Physics 402
Spring 2009
Prof. Anlage

Homework 1 Due Friday, February 6, 2009 @ 9 AM

1. Griffiths, 2nd Edition, Problem 4.1 (a) only **Commutation relations $[r_i, p_j]$, etc.**

2. Griffiths, 2nd Edition, Problem 4.2 (a) and (b) only **Separation of variables in a 3D Cartesian infinite cubical well. Find the eigenfunctions and eigenvalues. Determine the <u>degeneracies</u> of some of the lowest-energy states.**

3. Griffiths, 2nd Edition, Problem 4.3 **Construct some Legendre polynomials and spherical harmonics.**

4. Griffiths, 2nd Edition, Problem 4.13 (a) and (b) only **Use the H-atom GS WF to calculate expectation values $<r>$, $<r^2>$, $<x>$, $<x^2>$**

5. Griffiths, 2nd Edition, Problem 4.19 (a) and (b) only **Ang. Mom. commutation relations $[L_z, x]$, $[L_z, p_z]$, $[L_z, L_x]$, etc.**

6. Griffiths, 2nd Edition, Problem 4.22 (a) and (b) only **Ang. Mom. raising operator L_+ and Y_ℓ^ℓ.** **THIS PROBLEM IS NOW DUE WITH HW#2**

Extra Credit 1 **Schrod. Eq. in 3D → Separate variables → θ-equation → change of variables x=cosθ, etc. → Associated Legendre equation → take m=0 and use series solution method around x=0 → keep solution finite at x=±1 → find ℓ must be an integer**

Extra Credit 2 **Radial equation → substitute u(r) = rR(r) → find asymptotic behavior of u(r) → find new equation for v(r) → solve by series solution → find condition to keep solution normalizable → find eigen-energies of H-atom**

Office Hours Thursday, 3:00 – 4:30 PM, Room 0360 (see class web site for directions to the room)

TA (Wai-Lim Ku) Office Hours, Thursday 4:30 – 5:30 PM, Room 0104

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Discussion Worksheet for February 4, 2009

1. Consider the solutions to the radial part of the Schrödinger equation for the hydrogen atom, $R_{n\ell}(r)$. Note that the radial part of the probability density is proportional to $|rR_{n\ell}(r)|^2$.

a) Figure out a general expression for the number of zeros in $R_{n\ell}(r)$, excluding those at $r = 0$, and $r = \infty$, in terms of n and ℓ.

b) Sketch the effective potential for $\ell = 0$ and $\ell = 1$ and draw several bound states. Sketch solutions to the radial equation (given below) in terms of the "probability amplitude" $rR_{n\ell}(r)$ for $\{n = 1, \ell = 0\}$, $\{n = 2, \ell = 1\}$, and $\{n = 3, \ell = 1\}$. The effective potential is the term in square brackets:

$$\frac{-\hbar^2}{2m}\frac{d^2(rR)}{dr^2} + \left[\frac{-e^2}{4\pi\varepsilon_0}\frac{1}{r} + \frac{\hbar^2}{2m}\frac{\ell(\ell+1)}{r^2}\right](rR) = E(rR)$$

Use your knowledge of the asymptotic behavior of the solutions, as well as properties of solutions to one-dimensional differential equations, to make your sketches semi-quantitative.