PRELIMINARY EXAMINATION
DEPARTMENT OF PHYSICS
UNIVERSITY OF FLORIDA
Part B, 5 January 2004, 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

B1. (10 points) An ionized molecule consists of three equidistant atoms, each described in isolation by a single electronic state with energy F_0. A single electron is now added, and there exists a matrix element of the molecular Hamiltonian allowing it to jump between atoms, given as $\langle i|H_0|j\rangle \equiv -\alpha$ for $i \neq j$, with $i, j = 1, 2, 3$.

   (a) (4 points) Calculate the eigenvalues and eigenvectors of H_0 for the case of one single electron and state the degeneracies.

   (b) (3 points) Suppose an electric field is now applied in the z-direction as shown in the left-hand side of the figure, such that the potential energy of the top atom is lowered by u relative to the bottom two, and assume $|u| \ll |\alpha|$. Calculate the new levels and state the degeneracies.

   (c) (3 points) Suppose the electron is in the ground state at $t = 0$, when the field is rotated suddenly by $120°$ and now points towards atom 2, as shown in the right-hand side of the figure. Calculate the probability for the electron to remain in the ground state to leading order in u. If you can't calculate this, estimate the result to leading order in u on physical grounds.

Triangle molecule.
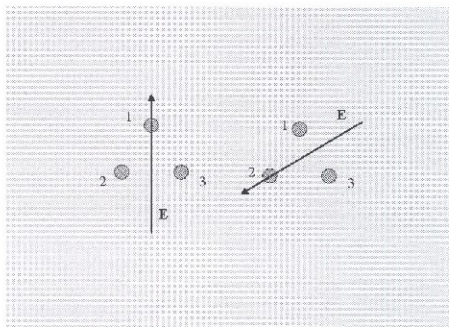
B2. A photon with initial wavelength λ as measured in the laboratory scatters off an electron (mass m_e) initially at rest. After scattering, the photon is deflected by angle θ and has wavelength λ', and the electron is also moving.

    (a) (2 points) What are the momentum and energy of a photon with wavelength λ?

    (b) (2 points) What is the relativistic energy of an electron with momentum p_e?

    (c) (3 points) Write equations expressing conservation of relativistic energy and momentum in the collision.

    (d) (3 points) Use these to compute the wavelength shift of the photon, $\lambda' - \lambda$.

B3. Two long straight wires, carrying opposite uniform line charge densities $\pm \lambda$ are situated on either side of a long conducting cylinder. The cylinder has radius R and carries no net charge. The wires are a distance d ($d > R$) from the axis of the cylinder.

    (a) (6 points) Find the electric potential at point P.

    (b) (4 points) If a test charge $+q$ of mass m is released from infinity on the left side, what is its speed when it reaches the cylinder?