

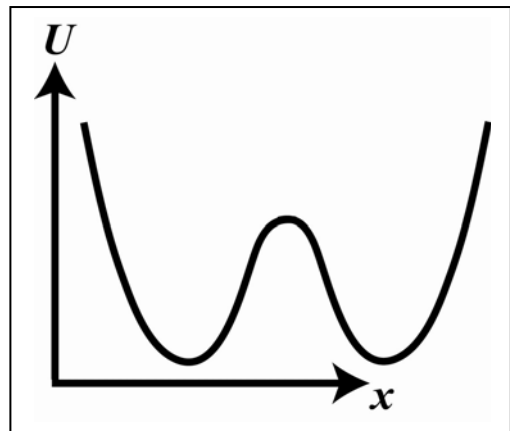
## Physics 302b – 2010 Practice Problems for Exam 2

You should be able to do each of these problems (including all sub-parts) in about 25 minutes or less (12 minutes or less for problem 3). If it takes you longer, you have not mastered the associated material thoroughly enough. **Note:** Of course, these problems don't cover exactly the same topics as the questions on the real exam. Therefore, doing well on these practice problems does not insure that you are adequately prepared for the exam. However, doing poorly on these problems does mean that you need to study more.

It is possible that one or more of the problems below will also appear on the actual exam.

**1.** A beam of electrons in the  $|+z\rangle$  state enters a uniform magnetic field of strength  $B_0$  in the  $x$ - $z$  plane, oriented at an angle  $\theta = 37.2^\circ$  with respect to the  $z$ -axis. **a)** What is the matrix form (in the  $z$ -basis) for the Hamiltonian for one of the electrons? **b)** Each electron in the beam is exposed to the magnetic field for a time  $T$ , and then enters an SGy device. What is the probability that an electron will have  $S_y = \hbar/2$ ? Show all your work, and explain your reasoning clearly. *Hints: You will probably not want to use the result from part a to do this part – there is a simpler way to approach this part. (You are welcome, however, to use the result of part a for this part if you wish.) Also, recall that the ket for a spin state at orientation  $\theta$  with respect to the  $z$ -axis in the  $x$ - $z$  plane is  $|+n\rangle = \cos \frac{\theta}{2} |+z\rangle + \sin \frac{\theta}{2} |-z\rangle$ , and the spin state with opposite orientation is  $|-n\rangle = \sin \frac{\theta}{2} |+z\rangle - \cos \frac{\theta}{2} |-z\rangle$ .*

**2.** An electron is confined by the symmetric double-well potential energy function shown here. The barrier between the two wells is high compared to the energy of the electron, but not infinitely high. Show that, if the electron is initially localized in the right well, it will oscillate between the two wells. (Present a complete argument, starting from basic principles.)



**3.** For a system of two spin- $1/2$  particles, let's define the operator  $\hat{S}_{1z,2x}$  to represent a simultaneous measurement of the  $z$ -component of spin for particle 1 and the  $x$ -component of spin for particle 2. **a)** What is the matrix representation of this operator in the basis  $|1\rangle = |+z, +z\rangle$ ,  $|2\rangle = |+z, -z\rangle$ ,  $|3\rangle = |-z, +z\rangle$ ,  $|4\rangle = |-z, -z\rangle$ ? **b)** Use what you already know about the eigenstates of the one-particle operators  $\hat{S}_z$  and  $\hat{S}_x$  to form a suitable superposition of the basis states  $|1\rangle$  through  $|4\rangle$  that should be an eigenstate of  $\hat{S}_{1z,2x}$ , and demonstrate that your superposition state really is an eigenstate of  $\hat{S}_{1z,2x}$ .