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

#### ECE 3318

#### Applied Electricity and Magnetism

**Exam 1**

#### March 21, 2019

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 (30 pts.)

An electrostatic field is given in cylindrical coordinates by

.

Find the voltage drop *VAB* between the points *A* = (2, 0, 0) [m] and *B* = (0, 3, 1) [m], where the points are specified in rectangular coordinates.

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**Solution**

Since this an electrostatic field we can choose any path that we wish. A convenient path is one that stays on a circle from point *A* to the point (0,2,0). Then the path goes from this point to the point (0,3,0), staying along the *y* axis. Finally, the path goes vertically from this point to the point (0,3,1). The voltage drop is

.

This is split into three parts as

.

Hence, we have

.

This gives us

.

Problem 2 (30 pts.)

A surface charge density  lies inside of an annular region defined by  that lies in the *xy* plane as shown below. The surface charge density is given by

.

Find the electric field vector at the point .



**Solution**

Using Coulomb’s law, we have

.

We have

 



.

Hence, we have



or



or

.

When we integrate in  the term with  integrates to zero. For the  term , we get a factor of *π*. Hence, we have

.

We now use

****.

This give us

.

Hence, we have

.

Problem 3 (40 pts.)

An infinite tube of volume charge density  having a radius *a* is surrounded by an infinite metal pipe as shown below. For  the charge density is given by

.

The metal pipe has an inner radius *b* and an outer radius *c*. The metal pipe is neutral.

a) Find the electric field vector in all three regions ( , , , ).

b) Find the surface charge densities  and  on the pipe surfaces at  and .

c) Now assume that the metal pipe is grounded. Give the new electric field vector in all four regions ( , , , ). If the electric field vector has not changed in a given region, you can simply say this.

d) After grounding, find the new surface change densities  and  on the pipe surfaces at  and .

e) Find the value of an effective line charge density  that will model the tube of volume charge density.

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**Solution**

**Part (a)**

Using Gauss’s law, we have

.

We also have

a) 

.

b) 

.

c) We are inside the PEC pipe, so we have

.

d) Since the pipe is neutral, we have the same formula for the electric field as we do in part (b). Hence, we have

.

**Part (b)**

Using Gauss’s law, with a Gaussian surface inside the metal pipe, we have



so

.

Since the pipe is neutral, we also have



so

.

**Part (c)**

The electric field is the same in all regions except (outside the pipe). In this region the electric field is now zero after grounding.

**Part (d)**

The surface charge density on the inner surface of the pipe does not change. On the outside surface of the pipe it is zero after grounding.

Hence,



.

**Part (e)**

The effective line charge density is given by



so

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