#### ECE 3318

#### Applied Electricity and Magnetism

**Exam 1**

#### March 20, 2025

**Name: SOLUTION**

**Instructions**

1. This exam is open-book and open-notes.
2. Cell phones, laptops, ipads, and any other devices that have communication functionality are not allowed during the exam.
3. Show all of your work. No credit will be given if the work required to obtain the solutions is not shown.
4. Write neatly. You will not be given credit for work that is not easilylegible.
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. Remember the UH Academic Honesty Policy. You must not receive or give assistance to anyone else during the exam, or communicate with anyone other than the instructor during the exam.

**TABLE OF INTEGRALS**

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**Problem 1 (30 pts.)**

A circular metal (PEC) pipe is infinite in the *z* direction. The metal pipe has an inner radius of *b* and an outer radius of *c*. (The outer radius *c* is not labelled in the figure below.) Inside the pipe is a cylindrical region of nonuniform volume charge density, having a radius of *a*. The nonuniform charge density is given by

.

The metal pipe is neutral.

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

(b) Find the surface charge density  on the outer surface of the pipe at .

(c) Find the charge in [C/m] that flows from the pipe to the ground after the pipe is grounded.

Note: Although the system is infinite in the *z* direction, you can choose to work with a length *L* =1 meter in the *z* direction if you wish.



**SOLUTION**

**Part (a)**

Using Gauss’s law with a cylindrical Gaussian surface of (arbitrary) height *h*, we have

.

We have:

.





Inside the pipe, there is no electric field.

Hence, we have









**Part (b)**

On the outer surface of the pipe, we have (taking a length *h* the z direction):

.

Hence, we have

.

**Part (c)**

The charge in a length *h* that flows from the outer surface of the pipe to ground is

.

Hence, the charge per unit length that flows to ground is

.

Hence, we have

.

**Problem 2 (40 pts.)**

A uniform surface charge density  [C/m2] exists on the *z* = 0 plane, in the region *x* < 0, as shown below. (A top view is shown below.) Find the electric field vector *E* at the observation point , where . (Note: The observation point is above the *z* = 0 plane, but you do not see this in the top view).

You may leave your answer in terms of integrals (i.e., you do not need to evaluate any integrals that appear in your result). However, your answer must clearly show what the components of the *E* vector are, with a formula for each one.



**SOLUTION**

**Part (a)**

Using the 2-D form of Coulomb’s law, we have

.

We have



In our problem we then have



or

.

We then also have

, .

We then have

.

The *y* component integrates to zero by symmetry. The answer is then



**Problem 3 (30 pts.)**

An infinite slab of volume charge density consists of two regions (a top region and a bottom region), as shown below. The volume charge density is described by



(a) Find the electric field vector *E* in the region .

(b) Find the electric field vector *E* in the region .

(c) Find the voltage drop , where *A* is a point at *x* = *h* and *B* is a point below it at *x* = -*h*.



**SOLUTION**

**Part (a)**

We use Gauss’s law with the top surface of the Gaussian surface outside the charge, since the electric field is zero there (since the charge density is an odd function of *x*). We choose the top of the Gaussian surface to be above the charge, and the bottom of the Gaussian surface to be at the point *x* (where the observation point is).

We have

.

Therefore,

.

We then have

.

**Part (b)**

By symmetry we have that the electric field is symmetrical (an even function of *x*). But the function *x* by itself changes sign as *x* goes from positive to negative. Therefore, we must include a negative sign in the answer. Hence, we have

.

**Part (c)**

We have

.

This gives us

.

We can write this as

.

Performing the integrations, we have

.

Simplifying, we have

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