Student ID Number: ________

PRELIMINARY EXAMINATION

Department of Physics
University of Florida
Part B, January 4, 2019, 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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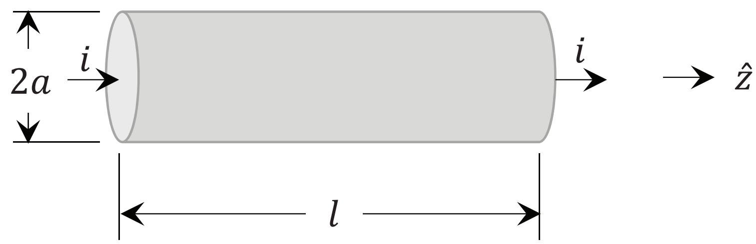
B1. The figure shows a cylindrical resistor of length l, radius a, and resistance R, carrying a current i. Use cylindrical coordinates for the vectors in this problem. The z-direction is shown.



(a) **[2 points]** Find the electric field vector $\vec{E}$ across the length of the conductor in terms of the quantities given above (magnitude and direction).

(b) **[2 points]** Find the magnetic field vector $\vec{B}$ due to i at the surface of the resistor in terms of the quantities given above and appropriate constants (magnitude and direction).

(c) **[3 points]** Find the Poynting vector $\vec{S}$ (magnitude and direction).

(d) **[3 points]** Find the rate at which energy flows into or out of the resistor by integrating the Poynting vector over this cylindrical surface.

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B2. A conductive disk of radius R, thickness h, and resistivity ρ is placed in a uniform magnetic field that changes in time as $B(t) = B_0 \cos(\omega t)$. The field is normal to the disk surface. Find the time-averaged power of heat dissipation caused by Eddy currents induced in the disk. *Hints: The changing magnetic field induces an electric field in the disk, which puts electrons in motion, which, in its turn, results in heat dissipation. To solve the problem, start from finding an answer for a thin ring of radius r and width dr. The total power is a sum of the powers dissipated in all such thin rings comprising the disk.*

(a) [**2 points**] Find induced electric field in the disk as function of radius and time.

(b) [**2 points**] Find current density in the disk as function of radius and time.

(c) [**1 point**] Find current in a ring of radius r and width dr, as a function of time.

(d) [**2 points**] Find the resistance of the ring.

(e) [**1 point**] Find the power dissipated in the ring as a function of time.

(f) [**1 point**] Find the time-averaged power dissipated in the ring.

(g) [**1 point**] Find the time-averaged power dissipated in the disk.

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B3. A non-conducting solid sphere of radius R caries a charge density

$$\rho = \frac{k}{r}$$

in the region $r \leq R$, where k is a positive constant and and r is the distance from the center of the sphere. The sphere is surrounded by a thick, concentric metal shell with an inner radius a and an outer radius b. The shell originally carries no net charge.

(a) [**1 point**] Find the surface charge density at the inner and the outer surface of the conductor.

(b) [**3 points**] Find the electric field $\vec{E}$ in all four regions (i) $r < R$; (ii) $R < r < a$, (iii) $a < r < b$, and (iv) $r > b$.

(c) [**3 points**] Find the potential V at the center of the sphere using infinity ($r = \infty$) as a reference point.

(d) [**3 points**] If the outer surface of the outer shell is now grounded, what would be the potential at the center of the sphere using the same reference point as in 3?