

Student ID Number: _____

PRELIMINARY EXAMINATION
DEPARTMENT OF PHYSICS
UNIVERSITY OF FLORIDA
Part D, 7 January 2003, 14:00 - 17:00

Instructions

1. You may use a calculator and CRC Math tables or equivalent. No other tables or aids are allowed or required. You may NOT use programmable calculators to store formulae.
2. All of the problems will be graded and will be tabulated to generate a final score. Therefore, you should submit work for all of the problems.
3. For convenience in grading please write legibly, use only one side of each sheet of paper, and work different problems on separate sheets of paper. The sheets for each problem will be stapled together but separately from the other two problems.
4. Your assigned student ID Number, the Problem Number, and the Page Number should appear in the upper right hand corner of each sheet. Do NOT use your name anywhere on the Exam.
5. All work must be shown to receive full credit. Work must be clear and unambiguous. Be sure that you hand your completed work to the Proctor.
6. Each problem is worth 10 points.
7. Following the UF Honor Code, your work on this examination must reflect your own independent effort, and you must not have given, nor received, any unauthorized help or assistance. If you have any questions, ask the Proctor.

University of Florida Honor Code: We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: *"On my honor, I have neither given nor received unauthorized aid in doing this assignment."*

DO NOT OPEN EXAM UNTIL INSTRUCTED

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- D1. The energy levels of the hydrogen atom are given to a good approximation by solving the Schrödinger equation for a non-relativistic electron moving in the Coulomb potential $V(r) = -e^2/(4\pi\epsilon_0 r)$, where $-e$ is the electron's charge. The ground state wave function for the electron in this approximation has the form

$$\psi_G(\mathbf{r}) \equiv \langle \mathbf{r} | G \rangle = N e^{-r/a}, \quad r \equiv |\mathbf{r}| .$$

- (a) (3 points) Show that this wave function does indeed solve the time-independent Schrödinger equation, and thereby determine the energy eigenvalue and the parameter a .
 - (b) (2 points) Determine $|N|$ from the normalization condition $\int d^3r |\psi_G|^2 = 1$.
 - (c) (3 points) In this approximation, the proton is, among other simplifications, assumed to be a point charge. In fact, the proton has a radius $R = O(10^{-15}m)$. Use perturbation theory to calculate the first order correction to the ground state energy level due to the finite size of the proton by assuming it is a uniform ball of charge with radius $R \ll a$.
 - (d) (2 points) Give an order of magnitude comparison of the level shift computed in (c) to the typical fine structure splittings in hydrogen.
- D2. (10 points) A shell of radius $R = 1$ m is uniformly charged with a charge $Q = 1$ C. Find the pressure experienced by the shell walls due to the electrostatic repulsion of the charge.

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- D3. (10 points) Two round platforms with the same radii, $R = 2$ m, are located at a distance of 5 m between their centers. They are rotating in opposite directions. The left platform is rotating counterclockwise, while the right platform is rotating clockwise. Both are rotating with an angular speed $\omega = 1$ rad/s. Two observers, A1 and A2, are standing right on the edges of the platforms. A1 is standing on the left platform and A2 is standing on the right platform. At the moment of interest, the observers happen to be located on the line connecting the centers of the platforms, as shown in the Figure below. What is the relative linear velocity of observer A2 with respect to observer A1? (Hint: do not rush to a conclusion! You may wish to check your answer by considering other observers with respect to A1 and A2.)

