**1-D Potential Exercise**

We’re going to examine some wave functions in 1-D potentials given our class discussions and an on-line simulation found at <http://phet.colorado.edu/simulations/sims.php?sim=Quantum_Tunneling_and_Wave_Packets>. Click on the Run Now! button. We’re mostly concerned with the stationary state solutions, so once it starts running simply click pause and rewind to t=0. Generally you’ll want to show the reflection and transmission probabilities, at least the real part of the wave function.

1. **Free particle**  
   Let’s start with something familiar: the free particle. Choose the appropriate potential and a particle of known kinetic energy.
   1. Describe the stationary state wave function, *φ*.
   2. Vary the energy and describe the change in the *φ*. Explain why this change occurs.
   3. Change the potential and describe and explain the resulting change in *φ*.
   4. Now make a wave packet and let it evolve several fs. Show the magnitude as well as the real part of *φ* and describe the changes. Do the wave function wave fronts move at the same speed as the packet?
2. **Step potential**Nowcreatea step potential and a deBroglie particle.
   1. Set E > V and adjust the step so V = 0. Increase the step (still V < E) and describe and explain the change in *φ*.
   2. Keep E > V and V ≠ 0. Given the energy values (which you can show), calculate and verify the (relative) amplitudes of the incident, reflected, and transmitted stationary state wave functions, and the transmission and reflection probabilities. You can choose to show the summed or separated incident wave parts.
   3. Look also at the imaginary parts of *φ*. Describe and explain the difference between the imaginary and real parts (the word you’re likely to need is *phase*).
   4. Increase the step so V > E. What happens? Compare also the real and imaginary parts of *φ*. Is it similar to the E > V case? Describe and explain.
3. **Barrier potential**  
   Now create a barrier potential. Start with it quite broad.
   1. With E > V, describe how *φ* varies over and beyond the barrier, and explain why.
   2. Now set E < V and describe the change. What is T?
   3. Can you make T > 0? Under what conditions, keeping E < V?