Physics 4B: Collected Homework 3

1. A particle of positive charge q and mass m enters parallel uniform electric and magnetic fields (of magnitudes E and B, respectively) both directed in the $+z$ direction with a velocity $\mathbf{v} = v_0\mathbf{i}$ perpendicular to both fields.

   (a) What is the the particle's initial acceleration? You can give your answer as a vector in component form.

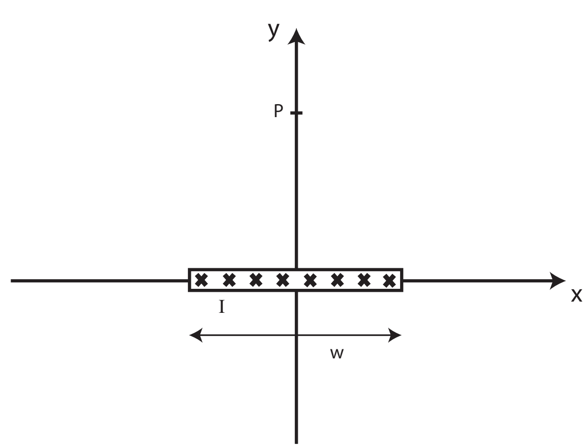
   (b) What is the radius of the particle's path (looking down the z-axis) if the magnetic field is $\mathbf{B} = B\mathbf{k}$? Does it depend on time?

   (c) How does the pitch, $p(z)$, of the particle's path vary with its z-axis coordinate? Let the electric field be given by $\mathbf{E} = E\mathbf{k}$. Assume that the particle enters the field in the x, y-plane (at $z = 0$) and let $p(z) = v_z(z)T(z)$ where $T(z)$ is the time period of a single orbit, and $v_z(z)$ is the component of the velocity along the z-direction.

2. The diagram shows the cross section of a thin ribbon wire of width w which extends along the z-direction and carries a current I into the page, in the $-z$-direction.

   (a) What is the magnetic field due to the current in the wire at point P, located on the y-axis at $(0, d)$?

   (b) If the wire ribbon was instead an infinite thin sheet of conductor carrying a current of current density J (current per unit length) extending along the entire x-axis ($w \to \infty$), would there be another way to solve this problem? If so, use the alternative method to find the magnetic field at point P for this case and check that your answer to part (a) agrees when you take $w \to \infty$.



3. A very long wire lies along the y-axis and carries a current I_w. Nearby, a circular loop of wire carries a current I_c clockwise as shown in the diagram. What is the net force on the circular loop due to the magnetic field of the straight wire? The loop lies in the x, y-plane, is centered on a point $(x_0, 0)$ on the x-axis axis, and the loop has a radius r where $2r = x_0$. You may use the fact that

$$\int_0^{2\pi} (1 + 2\sec\theta)^{-1} \mathrm{d}\theta = 2\pi(1 - 2/\sqrt{3})$$

if you find it useful.