{\mathbf{z}}$$

for some constant A . Find the current that flows through a rectangular surface with vertices at $(x, y, z) = (a, 2a, 3a)$, $(a, 6a, 3a)$, $(a, 6a, 5a)$, and $(a, 2a, 5a)$, where a is a constant with dimensions of length. You will need to choose an orientation for this rectangular surface. Describe the orientation you choose, and give an expression for the current that flows through the surface with that orientation.