Student ID Number: _____

PRELIMINARY EXAMINATION

DEPARTMENT OF PHYSICS
UNIVERSITY OF FLORIDA
Part B, 7 January 2002, 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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B1. The abundance of ^{235}U, which has a half-life of $t_{1/2} = 7.04 \times 10^8$ years, is currently 0.71% of the uranium in the Earth's crust. The rest of the uranium is primarily ^{238}U, $t_{1/2} = 4.47 \times 10^9$ years. How long ago would the concentrations have been equal? (The approximate age of the Earth is thought to be 4.5×10^9 years.)

B2. A particle of mass m is confined to the region between spheres of radii r_1 and r_2 ($r_1 < r_2$) by the potential

$$V = \begin{cases} \infty & \text{for } r < r_1 \quad , \\ 0 & \text{for } r_1 \leq r \leq r_2 \quad , \\ \infty & \text{for } r > r_2 \quad . \end{cases}$$

(a) (3 points) Find the general form of a spherically symmetric solution for the particle's wave function ψ that is an energy eigenstate. (Hint: let $\psi = u(r)/r$.)

(b) (3 points) Find the lowest energy eigenvalue and the form of the corresponding wave function ψ.

(c) (2 points) Estimate the uncertainty in the momentum of a particle in this ground state.

(d) (2 points) By performing a Fourier transform, find the wavefunction in momentum space for the ground state.

B3. A point charge q is placed either outside or inside a spherical shell of radius R made of a conductor. The distance between the point charge and the center of the sphere is a, which can be smaller or larger than R depending on whether the point charge is outside or inside. Each of the following questions concerns a different configuration. For a full credit, show your work or give your reasoning for every answer.

(a) (4 points) Configuration 1. In this configuration, the point charge is outside the spherical shell ($a > R$), and the shell is electrically grounded. Find the electric field, both inside and outside the sphere. Also find the total induced charge on the shell.

(b) (3 points) Configuration 2. Here the charge is inside the shell ($a < R$), which is grounded. Find the electric field, both inside and outside the sphere. Also find the total induced charge on the shell.

(c) (3 points) Configuration 3. Now the charge is back to outside the shell ($a > R$), but the shell is electrically neutral and not grounded. Find the electric field, both inside and outside the sphere.