Homework 3 **John Waczak**
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1. In the hydrogen atom, an electron is in the 1s state. What is the probability to find the electron in the region $0 \leq r \leq a_0/2$? (a_0 is the Bohr radius)

2. Consider positronium (i.e a bound system of an electron e^- and a positron e^+)

   (a) Compare the Bohr radius for this system with that for the hydrogen atom. How does the radius of positronium (i.e. the distance from the center of mass to the particle(s) compare to that of the hydrogen atom (draw the sketch of both and indicate the interparticle distances)? Discuss...

   (b) If we measure optical absorption spectrum of the hydrogen atom (i.e. transitions between some levels n_1, n_2, n_3, etc...) and find absorption lines at wavelengths $\lambda = 652.2, 486.1, 410.1$ nm, at what wavelengths should we expect some absorption of the positronium if we look at transitions between the same levels?

3. (a) Is the helium ion He^+ smaller or larger than the hydrogen atom in its ground state? By how much?

   (b) Is a muonic atom that consists of a proton and a μ^- muon (charge is charge of electron, mass $m_\mu \approx 200 m_e$) smaller or larger than a hydrogen atom in its ground state?

4. Sakurai 3.17 (grey edition)