# Name: SOLUTION

#### ECE 3318

#### Applied Electricity and Magnetism

**Exam 1**

#### March 23, 2017

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 (15 pts.)

An infinite slab of volume charge density, having thickness *d*, is described by

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The slab is infinite in the *x* and *y* directions.

Calculate the value of an effective surface charge density *ρseff* that models the slab. This means that when an infinite sheet of uniform surface charge density *ρseff* is placed at *z* = 0, it will produce the same electric field outside the slab as the original slab does.

You do not need to calculate any electric fields.



**Room for Work**

Solution

The effective surface charge density is given by

.

This gives us

.

Problem 2 (35 pts.)

A charge distribution consists of four segments of uniform line charge density *ρl*0 [C/m]. Each segment has a length of *L* and runs along either the ± *x* axis or the ± *y* axis, starting from the origin, as shown below.

Find the electric field vector at a point on the positive *z* axis, located at (0,0,*h*).

Note: You can feel free to use symmetry as much as possible.



**Room for Work**

Solution

By symmetry, the electric field at the observation point in purely in the *z* direction. The *z* component is four times that from a single segment. Hence, we can write

 ,

where *Ez*1 is the *z* component of the electric field produced by one of the segments, say the one on the *x* axis.

Using

,

we have

.

We then have



so that

.

Performing the integration, we have

.

Hence, we have

.

**Room for Work**

Problem 3 (50 pts.)

An infinite (infinite in the *z* direction) cylindrical region of volume charge density exists in the region *ρ* < *a*. The charge density is described by

.

Surrounding this charge density is a perfectly conducting cylindrical metal shell of inner radius *b* and outer radius *c*.

a) Assume that the metal shell is neutral, and calculate the electric field vector in all four regions (*ρ* < *a*, *a* < *ρ* < *b*, *b* < *ρ* < *c*, *ρ* > *c*).

b) Now assume that the metal shield is grounded. Give the new electric field vector in all four regions (*ρ* < *a*, *a* < *ρ* < *b*, *b* < *ρ* < *c*, *ρ* > *c*).

c) Find the voltage drop *VAB* between a point *A* on the *z* axis and a point *B* on the outside of the metal shell.



**Room for Work**

Solution

**Part a**

For *ρ* < *a*:

From Gauss’s law we have

.

Hence

.

For *a* < *ρ* < *b*:

From Gauss’s law we have

.

Hence

.

For *b* < *ρ* < *c*:

There is no electric field inside the PEC, so we have

.

For *ρ* > *c*:

Because the shell is neutral, is does not affect the electric field in this region. Hence we have

.

**Part b**

When the shell is grounded, the electric field goes to zero in the outer region. The electric field remains the same is all of the other regions. Hence, we have in the four respective regions the following results:







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**Part c**

We have

.

Hence, we have

.

This gives us

.