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

#### ECE 3318

#### Applied Electricity and Magnetism

**Exam 2**

#### April 26, 2018

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

**TABLE OF INTEGRALS**

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Problem 1 (25 pts.)

A circular loop of uniform line charge density *ρ*l0 with radius *a* lies in the *z* = 0 plane as shown below. Find the potential Φ(*x*) on the *x* axis assuming that the potential is Φ0 at the origin.

You may leave your answer in the form of an integral, as long as all terms in the integrand are clearly defined in terms of the parameters given.

**Room for Work**

The potential, with zero volts at infinity, is given by

.

We have

.

This gives us

.

Accounting for the potential at the origin, we have

.

We then have



so



or



or

.

Problem 2 (25 pts.)

A power line of radius *a* is located at a height *h* above the earth, as shown below. The earth may be modeled as a perfect conductor at the power line frequency, and the earth is taken to be at zero volts. The voltage of the power line is given as

.

Find the electric field vector for an observation point (*x*,*y*) that is at *x* = 0 and *y* > *h*+*a* (i.e., the observation point is directly above the power line).

You may use any equations that are already in the class notes to help you.

**Room for Work**

From the class notes, we have (for a static field)

.

We then have, from the image picture,

.

Hence, we have

.

Therefore, we have



Or

.

Accounting for the time variation, we have

.

Problem 3 (25 pts.)

A wire of radius *a* is surrounded by a cylindrical dielectric shell of inner radius *a* and outer radius *b*. The dielectric has a relative permittivity of *εr*. We have the following parameters:



a) Find the charge per unit length *ρ*l0 on the wire that will cause the dielectric material to start breaking down.

b) Find the charge per unit length *ρ*l0 on the wire that will cause the air region outside the dielectric to start breaking down.

c) If one increases the charge density *ρ*l0 on the wire, which region (air or dielectric) will break down first?

**Room for Work**

**Part (a)**

We set

.

This gives

.

Hence, using , we have

.

**Part (b)**

We set

.

This gives

.

Hence, using , we have

.

**Part (c)**

Since the result from part (b) is smaller than the result from part (a), the air will breakdown first.

Problem 4 (25 pts.)

An engineer is using a voltmeter to read the voltage *Vd* across a device as shown below. The leads between the voltmeter and the device run parallel to each other through a distance *L* to reach the device. The leads are separated by a distance *h*. The voltmeter reads a voltage of *Vm*.

Assume that there is a magnetic field inside the room given by

.

a) Determine a formula for what the error (in volts) will be for the voltmeter reading. The error voltage is defined as

.

b) Determine the error voltage *Verr* (*t*) (in volts) assuming the following parameters:



**Room for Work**

**Part (a)**

From Faraday’s law we have

.

The flux through the loop path in the *z* direction is given by

.

Hence we have

.

**Part (b)**

Inserting the values given, we have

.

**Room for Work**