**Physics 217**
**Problem Set 8**
**Due: Friday, November 2nd, 2018**

1. (5 points) Use the uncertainty relation between position and momentum to estimate the kinetic energy uncertainty associated with the momentum uncertainty using $\Delta E = (\Delta p)^2/2m$. The size of a lead nucleus is approximately $7.8 \times 10^{-15}$ m. Use the uncertainty relation to estimate the energy of an electron that can be emitted from the nucleus (in a weak interaction decay), assuming the electron was localized inside the nucleus before it emerged. Express your answer in MeV and compare with the electron rest mass. Calculate also the velocity uncertainty associated with the momentum uncertainty and compare with the speed of light.

2. (5 points) A beam of electrons is sent along the $x$-axis from $x = -\infty$ with kinetic energy $E = 6$ eV. It encounters a potential barrier of height $V = 4$ eV and width $2a = 2$ nm. What fraction of the beam is reflected back to $x = -\infty$?

3. (10 points) In class we discussed the reflection amplitude $r$ of a square barrier. Show that $|r| \leqslant 1$ for any $E$ and $V_0$, i.e. for any $k_1$ and $k_2$. Note that $k_1$ is always real, but $k_2$ may be real or imaginary, and you may want to treat those cases separately. Why would one expect that $0 \leqslant |r| \leqslant 1$, even without doing a calculation?

4. (10 points) Problem 19 from Chapter 6 of the Harris book.

5. (10 points) Problem 25 from Chapter 6 of the Harris book.