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

#### ECE 3318

#### Applied Electricity and Magnetism

**Final Exam**

#### May 10, 2016

**11:00 a.m. – 2:00 p.m.**

**SEC 204**

1. This exam is open-book and open-notes. A calculator is allowed (as long as it cannot be used to communicate), but no other device (laptop, phone, tablet, etc.) is allowed.
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

Problem 1 (20 pts.)

Please give a short answer to the questions below.

a) Explain what the RC analogy is and how it is useful to us.

This analogy allows us to find the resistance between two objects in a conducting problem if we know the capacitance between the corresponding objects in a dielectric problem.

b) What is the name of the differential equation that the potential function obeys in free space?

Laplace’s equation

c) Explain in words what the normal and tangential components of the magnetic field and magnetic flux density must do at a boundary between two different materials.

The tangential parts of the magmatic field must be continuous as long as there is no surface current. The normal components of the magnetic flux density must always be continuous.

d) When you use the formula that gives you potential from integrating over the charge density, what is the basic assumption about the potential at infinity?

The potential is zero at infinity.

**Room for Work**

Problem 2 (20 pts.)

There are two wires that run parallel to each other in the *z* direction, of different size. An engineer immerses them into a large tank of saltwater. (The tank is so large that it can be assumed to be infinite.) The conductivity of the saltwater is 0.1 [S/m]. Each wire is of length 20 [cm] in the *z* direction. The engineer measures a total resistance between the two wires as 4.427 [Ω].

Find the capacitance per unit length *Cl* [F/m] between the two wires when they are in free space.

**Room for Work**

Answer



Problem 3 (20 pts.)

A three-phase power line consists of three infinite parallel lines running in the *z* direction, each of radius *a*. The (*x*,*y*) coordinates of the center of each line and the voltage on that line are as follows:







The lines are above the earth, which may be modeled as a perfect conductor.

Find a formula for the potential Φ(*x*,*y*) at a point that is above the surface of the earth.

**Room for Work**

Answer



where







and

 

 

 

with



Problem 4 (20 pts.)

An infinite power line carries a uniform current in the *z* direction that is given by

 .

The power line is at a height *h* above the earth, which can be modeled as a perfect conductor at the low frequency of the power line. The solution to this problem consist of the original current together with an image current flowing in the opposite direction, at *y* = -*h*. That is, image theory works for currents as well as for charges.

Determine the magnetic field component *Hx* at any point (*x*,0) along the surface of the earth.

(Note that because the earth is being modeled as a perfect conductor, there should only an *x* component of the magnetic field on the surface of the earth in this problem.)

**Room for Work**

Answer



where

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Hence, we have

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Problem 5 (20 pts.)

A loop of radius *a* lies in the *z* = 0 plane and is centered at the origin. The loop carries a current *I* that flows counterclockwise as seen from above.

Derive a formula for the magnetic field at a point on the *x* axis at *x* = *x*0, for *x*0 > *a*.

You do not have to evaluate in closed form the integral that appears in your result, but you must set up the integral correctly, carrying out all necessary cross products of unit vectors. Your result should clearly show which direction the magnetic field is in at the observation point.

**Room for Work**

Answer



where

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Hence, we have



or



or



or

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Problem 6 (20 pts.)

A large loop carrying a current *I*1 is located near a smaller loop that is situated as shown below. Both loops lie in the *z* = 0 plane. The left end of the smaller loop is at *x* = *d*, while the right end of the smaller loop is at *x* = *d* + *L*. The smaller loop carries a current *I*2 as shown.

The large loop is so large that you can think of the magnetic field from it as coming from an infinite wire on the *y* axis.

Find the mutual inductance *M*21 between the large loop and the smaller loop.

**Room for Work**

Answer



where

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Hence, we have

.

Therefore,

.

This gives us

.