Prelim ID Number: ________

PRELIMINARY EXAMINATION

Department of Physics
University of Florida
Part A, 09:00–12:00, Jan 3, 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

PRELIMINARY EXAMINATION
DEPARTMENT OF PHYSICS
UNIVERSITY OF FLORIDA
Part A, 09:00–12:00, Jan 3, 2011

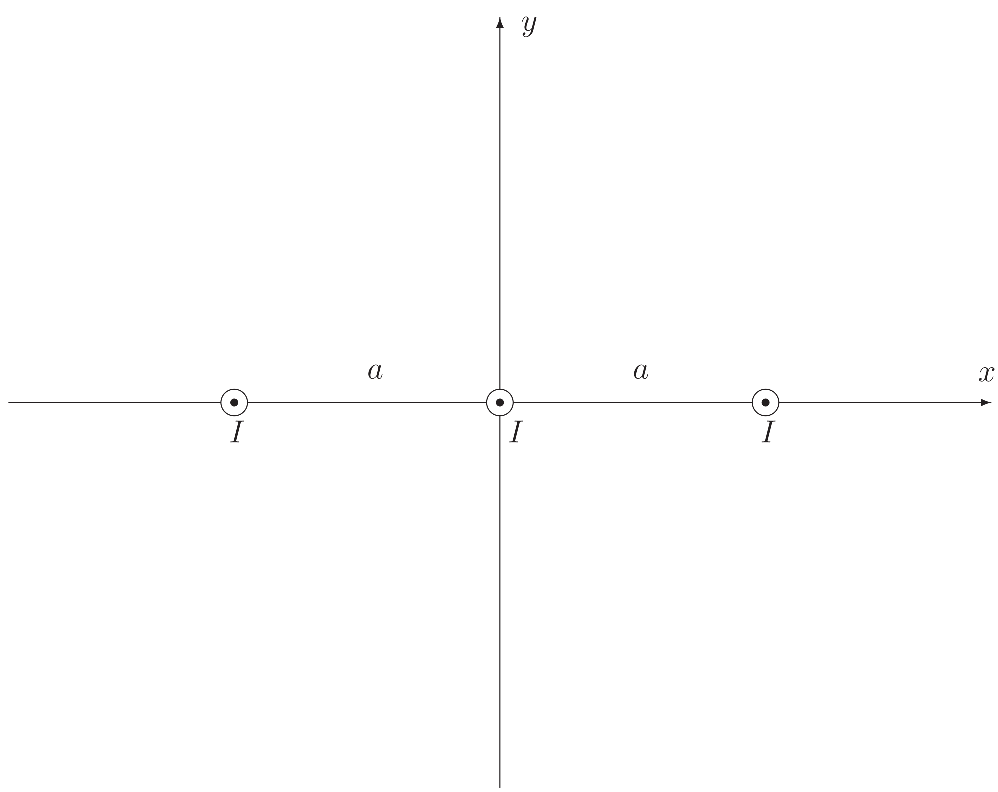
A1. Consider three straight, infinitely long, equally spaced wires (with zero radius), each carrying a current I in the same $(+\hat{z})$ direction. Let the coordinates of the wires in the (x, y) plane be $(-a, 0)$, $(0, 0)$ and $(+a, 0)$, as shown in the picture.

(a) (*3 points*) Find the location of all points in the (x, y) plane where the magnetic field created by the three wires is zero.

(b) (*1 point*) On the picture below, sketch the magnetic field line pattern.

(c) (*3 points*) Suppose that the middle wire is rigidly displaced upward by a very small distance $\varepsilon \ll a$ to the point $(x, y) = (0, \varepsilon)$, while the other two wires are held fixed. Describe qualitatively the subsequent motion of the middle wire. If it is oscillatory, find the frequency of small oscillations (assume the wires have linear mass density λ).

(d) (*3 points*) Now suppose that the middle wire were instead rigidly displaced to the right by a very small distance $\varepsilon \ll a$ to the point $(x, y) = (\varepsilon, 0)$, while the other two wires are held fixed. Describe qualitatively the subsequent motion of the middle wire. If it is oscillatory, find the frequency of small oscillations.



PRELIMINARY EXAMINATION

Department of Physics

University of Florida

Part A, 09:00–12:00, Jan 3, 2011

A2. The hamiltonian of an electron spin in an external magnetic field, $\vec{B}$, is

$$H = \frac{e}{m_e}\vec{S}\cdot\vec{B},$$

where the components of the spin operator are $S_\alpha = (\hbar/2)\sigma_\alpha$ and σ_α is a Pauli spin matrix. In the following take the magnetic field to be in the x-direction: $\vec{B} = B\hat{x}$.

(a) (*2 points*) Show that this hamiltonian has the units of energy.

(b) (*1 point*) At $t = 0$ the spin is an eigenstate of S_z with eigenvalue, $+\hbar/2$. In other words, it is pointing in the z-direction. What is the spinor wave function at $t = 0$?

(c) (*4 points*) Derive an expression for the wave function as a function of time using the initial condition in part (b).

(d) (*3 points*) Compute the expectation values of S_x, S_y, and S_z as a function of time for the wave function in part (c).

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A3. A small bead of mass m slides without friction on a circular hoop of radius R (see the figure). The hoop spins with a constant angular velocity ω about its vertical diameter.

(a) (*2 points*) Write down the Lagrangian for the bead.

(b) (*2 points*) Derive the equation of motion for the bead.

(c) (*3 points*) Find all possible equilibrium positions of the bead. Which of them are stable and which are unstable?

(d) (*3 points*) Find the frequencies of small oscillations about stable equilibrium positions.