QUANTUM MECHANICS

Do any 3 of the 4 problems.

1. In this problem you will explore the quantum mechanical treatment of a "bouncing ball". Consider a particle of mass m above an infinite, perfectly reflecting (i.e., perfected nonabsorbing) surface on the x-y plane and acted upon by the gravitational force $\boldsymbol{F} = -mg\hat{\boldsymbol{z}}$.

(a) Write down the expression for the potential energy V and sketch it.

(b) Write down the time-independent Schrödinger equation for the particle. We now want to solve this equation; hence,

(c) Rewrite the Schrödinger equation in terms of the dimensionless variable $\xi = b(mgz - E)$, and, consulting the information on the next page, find an expression for the constant b. Verify that b has the correct units.

(d) Apply the appropriate boundary conditions and find the energy eigenfunctions (to within the normalization) and an approximate closed-form expression for the energies. *Be careful*: Consult the graph to verify your lowest one or two quantum numbers.

(e) Find the ground-state energy of an electron. How does the electron ground-state energy compare in magnitude with that for a hydrogen atom? How high should an electron in the ground state "levitate" (i.e., what is the approximate expectation value of the height)? *Hint*: Consider the classical turning point.