# PRELIMINARY EXAMINATION

DEPARTMENT OF PHYSICS
UNIVERSITY OF FLORIDA
Part C, 13 August 2004, 09:00 - 12:00

C1. In models for electronic states in ring-shaped molecules, one is led to consider the following problem: Two identical fermions of mass $m$ and spin $S = \frac{1}{2}$ are confined to a circular ring of radius $r$, and their spins are constrained to point up. The particles interact via a potential of the form

$$V = A\cos(\alpha - \beta) \quad ,$$

where $\alpha$ and $\beta$ are the angular positions of the two particles and the positive constant $A$ is much smaller in magnitude than $\hbar^2/2mr^2$.

(a) (5 points) Find the energy, degeneracy, and wave functions for the ground state(s) and the first excited state(s) for $A = 0$.

(b) (5 points) Find the energies and degeneracies at first order in $A$.

C2. Two long parallel line charges with charge per unit length $\lambda$ equal in magnitude and opposite in sign separated by distance $d$ move parallel to their length with speed $v$.

(a) (3 points) What is the **electric force** per unit length (magnitude and direction) between the line charges?

(b) (3 points) What is the **magnetic force** per unit length (magnitude and direction) between the charges?

(c) (2 points) For what $v$ does the total force vanish?

(d) (2 points) In the rest frame of the charges, what is the **magnetic force**? Justify your response in detail.

C3. For most common metals, the heat capacity at constant volume, $c_v$, can be written as

$$c_v = \gamma T + \beta T^3 \quad .$$

(a) (2 points) What is the source of the $\gamma T$ term?

(b) (2 points) What is the source of the $\beta T^3$ term?

(c) (6 points) What is the temperature dependence of the entropy (and be specific about the details of your derivation, including the $T \to 0$ limit)?