Prelim ID Number: ______

PRELIMINARY EXAMINATION

Department of Physics

University of Florida

Part B, 14:00–17:00, Aug 19, 2010

Instructions

(a) 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.

(b) 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.

(c) 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.

(d) 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.

(e) 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.

(f) Each problem is worth 10 points.

(g) 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. A long cylinder of radius R is made of polarized dielectric. The polarization vector $\vec{P}$ is proportional to the radial vector $\vec{r}$ so that $\vec{P} = a\vec{r}$, where a is a positive constant. The cylinder rotates around its axis with an angular velocity ω, where $\omega R \ll c$.

(a) (*3 points*) Find the electric field $\vec{E}$ (direction and magnitude) at a radius r both inside and outside of the cylinder.

(b) (*4 points*) Find the magnetic field $\vec{B}$ (direction and magnitude) at a radius r both inside and outside of the cylinder.

(c) Find the total electromagnetic energy stored per unit length of the cylinder

i. (*1 point*) before the cylinder starts spinning,

ii. (*2 points*) and while it is spinning. Where did the extra Energy come from?

B2. Consider $1\,\mathrm{m}^3$ cubic cavity filled with air at normal atmospheric pressure ($P^0 = 1\,\mathrm{Atm} = 10^5\,\mathrm{pa}$) and at room temperature. In the middle of the cube there is an impenetrable partition, which splits the cube in half. The partition is then very slowly moved to the right, until the ratio of volumes inside the cube becomes $3:1$. Assume that the process is isothermal.

(a) (*5 points*) After the partition is moved what is the ratio of the pressures on the two sides of the partition?

(b) (*5 points*) While the partition was moving how much work (in Joules) was performed on the gas?

B3. Consider a particle of mass m, in one dimension x, whose Hamiltonian is

$$H = \frac{p^2}{2m} + \frac{1}{2}m\omega^2 x^2 + \frac{1}{4}\lambda x^4$$

with given parameters ω and λ.

(a) (*3 points*) What is the most general form of the ground state energy consistent with dimensional analysis? (Your answer will of course involve an arbitrary function of any dimensionless parameters that can be constructed.)

(b) (*3 points*) Use perturbation theory to compute the order λ correction to the ground state energy.

(c) (*2 points*) Use the variational technique to obtain the best possible bound on the ground state energy with a Gaussian trial wave function. If you need to solve a cubic or quartic equation in the course of this problem, just define the solution in terms of an arbitrary function and go on, for example,

$$x^3 + \alpha x^2 - \beta = 0 \qquad \Longrightarrow \qquad x = \sqrt{\frac{\beta}{\alpha}}\, g\Big(\sqrt{\frac{\beta}{\alpha^3}}\Big)\,.$$

(d) (*2 points*) Give an integral expression for the WKB estimate of the ground state energy.