Student ID Number: __________

PRELIMINARY EXAMINATION

Department of Physics
University of Florida
Part A, 3 January 2008, 09:00–12:00

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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A1. A nonrelativistic particle of mass m and energy E travels from the region $x < 0$ and is incident on a potential step

$$V(x) = \begin{cases} 0 & \text{for } x < 0, \\ V_0 & \text{for } x > 0, \end{cases}$$

where $E > V_0 > 0$.

(a) (*2 points*) Write down the general form of the time-independent wave function $\psi_-(x)$ in the region $x < 0$ and the corresponding wave function $\psi_+(x)$ in the region $x > 0$.

(b) (*3 points*) Specify the boundary conditions obeyed by $\psi_-(x)$ and $\psi_+(x)$ at $x = 0$. Use these boundary conditions to express the wave functions from (a) in terms of a single (unknown) amplitude.

(c) (*5 points*) Calculate $P_0(x)$, defined to be the limiting value as $dx \to 0$ of the ratio of the probability that a measurement of the particle's position will produce a result in the range $[x, x + dx]$ to the probability that the result will lie in the range $[0, dx]$. Sketch a graph showing the qualitative variation of $P_0(x)$ versus x in the vicinity of the potential step, also specifying the maximum and minimum values of $P_0(x)$.

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A2. An electric field associated with a plane electromagnetic wave propagating in empty space is described by the following equations:

$$E_x = E_0 \sin(kz + \omega t)$$

$$E_y = 0; \quad E_z = 0$$

Variables E_0, k, and ω are positive numbers. *All answers to the following questions should be given in terms of E_0, k, ω, ϵ_0, μ_0. No other variables can be used, unless you explicitly define them via variables listed above.*

(a) (*1 point*) What is the wavelength of these waves?

(b) (*1 point*) What is the speed of these waves?

(c) (*1 point*) What is the direction of wave propagation?

(d) (*2 points*) Write equations for x-, y-, z-components of the magnetic field B.

(e) (*2 points*) Write an equation for the energy density (amount of energy per unit of volume) as a function of time $u(t)$ at the point $(x, y, z) = (0, 0, 0)$.

(f) (*1 point*) What fraction of this energy is carried by the electric field?

(g) (*2 points*) If this wave is absorbed by a wall, what would be the pressure experienced by the wall?

A3. (*10 points*) As measured in the laboratory frame of reference, a 5 MeV alpha particle ($mc^2 = 3700$ MeV) collides head-on with an electron at rest ($m_e c^2 = 0.5$ MeV). Estimate the speed (in the laboratory frame) of the electron after the collision, assuming that the collision is elastic.