Phys. 827: Problem Set 9

Due Wednesday, December 3, 2008 at 11:59 P. M.

Each problem is worth 10 points.

1. Shankar, problem 12.5.3 (p. 329).

2. Consider a particle mass m moving in a spherically symmetric square well with potential $V = -V_0$ for r < a; $V = 0$ for r > a ($V_0 > 0$).

   (a). Obtain the radial equation.

   (b). Write down the solution for $r < a$ and for $r > a$ in the case $\ell = 0$. Hint: make the substitution R(r) = u(r)/r and find u(r).

   (c). By matching boundary conditions, obtain a transcendental equation for the energy E. ("Transcendental" means an equation involving trigonometric or exponential functions.)

   (d). What is the minimum potential depth in order for there to be an $\ell = 0$ bound state?

   (e). At what depth does the second bound level appear?

3. Given an attractive central potential of the form $V = -V_0 \exp(-r/a)$, solve the Schrödinger equation for the s-states by making the substitution $\xi = \exp[-r/(2a)]$. Obtain an equation for the eigenvalues.

4. Shankar, problem 12.6.11, parts (1) and (2) only. By "parity" is meant the following: Each solution will satisfy $\psi(-\mathbf{x}) = \pm\psi(\mathbf{x})$, where the + sign means that the state has even parity, and the − sign means that the state has odd parity. In spherical coordinates, if we write $\mathbf{x} = r, \theta, \phi$, then $-\mathbf{x} = r, \pi - \theta, \pi + \phi$.