Physics 417: Problem Set 7 (*DUE ON THURSDAY 11/7*)

Problem 1: Griffiths 4.13

Problem 2: Hydrogen atom

Suppose the hydrogen atom starts in the initial state

$$|\psi\rangle = \frac{4}{5}|1, 0, 0\rangle + \frac{3i}{5}|2, 1, 1\rangle \tag{1}$$

where the $|n, \ell, m\rangle$ are the usual energy eigenstates of hydrogen.

(a) Calculate $\langle E \rangle$, $\langle L^2 \rangle$ and $\langle L_z \rangle$ for this state. (This part should be really easy.)

(b) Calculate $\langle V \rangle$ (the expectation value of the potential energy) for this state. (This part will require a little more work.)

(c) Calculate $|\psi(t)\rangle$. Which of the expectation values in (a) and (b) vary with time?

Problem 3: More hydrogen atom

Calculate the probability than an electron in the ground state of hydrogen is outside the classically allowed region.

Problem 4: Even more hydrogen atom

What is the ground state energy, Bohr radius, and Lyman-α frequency ($n = 2 \to n = 1$ transition) for each of the following hydrogenic systems:
(a) A bound state of a deuteron and an electron ("heavy hydrogen")
(b) A bound state of a proton and a muon ("mesonium")
(c) He^+, a singly ionized helium atom

Problem 5: Griffiths 4.19