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

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

#### ECE 2317

#### Applied Electricity and Magnetism

**Exam 2**

#### April 25, 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.)

An infinite perfectly conducting cone is located above a perfectly conducting infinite ground plane as shown below. The ground plane is at zero volts, while the cone is at a potential of *V*0 volts. The angle of the cone is *θ*0. There is an insulating gap between the cone and the ground plane (which you can ignore) that keeps the cone from shorting to the ground plane.

1) Assume that the potential Φ between the cone and the ground plane is a function of *θ* only. Solve for the potential function Φ.

2) Find the surface charge density on the surface of the cone.

Helpful integral identity:

****.

*z*

*θ*0

ROOM FOR WORK

Solution

**Part 1**

The Laplace equation is

.

Because the potential is only a function of the angle *θ*, this reduces to

.

We thus have

.

Integrating, we have



so

.

Integrating, we have

.

Setting *θ = π* /2 gives us

.

Hence,

.

Setting *θ =θ*0 gives us



so

.

Hence the potential function is

.

**Part 2**

The surface charge density is

.

Using



we have

.

Hence we have

.

This gives us

.

Hence, we have

.

Problem 2 (25 pts.)

A wire of radius *a* is surrounded by an insulating dielectric coating that has a radius of *b*. A cross section is shown below. The coating has a relative permittivity of *εr* and a dielectric breakdown field strength of *Ecdiel*. Outside the dielectric coating is air, which has a relative permittivity of one and a dielectric breakdown field strength of *Ecair*, where *Ecair* < *Ecdiel*.

Assume that the wire has a uniform surface charge density on it. Derive a formula for the coating radius *b* in terms of the other given parameters, so that the dielectric breaks down at the same time as the air, as the charge density on the wire increases.

*a*

*b*

*εr*

ROOM FOR WORK

Solution

When the dielectric breaks down, it will break down at *ρ* = *a*. When the air breaks down, it will break down at *ρ* = *b.*

The breakdown in the dielectric will occur when

.

The breakdown in the air will occur when

.

Note that we are using the same value of line charge density, since breakdown will occur at the same time. Solving for the line charge densities and equating them, we have

.

This give us

.

Problem 3 (35 pts.)

A perfectly conducting sphere of radius *a* is centered at a height *h* above an infinite perfectly conducting ground plane as shown below.

1) Assume that the sphere has a total charge *Q* that is uniformly distributed on the surface of the sphere. Find the electric field vector on a line that is directly below the sphere, between the sphere and the ground plane. That is, find the electric field vector for a point on the *z* axis where 0 < *z* < *h*-*a*.

2) Find the voltage drop *VAB* between the sphere and the ground plane, where point *A* is located at the bottom of the sphere, at (0, 0, *h*-*a*), and point *B* is located on the ground plane directly below the sphere, at (0, 0, 0).

3) Find the capacitance between the sphere and the ground plane.

*z*

*a*

*h*

*x*

ROOM FOR WORK

Solution

**Part 1**

Using image theory, we have

.

**Part 2**

The voltage drop is given by

.

This gives us

.

Performing the integration, we have

.

The result is then



or

.

**Part 3**

The capacitance is given by

.

This gives us

.