Student ID Number: ________

PRELIMINARY EXAMINATION

Department of Physics
University of Florida
Part B, August 17, 2021, 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

PRELIMINARY EXAMINATION

DEPARTMENT OF PHYSICS
UNIVERSITY OF FLORIDA
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B1. Consider an infinite parallel-plate capacitor, with the lower plate (at $x = -d/2$) carrying charge density $-\sigma$ and the upper plate (at $x = +d/2$) carrying charge density $+\sigma$. (For all questions below, you need to get the signs correct as well as the magnitudes).

(a) [**4 points**] Determine all 9 elements of the Maxwell stress tensor in the region between the plates. Display your answer as a 3×3 matrix.

(b) [**3 points**] Use this tensor $\mathbf{T}$ to determine the force per unit area on the bottom plate via $F = \int\int \mathbf{T}.d\vec{s}$ where $d\vec{s}$ is the infinitesimal area element

(c) [**3 points**] What is the momentum per unit area, per unit time, crossing the xy plane, the xz plane, and the yz plane?

(d) [**2 points**] Now add a uniform magnetic field B_0 in the y-direction. What is the energy per unit area, per unit time, crossing the xy plane, the xz plane and the yz plane?

Hint: The elements of Maxwell stress tensor are defined as

$$T_{ij} = \epsilon_0 \left(E_i E_j - \frac{1}{2}\delta_{ij} E^2 \right) - \frac{1}{\mu_0} \left(B_i B_j - \frac{1}{2}\delta_{ij} B^2 \right)$$

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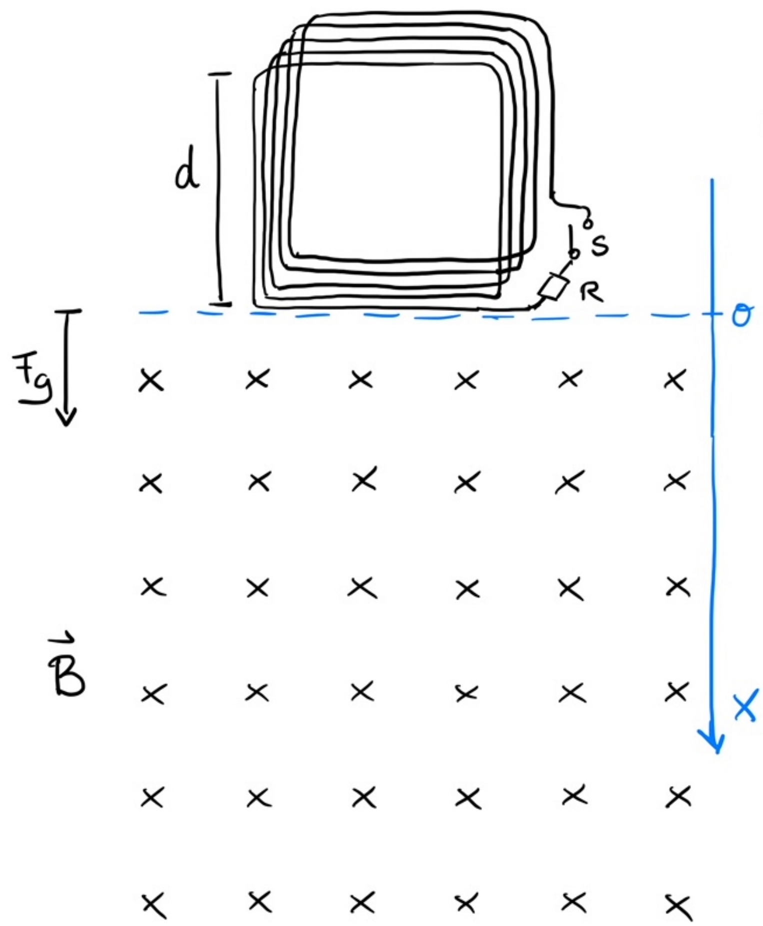
B2. A coil with a square cross section of diameter d and winding number N is dropped into a region penetrated by a homogeneous magnetic field $\vec{B}$ that begins at $x = 0$. The mass of the coil is m.



(a) [**3 points**] Assuming that the switch S is open when the coil is dropped from $x = 0$, calculate the time-dependent velocity of the falling coil and the time dependence of the voltage across the switch contacts. Indicate the polarity of the voltage.

(b) [**7 points**] The experiment is repeated with the switch S closed. Calculate the time-dependent current in the coil, as well as the maximum velocity the coil can reach before its entire cross section is inside the field region.

PRELIMINARY EXAMINATION
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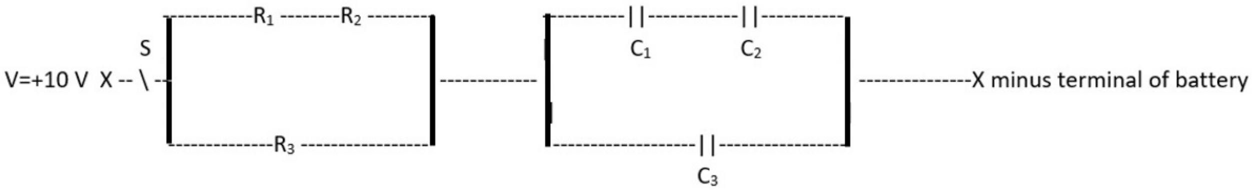
B3. Consider the circuit shown in the Figure below.



(a) **[2 points]** What is the equivalent resistance in the above circuit?

(b) **[2 points]** What is the equivalent capacitance in the above circuit?

(c) **[2 points]** If $R_1 = R_2 = R_3 = 10$ ohms and $C_1 = C_2 = C_3 = 5\ \mu$F, what is the RC time constant of this circuit, in units of seconds?

(d) **[4 points]** After connecting the 10 V battery thru switch 'S' (marked with – \ – in the Figure) to the circuit, how long would it take the current in the circuit to fall to 50% of its value at $t = 0$?