Student ID Number: __________

PRELIMINARY EXAMINATION

DEPARTMENT OF PHYSICS
UNIVERSITY OF FLORIDA
Part C, 19 August 2005, 9:00 - 12:00

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

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C1. In the matrix representation, the spin operator is given by

$$\overrightarrow{S} = \frac{1}{2}\,\hbar\,\overrightarrow{\sigma}$$

where the components of the Pauli matrices $\overrightarrow{\sigma}$ are:

$$\sigma_x = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \quad \sigma_y = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix} \quad \sigma_z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$

(a) (2 points) The magnetic moment of the electron is given by

$$\overrightarrow{M} = -\frac{eg}{2m_e c}\overrightarrow{S}$$

where g is the gyromagnetic ratio. Write down the Hamiltonian for an electron in the presence of an external magnetic field $\overrightarrow{B} = (0, 0, B)$.

(b) (4 points) Suppose that at time $t = 0$, the spin is in an eigenstate of S_y. Solve the Schrodinger equation for the time evolution of the spin.

(c) (4 points) Compute the expectation values of S^2, S_x, S_y, and S_z at arbitrary times.

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C2. With the switch open, a parallel plate capacitor made of two disks of radius a separated by a distance d is charged to the initial charge of $Q_\circ$. The switch is then closed, and the capacitor discharges through a resistor R (see figure). Express your answers in tems of a, d, $Q_\circ$, R, and any universal constants that you may need.

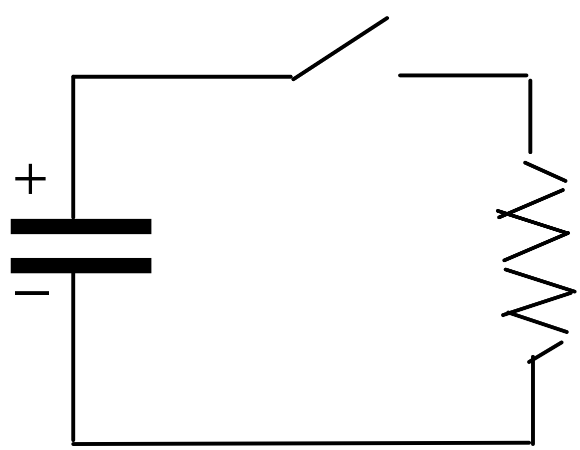
(a) (1 point) What is the capacitance C of the capacitor?

(b) (2 points) Find the electric field strength $E(t)$ inside the capacitor as a function of time t and indicate its direction.

(c) (4 points) Find the magnetic field strength $B(r, t)$ inside and outside the capacitor in a fictitious plane parallel to and positioned right between the capacitor plates as a function of radial distance r from the capacitor centerline and time t. Show the direction of the field.

(d) (1 point) Find the thermal energy power $P_R(t)$ being dissipated by the resistor R as a function of time t.

(e) (2 points) Find the total thermal energy U_R to be dissipated by the resistor R.



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C3. One kilomole of a monatomic ideal gas is carried around the reversible closed cycle, moving from points $1 \to 2 \to 3 \to 1$ as shown. This cycle consists of an isochore, an isobar and an adiabat, where $P_1 = 10$ bar, $V_1 = 2$ m^3, and $V_2 = 2\,V_1$.

(a) (5 points) Show that the entropy change around the closed loop is zero.

(b) (5 points) Calculate the efficiency of this engine.