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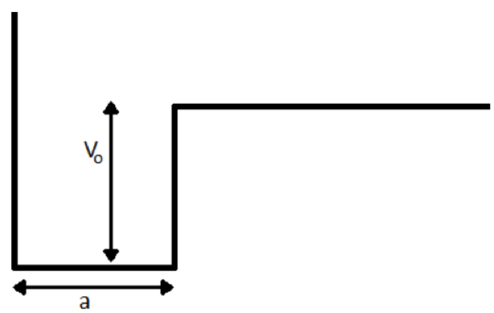
Chapter 2 Review Problems

Problem 1

Consider the one dimensional potential,

$$V(x) = \begin{cases} \infty & x < 0 \\ -V_o & 0 < x < a \\ 0 & x > a \end{cases}$$

1. For a fixed a find V_o for n bound states
2. At $t = 0$, the potential instantly disappears.For a particle originally in the ground state of the potential, what is the differential probability, dN/dp, for observing the particle with momentum p?



Problem 2
Consider a particle, mass m, under the influence of a potential

$$V(x) = V_0\Theta(-x) - \frac{\hbar^2}{2m}\beta\delta(x-a), \qquad V_0 \to \infty,\ \beta > 0.$$

1. Find a trancendental equation for the energy of a bound state.
2. Consider now a plane wave incident on the potential from $x = \infty$ in the $-\hat{x}$ direction which is reflected off the potential. For $x > a$, the waveform is $e^{-ikx} - e^{2i\delta}e^{ikx}$. Find the phase shift of the reflected wave.

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Problem 3

Here we will examine two problems dealing with a simple harmonic oscillator.

1. Calculate $\langle m|(a^\dagger a)^K a^\dagger (aa^\dagger)^M|n\rangle$ where $m = 1$ and $n = 0$.

2. In the case of the three dimensional case of a harmonic osciallator, given the quantum numbers n_x, n_y, and n_z, and that $N = n_x + n_y + n_z$, find the degeneracy in eigenstates up to $N = 2$.