#### ECE 3318

#### Applied Electricity and Magnetism

**Exam 1**

#### March 25, 2021

**Please read carefully the Zoom instructions on the first page and the general instructions on the second page.**

**Zoom Instructions**

* You are not allowed to use your computer, or any other device, to communicate with anyone other than the instructor during the exam.
* If you wish to ask a question during the exam, please use the “chat” feature of Zoom to chat with the instructor (please chat only with the instructor, not with “everyone”).
* Please leave your camera on during the entire exam.
* Please leave yourself muted unless the instructor asks you to unmute yourself.
* By taking this exam, you agree to the UH Academic Honesty Policy. You understand that the penalty for violating the UH Academic Honesty Policy will be most severe, including getting an F in the course and/or getting expelled from the university.
* The exam has three parts (three problems). Make sure that you upload your solution (as a pdf file) to each problem during the allowed time window. Late submissions may not be accepted, or will be assigned a penalty.

**General Instructions**

1. This exam is open-book and open-notes.
2. Show all of your work. No credit will be given if the work required to obtain the solutions is not shown.
3. Write neatly. You will not be given credit for work that is not **easily** legible.
4. Leave answers in terms of the parameters given in the problem.
5. Show units in all of your final answers.
6. Circle your final answers.
7. Double-check your answers. For simpler problems, partial credit may not be given.
8. If you have any questions, ask the instructor. You will not be given credit for work that is based on a wrong assumption.

**TABLE OF INTEGRALS**

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Problem 1 (30 pts.)

An electric field is given in cylindrical coordinates as

.

You may assume that this is a valid electrostatic field.

Find the voltage drop  between the points *A* and *B* shown below (the coordinates of the points are given in rectangular coordinates).

**Solution**

A suggested path is shown below, consisting of a circular arc and a straight-line path.

We have

.

We then have



or







.

Problem 2 (35 pts.)

A non-uniform line charge density of length *L* meters lies on the *x* axis as shown below, from *x* = 0 to *x* = *L*. The line charge density is given by

.

Find the electric field vector at the point  as shown below.



**Solution**

We have

.

We also have



so that



.

Hence, we have



or



or

.

Evaluating the integral, we have



or



Problem 3 (35 pts.)

A spherical region of non-uniform volume charge density  with radius *a* is given in spherical coordinates by

.

Surrounding this spherical region of charge density is a perfectly conducting shell of inner radius *b* and outer radius *c*. This shell has a total net charge of .

Surrounding the inner conducting shell is another perfectly conducting spherical shell of inner radius *d* and outer radius *e*. This shell has a total net charge of .

a) Find the total charge *Q* that is contained inside the spherical region of charge density.

b) Find the electric field vector in all six regions (*r* < *a*, *a* < *r* < *b*,  *b* < *r* < *c*, *c* < *r* < *d*, *d* < *r* < *e*, *r* > *e*).

c) Find the surface charge density  on the outer surface of the outer shell, at *r* = *e*.

d) If the outer shell is now grounded, how will the answer to part (c) change?

e) If the inner spherical region of charge density is removed (but the two PEC shells keep their same charge), what will the electric field be in the region *r* < *b*? What principle does this demonstrate?

**Solution**

**Part (a)**

.

Hence,



so



or

.

**Part (b)**









.







PEC:









PEC:







**Part (c)**





so

.

Hence, we have



So that



**Part (d)**

The surface charge density on the outer surface of the outer (grounded) shell will now be zero.

**Part (e)**

The electric field will be zero, due to the Faraday cage effect.