Physics 14 Quantum Physics Assignment #11 Spring 2005

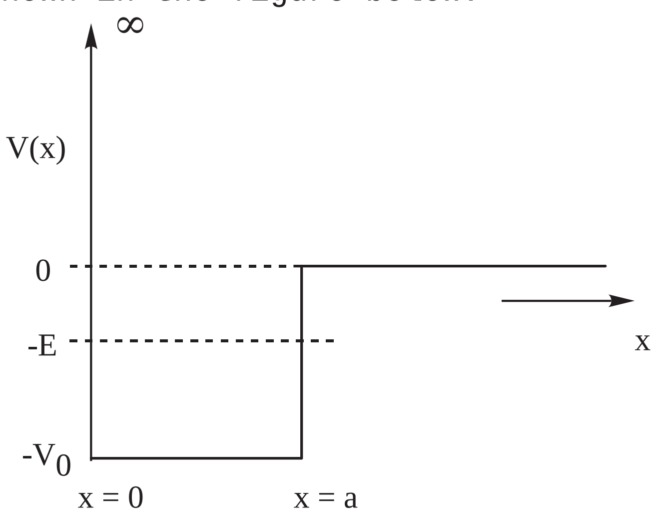
Readings for week #7 of Quantum Mechanics

Pages 169-196 in Boccio Wave Mechanics Notes
Chapters 4 and 8 in French

Exercises

[30] Deuteron model

(a) For the potential energy function below, find the transcendental equation which determines the bound state energies and analyze the equation graphically.
(b) Determine the condition for no bound state to exist.
(c) Determine the condition for exactly 1 bound states to exist.
(d) Now consider the motion of a particle of mass $m = 0.8\times10^{-24}\,gm$ in the well shown in the figure below:



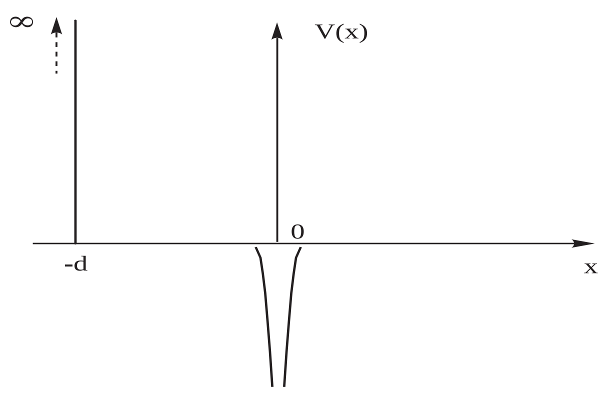
The size of the well (range of the potential) is $a = 1.4\times10^{-13}\,cm$. If the binding energy of the system is 2.2 MeV, find the depth of the potential V_0 in MeV. This is a model of the deuteron in one dimension.

[31] Atom near a wall

An approximate model for an atom near a wall is to consider a particle moving under the influence of the one-dimensional potential given by

$$V(x) = \begin{cases} -V_0\delta(x) & x > -d \\ \infty & x < -d \end{cases}$$

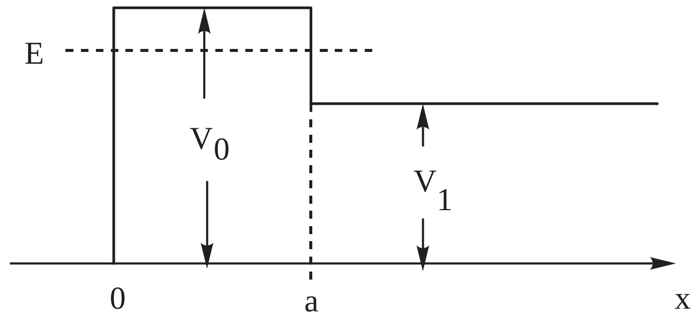
as shown below:



(a) Find the modification of the bound-state energy caused by the wall when it is "far away". Define what you mean by "far away".
(b) What is the exact condition on V_0 and d for the existence of at least one bound state ?

[34] A Barrier

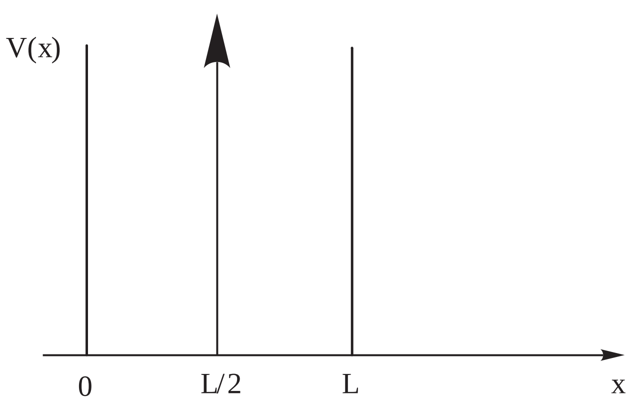
A one-dimensional potential barrier is shown in the figure below.



Define and calculate the transmission probability for a particle of mass m and energy E $(V_1 < E < V_0)$ incident on the barrier from the left. If you let $V_1 \to 0$ and $a \to 2a$, then you can compare your answer to other textbook results.

[37] Delta function in a well

A particle of mass m moving in one dimension is confined to a space $0 < x < L$ by an infinite well potential. In addition, the particle experiences a delta function potential of strength λ ($\lambda\delta(x - L/2)$) located at the center of the well as shown in the figure.



Find a transcendental equation for the energy eigenvalues E in terms of the mass m, the potential strength λ, and the size of the well L.