##### DO NOT BEGIN THIS EXAM UNTIL TOLD TO START

# Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

#### ECE 2317

#### Applied Electricity and Magnetism

**Final Exam**

#### Dec. 12, 2013

1. This exam is closed-book and closed-notes notes. A formula sheet is provided.
2. Show all of your work. No credit will be given if the work required to obtain the solutions is not shown.
3. Perform all your work on the exam in the space allowed.
4. Write neatly. You will not be given credit for work that is not **easily** legible.
5. Leave answers in terms of the parameters given in the problem.
6. Show units in all of your final answers.
7. Circle your final answers.
8. Double-check your answers. For simpler problems, partial credit may not be given.
9. If you have any questions, ask the instructor. You will not be given credit for work that is based on a wrong assumption.
10. Make sure you sign the academic honesty statement on the next page.

Academic Honesty Statement

I agree to abide by the UH Academic Honesty Policy during this exam. I understand that the punishment for violating this policy will be most severe, including the possibility of getting an F in the class and/or getting expelled from the University.

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Signature

FORMULA SHEET

































































































































**Electrostatic TriangleTABLE OF INTEGRALS**



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TABLE OF COORDINATE SYSTEM FORMULAS

 

 

 































Problem 1 (30 pts.)

A high-voltage power line has a radius *a*. The center of the line is at a height of *h* above the earth, which may be modeled as an infinite ground plane. Assume that the voltage on the line is *V*0, and that the earth is taken as zero Volts. The radius of the wire is much smaller than the height of the wire above the earth, so that any charge density on the wire may be assumed to be uniform. The earth may be modeled as a perfect conductor at the power-line frequency.

1. Find an expression for the electric field vector *E* at a point on the surface of the earth that is located at *y* = 0 and *x* = *x*0. (Note: Since the earth is modeled as a perfect conductor, there should be no horizontal component of the electric field at the surface.)
2. Find an expression for the electric field vector *E* at the point *x* = 0, *y* = *h*-*a*. This is a point that is on the surface of the wire, located at the bottom of the wire.
3. Find a formula for the maximum voltage *Vmax* that can be placed on the wire (with respect to ground) before the air breaks down on the wire. You may assume that the air will first breakdown at the bottom of the wire, and the critical breakdown strength of the air is *E*c.

Earth

*h*

*x*

*y*

*V*0

**Room for Work**

**Part (a)**

From the formula sheet we have

.

The electric field at the surface is vertical, and is twice that of the original charge.

Hence



Hence we have



therefore, we have



**Room for Work**

**Part (b)**

.

**Part (c)**



Hence we have

.

Problem 2 (20 pts.)

A coaxial cable is shown below. The radius of the inner conductor is *a* and the radius of the outer conductor is *b*. Inside the cable (between the inner and outer conductors) is a material that has a relative permittivity *εr* and a conductivity *σ*.

a) Find the capacitance between the inner and outer conductors, assuming a length *h* of cable.

b) Find the resistance *R* between the inner and outer conductors, assuming a length *h* of cable.

*h*

*b*

*a*

*z*

**Room for Work**

The capacitance is

,

where

.

Using the RC analogy, we have

c.

Hence we have

.

**Room for Work**

Problem 3 (30 pts.)

An infinite tube of copper has an inner radius of *a* and an outer radius of *b*. The tube carries a current of *I* Amps in the *z* direction. The current density is uniformly distributed within the cross section of the tube, since it is a DC current.

a) Calculate the magnetic field in all three regions:

*ρ* < *a*

*a < ρ* < *b*

*ρ*  > *b*

b) Calculate the stored magnetic energy contained within a length *h* of the tube in the *z* direction.

c) Assuming that the copper has a conductivity *σ*, calculate the power being dissipated inside the tube as heat, assuming a length *h* of the tube in the *z* direction.

*z*

*a*

*b*

**Room for Work**

**Part (a)**

*ρ* < *a*

.

*a < ρ* < *b*

,

where

.

Hence

.

*ρ*  > *b*

.

**Part (b)**

.

Hence

.

**Room for Work**

We then have



Hence



We then have



**Part (c)**



Hence



We can write this as

,

where

Problem 4 (20 pts.)

Calculate the magnetic field at the origin for the system shown below, consisting of a loop of current *I* that consist of two circular arcs and two straight pieces of wire.

*a*

*b*

*x*

*y*

*I*

**Room for Work**

The Biot-Savart law is

.

The straight pieces do not contribute to the magnetic field at the origin because *dl* and the unit vector are parallel to each other.

For the inner loop we have



Similarly, for the outer loop we have



**Room for Work**

The total magnetic field at the origin is then

.