Prelim ID Number: _____

PRELIMINARY EXAMINATION

Department of Physics
University of Florida
Part C, 09:00–12:00, Aug 19, 2011

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. You will be assigned a **Prelim ID Number**, *different from your UF ID Number*. The **Prelim 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 or UF ID Number 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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C1.

An electric charge q is placed between two grounded parallel metallic plates separated by distance d. The charge is located distance x from the mid-point between the plates.

(a) (*3 points*) Describe mathematically the locations of all of the image charges. You may wish to draw a figure.

(b) (*4 points*) Find the electrostatic force acting on a charge, assuming that $x \ll d$.

(c) (*2 points*) Evaluate the numerical coefficient in part (b), perhaps by using the hint:

$$\zeta(3) \equiv \sum_{k=1}^{\infty} \frac{1}{k^3} = 1.202\ldots$$

(d) (*1 point*) What would happen if the metal surfaces were not grounded? Explain.

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C2.

You are performing an experiment in which the independent variables you measure are B, C and D. Theory says that, $Q = (A)\frac{(B)\,(C)}{D^2}$ where A is a known exact number. You take many measurements of B, C and D, finding mean values $\bar{B}$, $\bar{C}$ and $\bar{D}$, and standard deviations ΔB, ΔC, ΔD, respectively.

(a) (*6 points*) Write down an expression for the anticipated error in Q (one standard deviation).

(b) (*2 points*) By far most of the scatter in your measurements occurs in C. To reduce the likely error in Q by about a factor of 12 what should you do?

(c) (*2 points*) Your value of Q is higher than that of 3 other studies by more than 3 standard deviations what do you check for before publishing your result?

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C3.

Consider three $S = 1/2$ spins—$\vec{S}_1$, $\vec{S}_2$, and $\vec{S}_3$—located at the three corners of a microscopic triangle. We will call this arrangement a "molecule". The Hamiltonian of the molecule is given by $\mathcal{H} = J(\vec{S}_1 \cdot \vec{S}_2 + \vec{S}_2 \cdot \vec{S}_3 + \vec{S}_3 \cdot \vec{S}_1)$, where J is a positive constant. As you may recall, this has two energy levels, separated by $3J/2$, both of which are fourfold degenerate. Throughout this problem, ignore any motion of such molecules and any interaction between them, magnetic or not.

(a) (*2 points*) Write down the canonical partition function z per molecule.

(b) (*2 points*) Give an expression for the internal energy $U(T)$ of one mole of such molecules as a function of temperature.

(c) (*2 points*) Give an expression for the heat capacity $C(T)$ of one mole of these molecules as a function of temperature.

(d) (*1 point*) What is the heat capacity at $T = 0$ and at $T = \infty$?

(e) (*2 points*) Give an expression for the entropy $S(T)$ of one mole of these molecules as a function of temperature.

(f) (*1 point*) What is the entropy at $T = \infty$?