BCHM485 Graded HW#3 (25 points) Due date/time: Friday April 17, 2026 by 12:00pm

Consider an excited state of hydrogen atom with electron in the 2p orbital with $m_l = -1$. Answer the following questions. You don't need to provide fully numerical answers – they can be expressed via a combination of numerical factors and physical constants, like e, $\hbar$, ε_o, a_o, etc

A. Write the expression for the probability density to find the electron at a given point (r,θ,ϕ) in the 3D space. (You may leave the numerical factors as they are: no need to reduce or calculate them.)

B. In which point(s) in the 3D space within the atom you are least likely to find the electron?

C. At what distance from the nucleus you are most likely to find the electron?

D. Calculate the mean value of the distance ($\langle r \rangle$) of the electron from the nucleus and compare it with the $\langle r \rangle$ value for 1s electron (you will need to calculate this one, too). Provide an explanation for why the $\langle r \rangle$ value for one of the electrons is larger than for the other electron.

E. Calculate the average potential energy of the electron in this orbital and compare it with the total energy in this state. Does the relationship ($\langle V \rangle = 2E$) we derived in class for the 1s orbital still hold?

The following table integral could be useful for some calculations: $\int_0^\infty x^m e^{-ax} dx = \frac{m!}{a^{m+1}}$