203a Homework 5, due March 5

$\star$ Exercises from O'Neil:

1. An electron is initially at rest at the origin, $\vec{x}(t=0)=\vec{0}$. There are constant fields $\vec{E}=E_0\hat{y}$ and $\vec{B}=B_0\hat{z}$, with $E_0 \ll B_0$. Find the particle's velocity and position for $t>0$.

2. Determine the drift motion of an electron moving in the vicinity of a long, current-carrying wire, using $\vec{B}=\hat{\theta}2I/rc$.

3. Jackson 12.9. Use $\vec{B}=-\nabla(\vec{M}\cdot\vec{r}/r^3)=(3\hat{r}(\hat{r}\cdot\vec{M})-\vec{M})/r^3$.

4. When a plasma is confined in a mirror trap, an electric potential develops because electrons scatter into the loss cone faster than ions. Write the magnetic field along a field line as $B(s)$ and the electric potential as $\phi(s)$.

   (a) Show that $\frac{d}{ds}(\frac{1}{2}mv_\perp^2/B)\approx 0$ in the non-rel limit.

   (b) Show that the condition for confinement is (where 1 is where the field is a minimum and 2 is where the particle should be reflected),

$$0 \geq \tfrac{1}{2}mv_{||,2}^2 = \tfrac{1}{2}mv_{||,1}^2 + \tfrac{1}{2}mv_{\perp,1}^2\left(1-\frac{B_2}{B_1}\right) + e(\phi_1-\phi_2).$$

   (c) For a relativistic particle, show that $\frac{d}{ds}(\frac{1}{2}\gamma^2 mv_\perp^2/B)\approx 0$