University of Washington **Autumn Quarter 2017**
Physics 513 **December 13, 2017**
Graduate Electrodynamics I

Final Exam

Printed Name _____
last *first*

- If you need more space than is available to answer any part of a problem, use the **back side of the same page** to complete your answer. Scratch paper will not be graded.
- Show your work in enough detail so that the grader can follow your reasoning and your method of solution.
- Feel free to ask for an equation. I have a copy of Jackson and can look up an equation for you.

POINTS

1. _____/25

2. _____/25

3. _____/25

4. _____/25

Total _____/100

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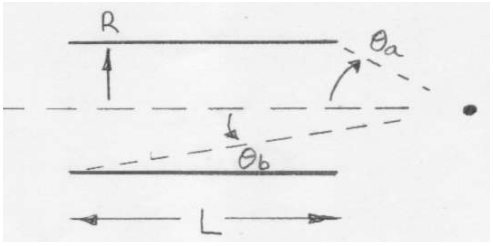
I. (25 points) Magnetic field calculation.

a. Circular loop. Consider a circular loop of radius *R* carrying current *I*. Find the magnetic field **B** everywhere on the loop axis.

b. Solenoid. Consider a cylinder of length *L* and radius *R* carrying solenoidal surface currents **K**. Find the magnetic field **B** everywhere on the solenoid axis. Express your answer in terms of θ_a and θ_b (the angles to the edges of the solenoid face as "seen" by the field point) shown below.



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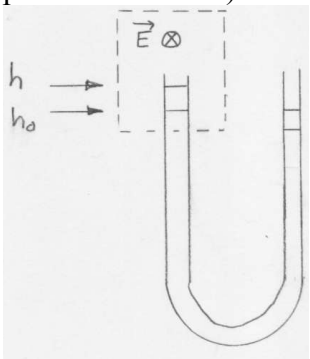
II. (25 points) Forces on dielectrics. Consider a "U-tube" containing a liquid linear dielectric of permittivity ε and mass density ρ. One arm of the tube is between plates of a capacitor. (You can assume the capacitor is ideal, so the electric field $\mathbf{E_0}$ between the plates is uniform.) See the sketch below.



a. With the cross-section of the U-tube circular, find the height the liquid rises h-h_0 when the electric field is applied. Hint: recall the electric field within a dielectric cylinder with axis at right angles to a uniform applied field E_0 is $2E_0/(1+\varepsilon/\varepsilon_0)$.

b. How would your result change if the U-tube cross section is a rectangle with a very long edge parallel to the applied field, and a very short edge normal to the electric field?

c. How would your result change if the U-tube cross section is a rectangle with a very short edge parallel to the applied field, and a very long edge normal to the electric field?

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III. (25 points) Mutual Inductance. Consider two coaxial thin circular wires of radii a and b with their centers a distance d apart and $d >> a$ and b. Find the mutual inductance.

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IV. (25 points) Image currents, magnetic materials, inductance.

a. A long thin wire carrying current *I* lies a distance *d* in vacuum from the surface of a semi-infinite slab of linear permeable material (with permeability μ, and as usual $\mu > \mu_0$). Find the force per unit length on the wire. Hint: Choose a sensible location of the image currents.

b. The wire is replaced with a circular loop of thin wire placed on the surface of the semi-infinite slab. What is the ratio of the loop's self-inductance when on the slab surface to the loop's self-inductance when in free space? Hint: (i) You may want to consider part a to infer the location of the image current. (ii) You may want to consider the location of sources of B field to infer the "shape" of the B field.

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