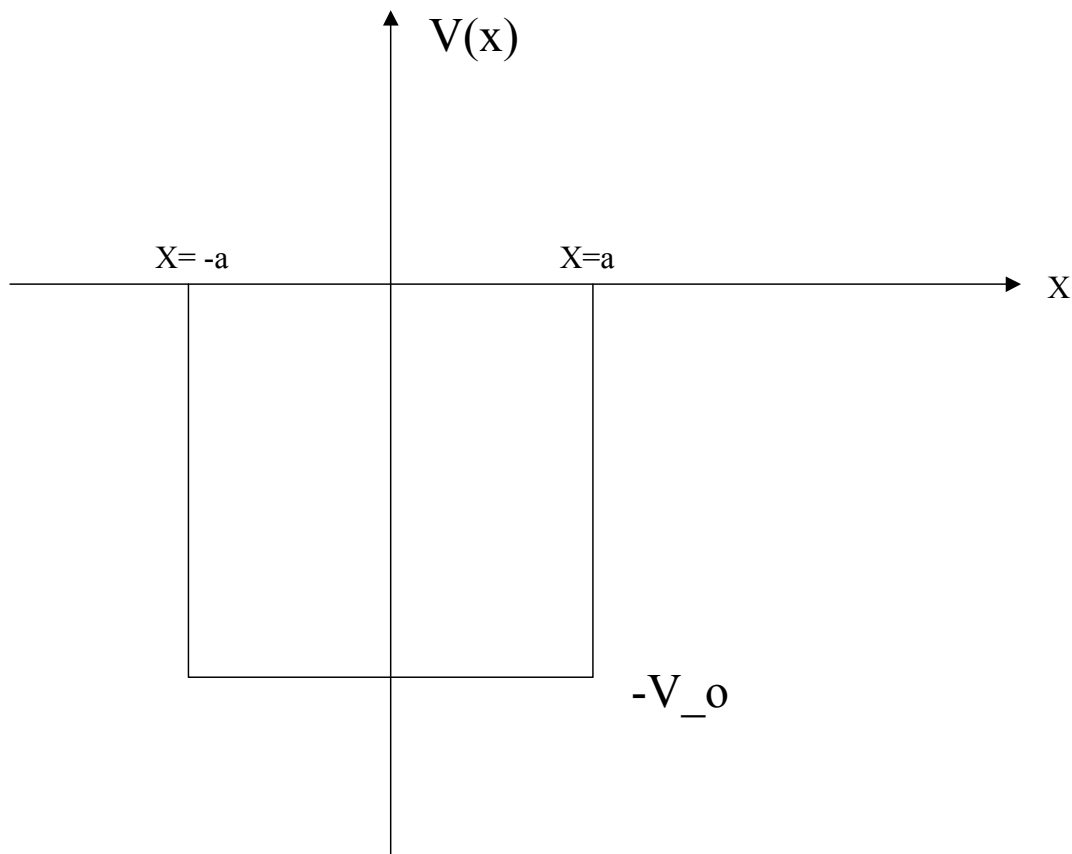


## Spring Term 2003

### 22.02 Introduction to APPLIED NUCLEAR PHYSICS

#### Problem Set #3

1. A particle of mass  $m_0$  is just being bound by a one-dimensional potential well of width  $2a$  and depth  $-V_0$ . What is the minimum value of:  $V_0 \neq 0$  for an ODD parity eigenfunction? (Hint: This problem can be solved with the simple de Broglie wave concept, but this must be justified. Otherwise, the more tedious way of using boundary conditions at  $x = a$  and  $x = -a$  must be used. In either case ask yourself what the condition of “just being bound” implies.)



2. Liboff, problems 5.12, 5.19, 5.25

3. Suppose system of Question 1 from Problem Set #2 is prepared at  $t = 0$ , with wavefunctions,

$$\psi = a_1\psi_1 + a_3\psi_3.$$

Evolve the system according to the Schrödinger equation to derive  $\psi(x, t)$  and compute the probability that a measurement of the particle's position finds the particle between  $x = \frac{L}{2}$  and  $x = \frac{L}{2} + \Delta x$ , at time  $t$ . What is the probability that a measurement of the energy of the system finds: a)  $E = E_1$ , b)  $E = E_2$ , and c)  $E = E_3$ , where the eigenstate energies are  $E_n = \frac{\hbar^2\pi^2}{2mL^2}n^2$ ?

4. For a quantum particle moving in a 3D potential,  $V(\mathbf{x}) = V(x, y, z)$ , which directions, if any, of the particle's momentum are conserved if the potential takes the following form:

(a)  $V = ax + by^2 + cz^3$ , where the constants,  $a$ ,  $b$ , and  $c$  are all positive.

(b)  $V = a \arctan(x/L)$

(c)  $V = b \exp(-y^2/d^2)$

5. For which systems characterized by the potentials listed below, do the energy and parity observables have common eigenfunctions?

(a)  $V = e^2/r$ ; where  $r = \sqrt{x^2 + y^2 + z^2}$ .

(b)  $V = ax + by^2 + cz^3$

(c)  $V = axy$

6. Liboff, problems 9.3, 9.25(a), 9.30, 9.34, 9.35.