1. What is the basic connection between the properties of a free particle wave function and the behavior of the associated particle? Explain carefully.

2. Since the wave function describes the behavior of a particle satisfies a differential equation, its evolution in time is perfectly predictable. How do you reconcile this with the uncertainty principle?

3. Why must an eigenfunction be well behaved in order to be acceptable in the Schrödinger theory?

4. Give a qualitative description of what is meant by the spin-orbit interaction. Explain.

5. At a certain time, the dependence of a wave function on position is shown in the figure below. (a) If a measurement that could locate the associated particle in an element \(dx\) of the \(x\) axis were made in that instant, where would it most likely be found?

\[\Psi(x, t)\]

(b) Where would it least likely to be found?

(c) Are the chances better that it would be found at any positive value of \(x\) or are the chances that it would be found at any negative value of \(x\) better?

6. A particle of energy \(E < V_0\) is incident upon a potential barrier of height \(V_0\) and width as shown in the figure below. Calculate the transmission coefficient for the wave that makes it through the barrier as a function of \(E\). Make sure to use the boundary conditions etc.

7. Find the values of \(r\) for which the function \(P(r)\) of 2s state has its maximum values?

8. Using the appropriate Einstein coefficient, write down an expression for the number absorptions that would occur causing an atom to make a transition from energy level \(E_1\) to the level \(E_2\).
9. An unpolarized beam of atoms of angular momentum quantum number $j=1$ passes through a z-oriented nonhomogeneous magnetic field as shown below.

(a) What would you expect classically to be the beam shape and orientation of atoms on the target?

(b) Into how many beams does quantum mechanics predict that the incident beam will split by the deflecting magnet?