Student ID Number: ________

PRELIMINARY EXAMINATION

DEPARTMENT OF PHYSICS
UNIVERSITY OF FLORIDA
Part D, 6 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

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D1. In this problem, consider two equal cubical volumes, $V_{\circ}$. One is made of pure aluminum with density ρ_{Al}. The other is a rigid closed container of argon gas, which may be considered to be an ideal gas with mass per mole M. The aluminum and argon are each at the same temperature, $T = 300$ K, and pressure, $P = 1$ bar.

(a) (3 points) For each material, define the quantity relating the change of temperature, ΔT, for a *given amount* of material to the heat, Q, transferred to or from it. Your definition should be appropriate for the conditions stated and, for each material, describe the conditions for which your definition holds.

(b) (3 points) The quantities you defined above should have been extensive quantities (*i.e.* they depend on the given amount of material). Using the information given above, convert these to an intensive property (*i.e.* independent of the amount of material) for both aluminum and argon.

(c) (4 points) Suppose that the argon were instead contained in an easily stretched, elastic balloon. How would the intensive property given in (b) now differ? Would this property now be numerically larger or smaller? Explain in detail.

D2. The electric field associated with an electromagnetic wave is given (in Cartesian coordinates) by the following expression,

$$\vec{E} = \frac{E_0}{\sqrt{5}} \exp\left\{-i\omega\left(\frac{ny}{c} + t\right)\right\}(\hat{x} + 2\hat{z}) \quad ,$$

where n is the refractive index of the medium, c is the speed of light in vacuum, and E_0 is the amplitude of the electric field. Throughout this problem, you may assume that both n and E_0 are real, and that the permeability is that of free space, $\mu_{\circ}$.

(a) (1 point) Evaluate the velocity of this wave and express your answer as a vector.

(b) (2 points) Evaluate the associated magnetic field.

(c) (4 points) The wave impinges on a boundary defined by the $y = 0$ plane. The refractive index for $y \geq 0$ is $n_1 = 1$, while the refractive index for $y < 0$ is $n_2 = 1.5$. Evaluate expressions for the electric and magnetic fields associated with the electromagnetic waves which are reflected and transmitted at the boundary.

(d) (3 points) Show that the transmitted and reflected power per unit area corresponds to the original power per unit area incident on the boundary.

D3. (a) (3 points) An unstable particle has a half life of 1.0 μs. What is the particle's mean lifetime?

(b) (4 points) Particles of mean lifetime τ are created at $t = 0$, and their decay events are detected. Because of the dead time of the electronics, the detection starts at $t = t_d$, before which no decay can be detected. Using calculus, find the mean lifetime $< t >$ of the particles measured by this setup.

(c) (3 points) Using only a simple logic and no calculus, derive the same result.