Student ID Number: ________

PRELIMINARY EXAMINATION
DEPARTMENT OF PHYSICS
UNIVERSITY OF FLORIDA
Part B, August 17, 2022, 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
B1. A parallel plate capacitor made of two disks of radius \( a \) separated by distance \( d \) is charged to the initial charge of \( Q_0 \). At time \( t = 0 \), the switch is closed and the capacitor discharges through a resistor \( R \) (see figure).

Express your answers via \( a, d, Q_0, R \) and any universal constants that you may need.

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

(b) [1 point] Find the electric field strength \( E(t) \) inside the capacitor as a function of time \( t \). Show its direction.

(c) [3 points] Find the magnetic field strength \( B(r, t) \) inside and outside the capacitor in the plane parallel to, and positioned right between, the capacitor plates as a function of radial distance \( r \) from the central axis of the capacitor and time \( t \). Show the direction of the field.

(d) [1 point] Where and when is the magnetic field strength maximal?

(e) [1 point] Find the thermal energy power \( P_R(t) \) being dissipated by the resistor \( R \) as a function of time \( t \).

(f) [1 point] Find the total thermal energy \( U_R \) dissipated by the resistor \( R \).

(g) [1 point] What was the total energy stored on the capacitor \( U_C \) at time \( t = 0 \)?

(h) [1 point] Why is \( U_R < U_C \)?
B2. A dipole moment of magnitude $p$ is located at distance $h$ above a grounded metallic plane, as shown in the Figure.

(a) [5 points] Find the charge density and total charge induced on the metallic surface.

(b) [5 points] Find the force on the dipole.

The results should not include any quantities not specified in the formulation of the problem, except for vacuum permittivity $\varepsilon_0$. 
B3. For the circuit shown in the Figure below the resistors each have a resistance of 100Ω and the connecting wires have negligible resistance.

(a) [1 point] If $R_2$, $R_3$ and $R_4$ are reduced to an equivalent single resistor what is its resistance?

(b) [1 point] Including $R_1$ what is the equivalent resistance of all the resistors that the 12V power supply sees?

(c) [1 point] Assuming an ideal power supply of 12V what current must it source?

(d) [1 point] How much current flows through $R_1$?

(e) [1 point] How much current flows through $R_2$?

(f) [1 point] How much current flows through $R_3$?

(g) [1 point] What is the voltage drop across $R_3$?

(h) [1 point] What is the voltage drop across $R_4$?

(i) [1 point] How much power is dissipated across $R_1$?

(j) [1 point] How much power is dissipated across $R_3$?