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

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

#### ECE 2317

#### Applied Electricity and Magnetism

**Final Exam**

#### May 2, 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 (40 pts.)

A perfectly conducting sphere of radius *a* has a dielectric coating of radius *b*. The dielectric has a relative permittivity of *εr*. Assume that the air outside the dielectric has a dielectric breakdown field strength of *Ec*, and that the air will breakdown before the dielectric does.

a) Find the maximum charge *Qmax* that can be put on the sphere before the air breaks down. Your answer should be in terms of the parameters given.

b) Find the maximum voltage *V*0*max* that is on the sphere (assuming that we have zero volts at infinity) when the air starts to breaks down. Your answer should be in terms of *Qmax* and the parameters that are given.

*b*

*a*

*εr*

Room for Work

We have

.

Hence

.

We then have

.

This gives us

.

Problem 2 (40 pts.)

A spherical shell of uniform surface charge density has a radius of *a* and a total charge of *Q*1 [C]. Surrounding this sphere is another larger spherical shell of uniform surface charge density, having a radius of *b* and a total charge of *Q*2 [C]. The charges are in free space. Assume that the potential at infinity is zero.

a) Find the potential function Φ in all three regions:



Do this by finding the electric field first, and then integrating.

b) Find the stored energy in the system, using your answer to part (a) for the potential function.

*a*

*b*

*Q*1

*Q*2

Room for Work

The electric field is







The potential function is

.

Hence we have







Hence we have







The stored energy is given by

.

Hence we have

.

We thus have



where



.

Problem 3 (40 pts.)

A square ring of uniform line charge density lies in the *z* = 0 plane, centered at the origin, as shown below.

a) Find the potential on the positive *z* axis, assuming that the potential at the origin is zero volts. Use symmetry as much as possible to avoid unnecessary work.

b) Find the electric field on the positive *z* axis, using your answer to part (a).

2*a*

*x*

*y*

*z*

*r*

*ρl*0

2*a*

Room for Work

If the potential is zero at infinity, then we have, from symmetry,

.

Next, we use

**.**

Hence, we have

.

This gives us

.

For a potential of zero at the origin, we have

.

For the electric field we have

.

The electric field on the *z* axis is in the *z* direction, so we have

.

This gives us



Problem 4 (50 pts.)

An infinite wire of radius *a* has a relative permeability of *μr*. The current density inside the wire is *z*-directed and uniform, and the total current flowing in the *z* direction inside the wire is *I* [A].

a) Find the magnetic field vector *H* inside the wire.

b) Find the stored magnetic energy per unit length in the *z* direction, from the magnetic field that is inside the wire.

c) Find the “internal inductance” per unit length, which is defined as the inductance per unit length (in the *z* direction) due to the magnetic energy stored inside the wire.

*x*

*y*

*z*

*μr*

*a*

Room for Work

From Ampere’s law we have

.

Hence we have

.

The stored magnetic energy is

.

Hence

.

We then have



or

.

Evaluating the integral, we have

.

Simplifying, we have

.

The internal inductance is given by

.

Hence, we have

.

Problem 5 (40 pts.)

An infinite wire carries a current of *I* [A], and lies in the *z* = 0 plane. The wire has two (infinite) straight sections and a circular section of radius *a*, as shown below.

Find the magnetic field vector *H* at the origin.

*x*

*a*

*I*

*I*

*I*

*y*

Room for Work

The two semi-infinite wires do not contribute to the magnetic field at the origin, since the wire direction is parallel to the vector that points from the source point to the observation point.

For the circular loop part, we have

.

This gives us

.

Hence we have

.

The final answer is then

.