1.  
   (a) Find a formula for the maximum kinetic energy of electrons scattered via the Compton effect \((\gamma e \rightarrow \gamma e)\) as a function of the wavelength, \(\lambda\), of the incident light. The electron mass and fundamental constants \((\hbar, c)\) will appear as parameters. 
   (b) Use the formula found above to calculate this quantity for incident light of 0.0420 nm.

2. Calculate the de Broglie wavelength of the following (note that the energies in this problem always refer to the kinetic energy of the particle, – which must often be interpreted from context).
   (a) A 10 MeV proton. \(m_p = 938 \text{ MeV} c^{-2}\).
   (b) A 10 MeV electron. \(m_e = 0.511 \text{ MeV} c^{-2}\).
   (c) A 100 eV electron.
   (d) A thermal neutron. “Thermal”, for a point particle, means of energy \(\frac{3}{2} k_B T\). Take \(T\) to be room temperature, 300 K. \(m_n = 940 \text{ MeV} c^{-2}\).

3. Harris 4.23

4. Harris 4.27

5. Consider a wavefunction which is a linear superposition of 2 plane waves  
   \[
   \Psi(x,t) = A\Psi_1(x,t) + B\Psi_2(x,t)
   \]

   where  
   \[
   \Psi_1 = \exp[i(k_1 x - \omega_1 t)]
   \]

   and  
   \[
   \Psi_2 = \exp[i(k_2 x - \omega_2 t)]
   \]

   with \(A\) and \(B\) real constants.

   (a) Show that \(\Psi(x,t)\) is a solution of the time-dependent Free Particle Schrödinger Equation. Note: This requires establishing relationships between parameters of \(\Psi\).

   (b) Show that  
   \[
   |\Psi|^2 = A^2 + B^2 + 2AB \cos((k_2 - k_1)x - (\omega_2 - \omega_1)t).
   \]

   What is it’s maximum? It’s minimum?
6. As discussed in class, the momentum operator is

\[ \hat{p} = \frac{\hbar}{i} \frac{\partial}{\partial x} \]

and the energy operator is

\[ \hat{E} = \hbar \frac{\partial}{\partial t} \]

(see Table 5.2).

For the wavefunction of the previous problem:

(a) If a momentum measurement is made, what values may be obtained?

(b) Is it an eigenstate of momentum? Explain.

(c) If an energy measurement is made, what values may be obtained?

(d) Is it an eigenstate of energy? Explain.