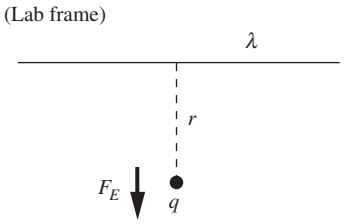
PHY102 : Assignment 7

1. (P& M Example) A charge q is at rest a distance r from a long rod with linear charge density λ, as shown in the Fig. The charges in the rod are also at rest. The electric field due to the rod takes the standard form of $E = \lambda/2\pi\epsilon_0 r$, so the force on the charge q in the lab frame is simply $F = qE = q\lambda/2\pi\epsilon_0 r$. This force is repulsive, assuming q and λ have the same sign. Now consider the setup in the frame that moves to the left with speed v. In this frame both



the charge q and the charges in the rod move to the right with speed v. What is the force on the charge q in this new frame ? Solve this in three different ways.

   (a) Transform the force from the lab frame to the new frame.

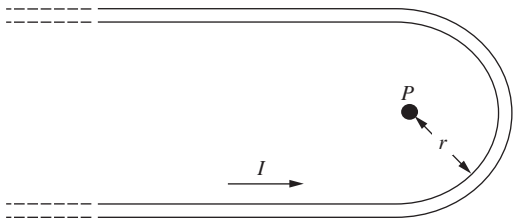
   (b) Directly calculate the electric and magnetic forces in the new frame.

   (c) Transform the fields using the Lorentz transformations.

2. (P& M 6.2) A 50 kV direct-current power line consists of two wire conductors 2 m apart. When this line is transmitting 10 MW of power, how strong is the magnetic field midway between the conductors ?

3. (P& M 6.42) See if you can devise a vector potential that will correspond to a uniform field in the z direction : $B_x = 0$, $B_y = 0$, $B_z = B_0$.

4. (P&M 6.50) A long wire is bent into the hairpin-like shape shown in Fig. Find an exact expression for the magnetic field at the point P that lies at the center of the half-circle.



5. (P& M 6.66) In the neighborhood of the origin in the coordinate system x, y, z, there is an electric field **E** of magnitude 100 V/m, pointing in a direction that makes angles of 30 degrees with the x axis and 60 degrees with the y axis. The frame F' has its axes parallel to those just described, but is moving, relative to the first frame, with a speed 0.6c in the positive y direction. Find the direction and magnitude of the electric field that will be reported by an observer in F'. What magnetic field does the observer report ?

6. A loop in the form of a semicircle in the xy plane is carrying a current I in the anticlockwise direction. A uniform magnetic field in the $+y$ direction is applied. Find the force (magnetic) acting on the straight segment and the semicicular portion.

7. A loop in the form of a rectangle is carrying a current I in the anticlockwise direction and is again lying on the xy plane. A uniform magnetic field in the $+x$ direction is applied parallel to the plane of the loop. What is the torque acting on the loop. Now suppose that the loop makes an angle θ with respect to the magnetic field. What is the torque ?