Fall Term 2006

22.02 Introduction to APPLIED NUCLEAR PHYSICS
Problem Set #3

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1. For the scattering configuration depicted in Fig. 7.20 of Liboff, take, $V = \frac{5}{4}E$, and compute the value of, x, where the density in region II is one quarter the density of particles in the incident beam. Take the beam to be protons with rest mass, $m_p c^2 = 938\ MeV$, and compute the distance, x, in Fermis.

2. A neutron of energy 20 Mev is incident on a square barrier of height 40 Mev and width, 10 F (Fermi). Estimate the tunneling probability for the neutron to penetrate the barrier in two ways. First make a simple estimate using only the exponential part of the decay, $P_{tun} \simeq \exp(-2\kappa L)$, as discussed in class. In doing this calculation make the first rough estimate of the numbers using,

$$\begin{aligned} m_n c^2 &\approx 1000\ MeV \\ \hbar c &\approx 200\ MeV - F \end{aligned}$$

and then put in the proper neutron rest mass, and use, $\hbar c = 197\ MeV - F$. Second use the formula from Liboff, eq. 7.147 in the limit when, $\kappa L \gg 1$. Note that this limit implies, $\sinh(2\kappa a) \rightarrow 1/2 \exp(2\kappa a)$, where, $2a = L$. Expand first the denomenator in Liboff to display the same exponential decay as in our simple estimate. Compare any differences in these two answers.

3. For the finite square well energy eigenvalue we discussed in lecture, estimate the ground state energy (negative of binding energy) for the odd parity energy eigenstate as follows. Assume the quarter wave argument holds to give, $\lambda = 4a$. Compute the kinetic energy associated with this wave,

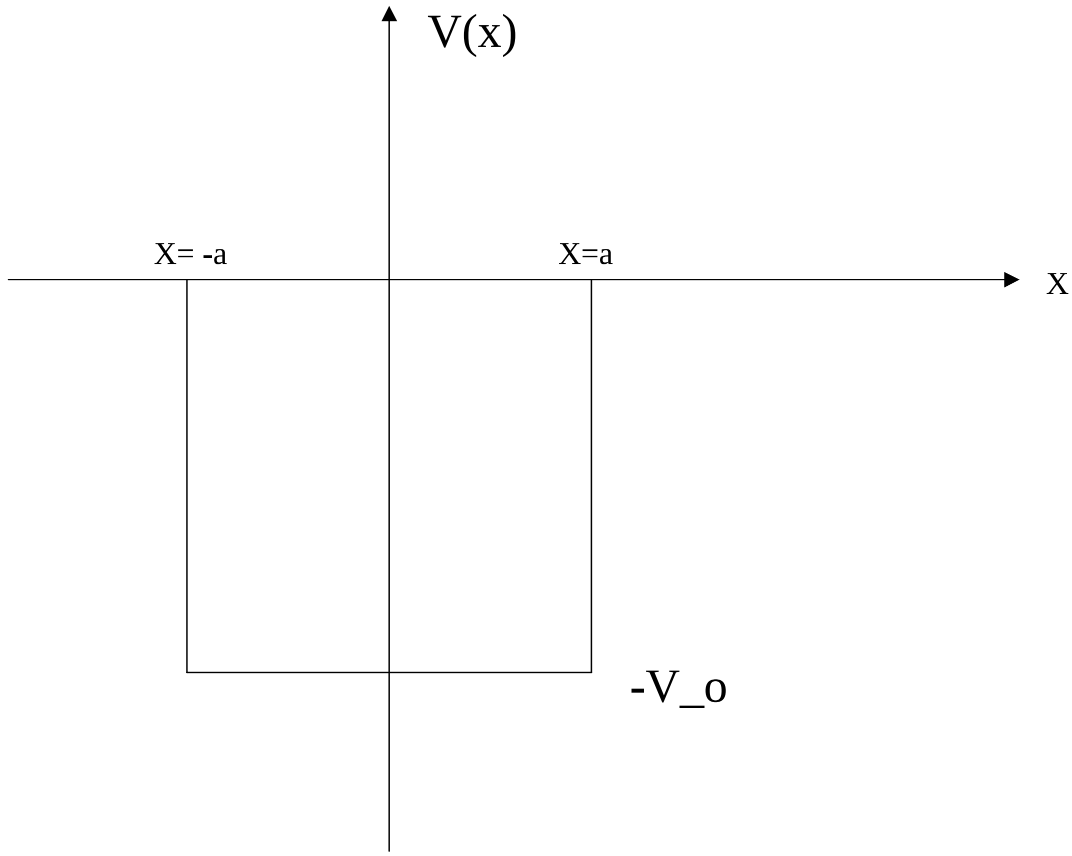
$$E_{kin} = \frac{\hbar^2 k^2}{2m}$$

and add this to the well depth, $-V_0$. Draw a picture to describe what you are calculating. Compute the numbers using,

$$\begin{aligned} a &= 1.26\ F \\ V_0 &= 35\ MeV \\ mc^2 &= 469\ MeV \end{aligned}$$

Recall that,

$$\hbar c = 197\ MeV - F$$


V(x)
X= -a
X=a
X
-V_o