



Figure 1: The current loop in Problem 11.1

Problem Set 11

Problem 11.1

Figure 1 shows a rectangular current loop ABCD. In the loop's rest frame, S, the loop has length a and width b , the current density is j , the area of the cross section is s and the charge density is zero.

- a) Show that in the rest frame the loop's electric dipole moment is zero and the magnetic moment is $\mathbf{m} = I\mathbf{a} \times \mathbf{b}$, where $I = js$.

In the following we will observe the loop from the system S' where the loop is moving with velocity \mathbf{v} to the right ($\beta = v/c$ and $\gamma = 1/\sqrt{1-\beta^2}$). We will now give a description of the system in S'.

- b) Describe the loop's geometry.
- c) Show that CD and AB have charge $\pm \frac{aIv}{c^2}$.
- d) Show that the loop's electrical dipole moment is $\mathbf{p}' = \frac{1}{c^2}\mathbf{m} \times \mathbf{v}$.
- e) Find the current density in the different parts of the loop. Show that the current is $I\gamma$ in the AB and CD and I/γ in BC and DA.
- f) Show that the magnetic moment is $\mathbf{m}' = (1 - \beta^2/2)\mathbf{m}$.