Student ID Number: ________

PRELIMINARY EXAMINATION

Department of Physics
University of Florida
Part B, January, 2017, 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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B1. **(Tanner)** An electromagnetic wave contains electric and magnetic fields. These exert forces on charges according to the Lorentz force law. A particle of charge Q and mass M is free to move in response to external fields. Suppose the particle is subjected to a plane electromagnetic wave propagating in the x direction. The wave has frequency ω and electric field amplitude E_0. You are to work out the response of the particle to this wave.

(a) [**1 point**] Write the electric and magnetic fields of the wave. You might as well take the phase to be zero and the electric field to be in the y direction. (The wave is in vacuum!) Use of Maxwell's equations is allowed but not required.

(b) [**2 points**] Write the equation of motion of the particle. (Newton's law applied to this case.)

(c) [**3 points**] Find the velocity of the particle as a function of time. Here, you should ignore for the moment the magnetic force.

(d) [**1 point**] Calculate the average velocity of the particle. Adjust (if necessary) the answer to part c so that the average velocity is exactly zero.

(e) [**2 points**] Now, using the velocity from part (c), as adjusted in part (d), find the magnetic force on the particle.

(f) [**1 point**] Calculate the time-averaged magnetic force on the particle.

Hint: It is up to you, but the problem might more easily be worked considering the observable fields rather than the complex fields that are usually written.

Hint: Be sure to state what system of units (SI or cgs) you are using.

Note: $\sin 2\phi = 2 \sin\phi \cos\phi$

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B2. **(Meisel)** A uniformly charged, solid sphere of radius R has a total charge Q, so its volume charge density is $\rho = (3Q)/(4\pi R^3)$. This solid sphere is spinning with angular velocity ω about the z-axis such that $\vec{\omega} = \omega\hat{z}$. What is the magnetic dipole moment of the sphere?

You may or may not find the following information useful. *Not certain if we want to include this information? The cosine integral is included to get them to choose correctly.*

$$\int \sin^3 ax\, dx = -\frac{1}{3a}(\cos ax)(\sin^2 ax + 2) \qquad \int \cos^3 ax\, dx = \frac{1}{3a}(\sin ax)(\cos^2 ax + 2)$$

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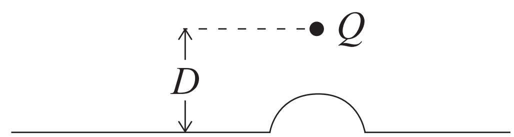
B3. **(Ramond)** A conductor at zero potential is in the shape of an infinite plane except for a hemispherical bulge of radius R. A charge Q is placed above the center of the bulge at a distance $D > R$.



Use the method of images to find the force on the charge Q.