1. Calculate the expectation values of the kinetic and potential energies for a particle in an infinite potential well.

2. Consider the eigenvalue equation

$$\hat{A}u = \lambda u, \qquad \hat{A} = -\frac{d^2}{dx^2},$$

for $x \in [-a, a]$. Furthermore, let us set boundary conditions $u(-a) = u(a) = 0$ and $\lambda > 0$. Calculate the eigenvalues λ and the corresponding eigenfunctions u.

3. Particles scatter from a potential step. Show that from the conservation of the probability current it follows that the reflection and transmission coefficients R and T satisfy the condition

$$R + T = 1.$$

4. A particle scatters from a potential step of height V_0. The energy of the particle $E < V_0$.
   a) Show that the probability current inside the potential step vanishes.
   b) Show that total reflection happens.
   c) Estimate the penetration depth by evaluating $\langle x \rangle$ inside the step.

5. Consider a similar setup as in the previous exercise.
   a) Show that there is a phase shift between the incoming and the scattered wave.
   b) Study the behavior of the probability density outside the potential step.