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

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

#### ECE 2317

#### Applied Electricity and Magnetism

**Exam 1**

#### March 19, 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















































**TABLE OF INTEGRALS**

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TABLE OF COORDINATE SYSTEM FORMULAS

 

 

 































Problem 1 (30 pts.)

A spherical conductor of radius *a* is inside an outer conducting spherical shell of radius *b*. The region between the two conducting spheres, *a* < *r* < *b*, is filled with a conducting fluid having a conductivity *σ*. Assume that *I* Amps comes out of the inner sphere when the system is connected to a battery, as shown below. Assume that the current spreads equally in all directions from the inner sphere.

a) Find the voltage drop *V*AB, where *A* is a point on the surface of the inner sphere, and *B* is a point on the surface of the outer sphere.

b) What is the resistance seen by the battery?

*a*

*b*

*σ*

*V*

*I*

ROOM FOR WORK

The electric field vector is

.

The voltage drop is then

.

Hence,



The resistance is then

.

Hence, we have

.

Problem 2 (30 pts.)

A circular disk with radius *a* lies in the *z* = 0 plane, centered at the origin, as shown below. The disk has a surface charge density

.

(Practical note: This is the shape of the charge density that would be on a circular metal disk if it were charged with a net charge *Q*. Note that the surface charge density goes to infinity at the edge of the disk!)

 Find the electric field vector at a point on the *x* axis that is at a distance *d* from the origin, where *d* > *a*. You may leave your answer in the form of integrals (you do not need to evaluate any integrals), but you should set up the problem completely and carefully, and indicate what direction the electric field will be in. Your answer should have only cylindrical coordinate variables appearing in the final integrand.

*a*

*x*

*y*

*z*

*r*

*d*

*ρs*

ROOM FOR WORK

We start with the general formula

.

This gives us

.

We have

.

We then have

.

By symmetry, we know that the electric field should be in the *x* direction for an observation point that is on the *x* axis. Hence we have

.

Converting the integrand to cylindrical coordinates, we have

.

Problem 3 (40 pts.)

A point charge *q* is located at the center of a spherical perfectly conducting spherical shell that has an inner radius of *a* and an outer radius of *b*. In the region *r* < *a* there is a uniform volume charge density *ρv*0. The conducting shell is neutral.

a) Find the electric field vector in all three regions: *r* < *a*, *a* < *r* < *b*, and *r* > *b*.

b) Find the surface charge density on the outer surface of the shell at *r* = *b*.

c) Find the voltage drop *V*AB, where *A* is a point on the outer surface of the conducting shell, and *B* is a point at infinity.

d) Indicate how the answers to the above parts (a), (b), and (c) change if the conducting shell is now grounded.

*b*

*a*

*ρv*0

*q*

PEC

ROOM FOR WORK

We use Gauss’s law in spherical coordinates, so that

**Part (a)**

.

*r* < *a*:



*r* > *b*:

.

In the region *a* < *r* < *b* there is no electric field (PEC).

**Part (b)**

Because it is a neutral shell, we have

.

From Gauss’s law (with a Gaussian surface inside the shell), we also have

.

Hence, we have

.

The surface charge density on the outer surface is then

.

The final result is then

.

**Part (c)**

.

The final result is then

.

**Part (d)**

After grounding:

* The electric field inside the inner region (*r* < *a*) does not change.
* The electric field inside the shell remains zero (PEC).
* The electric field in the outer region (*r* > *b*) is now zero.
* The surface charge density *ρsb* on the outer surface is now zero.
* The voltage drop *VAB* is now zero.