Student ID Number: _____

PRELIMINARY EXAMINATION

Department of Physics
University of Florida
Part B, 21 Aug 2008, 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

PRELIMINARY EXAMINATION

DEPARTMENT OF PHYSICS

UNIVERSITY OF FLORIDA

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B1. An unperturbed Hamiltonian is given by

$$H_0 = \alpha J^4$$

where J is the angular momentum operator.

(a) (*2 points*) What are the eigenvalues of this Hamiltonian and what are the degeneracies of the levels?

(b) (*5 points*) A perturbing Hamiltonian is now applied to the system and is given by

$$H_1 = \lambda(J_x^2 - J_y^2)$$

How is the degeneracy of the $J = 1$ manifold (i.e. the states $|J = 1, m = \pm 1, 0\rangle$) changed by this perturbation? Find the change in energies and the new eigenstates for the $J = 1$ manifold.

(c) (*3 points*) What happens to the degeneracy of the $J = 1$ manifold if the perturbing Hamiltonian was

$$H_1 = \lambda(J_x^2 + J_y^2)$$

instead? Find the new energies and eigenstates.

B2. (*10 points*) An object of unit mass is subject to a (1-dimensional) potential given by

$$U(x) = x^2(x-2),$$

where x is the position along the x-axis. The position, velocity and acceleration of the object as a function of time are given by $x(t)$, $\mathbf{v}(t)$ and $\mathbf{a}(t)$.

In the ensuing motion, find

(i) the maximum positive value of $x(t)$

(ii) the maximum positive value of $\mathbf{v}(t)$

(iii) the maximum positive value of $\mathbf{a}(t)$

when the initial conditions are each of the following:

(a) $x(0) = 1,\ \mathbf{v}(0) = 0$

(b) $x(0) = 1,\ \mathbf{v}(0) = \sqrt{2}$.

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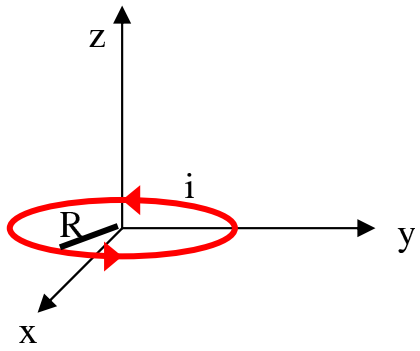
B3. A circular loop of wire of radius R carries a current i counterclockwise in the x-y plane, with the center of the loop at the origin.



(a) (*5 points*) What is the magnetic field (magnitude and direction) at a position z_0 along the z axis?

(b) (*5 points*) A second identical circular loop of wire with the same current i in the same direction as in the first loop is placed parallel to the x-y plane at a position $z = -d$ below the first loop (with its center on the z axis). What is the magnitude and direction of the force acting on this second loop assuming $d \gg R$?