Student ID Number: _____

PRELIMINARY EXAMINATION

Department of Physics

University of Florida

Part D, January, 2014, 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.

   (a) 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.

   (b) 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.

   (c) 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.

   (d) 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.

   (e) Each problem is worth 10 points.

   (f) 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 partition function for an interacting gas is assumed to be

$$Z \;=\; \left(\frac{V-Nb}{N}\right)^{N} \left(\frac{mk_BT}{2\pi\hbar^2}\right)^{3N/2} \exp\left(\frac{N^2a^2}{Vk_BT}\right) \quad ,$$

where a and b are constants. Obtain an expression for the pressure of this system, and comment on this result in the limit when $a \to 0$ and $b \to 0$.

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D2. A π^+ particle undergoes a 2-body decay into a muon and a muon neutrino. Calculate the energy and momentum of the two final state particles, assuming the pion decays at rest.

$M_{\pi^+} = 140$ MeV/C^2, $M_\mu = 106$ MeV/C^2, $M_\nu = 0.15$ MeV/C^2

Assume that the neutrino is massive.

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D3. At the Earth's equator there are often long periods of time when the winds disappear, trapping sailing vessels for days or weeks (equatorial doldrums).
Suppose that a small sailboat is becalmed at the equator. The captain, a former physics major, decides to put the boat into motion by raising the anchor ($m = 200$ kg) to the top of the mast ($h = 20$ m). The rest of the boat has a mass $M = 1000$ kg. In case you need the value of the Earth's radius, you may take it to be $R_E = 6400$ km.

(a) **[2 points]** Why will the boat begin to move?

(b) **[2 points]** In which direction will the boat move?

(c) **[6 points]** What is the boat's final velocity (with respect to the Earth)?