1. **(Problem 1.9)** Let $P_{ab}(t)$ be the probability of finding the particle in the range $(a < x < b)$, at time $t$.

   (a) Show that
   
   $$ \frac{dP_{ab}}{dt} = J(a, t) - J(b, t) $$
   
   where
   
   $$ J(x, t) = \frac{i\hbar}{2m} \left( \Psi^* \frac{\partial \Psi}{\partial x} - \Psi \frac{\partial \Psi^*}{\partial x} \right). $$
   
   What are the units of $J(x, t)$? $J$ is called the probability current, because it tells you the rate at which probability is “flowing” past the point $x$. If $P_{ab}(t)$ is increasing, then more probability is flowing into the region at one end than flows out at the other.

   (b) Find the probability current for the wave function
   
   $$ \Psi(x, t) = Ae^{-\lambda |x|}e^{-ixt}. $$

2. **(Problem 2.33)** Consider the step function potential:

   $$ V(x) = \begin{cases} 0 & \text{if } x \leq 0 \\ V_0 & \text{if } x > 0 \end{cases} $$

   (a) Calculate the reflection coefficient, for the case $E < V_0$, and comment on the answer.

   (b) Calculate the reflection coefficient for the case $E > V_0$.

   (c) For a potential such as this that does not go back to zero to the right of the barrier, the transmission coefficient is not simply $|F|^2/|A|^2$, with $A$ the incident amplitude and $F$ the transmitted amplitude, because the transmitted wave travels at a different speed. Show that

   $$ T = \sqrt{\frac{E - V_0}{E}} \frac{|F|^2}{|A|^2} $$

   for $E > V_0$. What is $T$ for $E < V_0$?