Student ID Number: _____

PRELIMINARY EXAMINATION

Department of Physics
University of Florida
Part B, August 2012, 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.

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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B1. Four identical spherical conductors of radius R are placed with their centers at the vertices of a regular tetrahedron with side length $L > 2R$. Label the conductors 1,2,3,4 Let conductor 1 initially carry charge Q, while conductors 2, 3 and 4 are initially neutral. Conductor 1 is briefly connected and disconnected, in turn, to each of conductors 2, 3 and 4. Find the charges Q_1, Q_2, Q_3, and Q_4 on each of the conductors:

(a) [2 points] Just after the disconnection from conductor 2.

(b) [2 points] Just after the disconnection from conductor 3.

(c) [2 points] Just after the disconnection from conductor 4.

(d) [3 points] Justify your answers to (a), (b), and (c).

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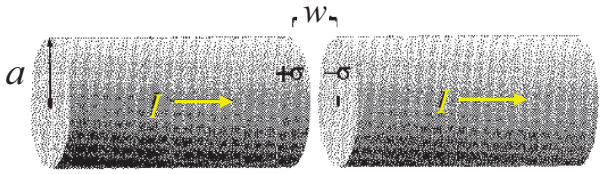
B2. A long conducting wire, radius a, carries a constant current I, uniformly distributed over its cross section. A narrow gap in the wire of width $w \ll a$, forms a parallel plate capacitor. At $t = 0$ there is no charge density on the face of the wire, $\sigma(t = 0) = 0$.



(a) [3 points] Find $\mathbf{E}$ in the gap as functions of the distance s from the axis and of the time t.

(b) [3 points] Find B in the gap as functions of the distance s from the axis and of the time t. If you could not do part (a), express your answer in terms of $\mathbf{E}(s, t)$.

(c) [2 points] Find the electromagnetic energy density u_{em} and the Poynting vector $\mathbf{S}$ in the gap. Be sure to specify both the direction and magnitude of $\mathbf{S}$.

(d) [2 points] Verify the conservation of energy in the gap locally. (Hint: you may need $\nabla \cdot \mathbf{v} = \frac{1}{s}\frac{\partial}{\partial s}(sv_s) + \frac{1}{s}\frac{\partial v_\phi}{\partial \phi} + \frac{\partial v_z}{z}$.)

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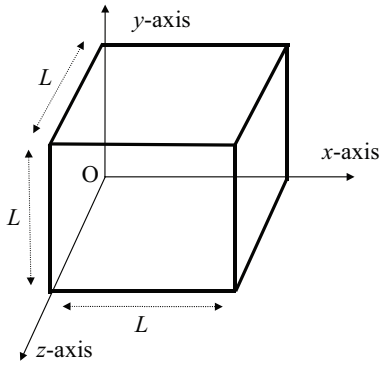
B3. Consider a cube of sides L, as shown in the figure. Suppose that a *non-uniform* electric field is present and is given by $\vec{E}(z) = (a + bz)\hat{z}$, where $\hat{z}$ is a unit vector in the z direction. (Note that $K = 1/(4\pi\epsilon_0) = 8.99 \times 10^9 \mathrm{Nm}^2/\mathrm{C}^2$.)



(a) [2 points] What is the electric flux through the face of the cube that lies in the xy-plane at $z = 0$? (*Express your answer in terms of a, b, and L.*)

(b) [2 points] What is the total electric flux through cube? (*Express your answer in terms of a, b, and L.*)

(c) [3 points] What is the volume charge density $\rho(x, y, z)$ within the cube? (*Express your answer in terms of K, a, b, and L.*)

(d) [3 points] If $L = 2$ m, $a = 1$ N/C, and $b = 0.5$ N/(C·m), what is the total net charge within the cube (in picoC)? Calculate the net charge both from the electric flux and from the volume charge density and show that you get the same answer.