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

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

#### ECE 2317

#### Applied Electricity and Magnetism

**Exam 2**

#### Dec. 6, 2012

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 (25 pts.)

Consider the electric fields given below. Some of them correspond to a valid electrostatic field in a vacuum region with no charge density, while the others do not. Determine which of them is a valid electrostatic field in a vacuum region with no charge density. In order to receive credit, you must justify your answer.

a) 

b) 

c) 

d) 

e) 

f) 

g) 

h) 

i) 

Room for Work

**Solution**

To be a valid electrostatic field in a charge-free region, the field should have both zero curl and zero divergence.

The fields that have zero curl: (a, c, f, g).

The fields that have zero divergence: (b, c, e, f, g).

Hence, the valid fields are: (c, f, g).

Problem 2 (25 pts.)

A circular ring of uniform line charge density *ρl*0 [C/m] with radius *a* lies in the *z* = 0 plane as shown below. The potential at the center of the ring (the origin) is zero volts.

(a) Calculate the potential on the positive *x* axis, at a point (*x*, 0, 0). You may leave your answer in the form of an integral.

(b) Calculate the electric field vector on the *x* axis at the point (*x*, 0, 0), starting from your solution to part (a). You may leave your answer in the form of an integral.

*x*

*y*

*z*

*a*

*r*

*ρ l*0

Room for Work

**Solution**

Using superposition (Coulomb’s law), we have

.

Hence, we have

.

This can also be written as

.

Setting *x* = 0, the constant *C* is given by

.

Hence, we have



or

.

Problem 3 (25 pts.)

A wedge-shaped capacitor is shown below. Assume that we can ignore fringing at the inner edge (*ρ* = *a*) as well as at the outer edge (*ρ* = *b*) of the capacitor. (The electric field will thus be purely in the *φ* direction.) Between the plates is a material with a relative permittivity *εr*.

Calculate the capacitance between the two plates, assuming a one meter length in the *z* direction.

*x*

*y*



*b*

*a*



Room for Work

**Solution**

The potential is found from Laplace’s equation, and is



The electric field is



The charge density on the top plate is



The total charge of the top plate is



The capacitance is then



Problem 4 (25 pts.)

A 60 Hz power line is over the earth at a height *h* above the earth as shown below (the height is measured from the center of the wire). The radius of the wire is *a*. The voltages of the wire with respect to the earth is



where *ω* = 2*π f* and *f* = 60 [Hz].

Assume that the frequency is low enough so that electrostatics may be used. This means that at any instance of time, the voltage on the wire may be assumed to be constant for the purposes of calculating the field from the wire. Assume that at this low frequency the earth can be modeled as a perfect electric conductor, which is at zero volts. Assume that the effects of the tower and supporting structure can be neglected.

Calculate the electric field vector as a function of time at a point that is on the surface of the earth (*z* = 0) at *x* = *x*0.

Power line

*z*

Earth

*x*

Room for Work

**Solution**

The potential line charge is given by

.

Using image theory, the electric field is



where



and



.

This gives us



or

.