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

#### ECE 3318

#### Applied Electricity and Magnetism

**Exam 1**

#### March 27, 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 (30 pts.)

An electrostatic dipole consists of a charge *q* located on the *z* axis at  and a charge -*q* located on the *z* axis at . In the limit as , the electric field is given in spherical coordinates by

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Find the voltage drop *VAB* between the points *A* = (0, 0, 2) [m] and *B* = (3, 0, 0) [m], where the points are specified in rectangular coordinates. Do this by integrating the electric field from point *A* to point *B*. Note that this is an electrostatic field.

Assume that  to simplify the calculation.

**Room for Work**

**Solution**

Since this is an electrostatic field, we can use any path that we want. Since the electric field is given in spherical coordinates, a good choice of path would be one that lies along an arc of a circle in the *xz* plane from point *A* to the point *P* = (2,0,0), and then from point *P* to point *B*. We then have



Hence, we have

.

Problem 2 (35 pts.)

A uniform surface charge density  lies inside of a region defined by  and  as shown below.

Find the electric field component  at the origin.



**Room for Work**

**Solution**

From Coulomb’s law, we have

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We have that



 

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Hence, we have



Therefore, we have



The answer is then

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Problem 3 (35 pts.)

A sphere of uniform volume charge density of radius *a* is centered at the origin. Surrounding this sphere of uniform volume charge density is a PEC shell of inner radius *b* and outer radius *c*. The total charge on the entire system (volume charge and metal shell) is *QT*.

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

b) Find the surface change densities  and  on the surfaces *r* = *b* and *r* = *c*.

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

d) After grounding, find the new surface change densities  and  on the surfaces *r* = *b* and *r* = *c*.

**Room for Work**

**Solution**

From Gauss’s law, we have

**Part (a)**

a) 

b) 

c)  (since we are inside the PEC)

d) 

**Part (b)**

The total charge on the *r* = *b* surface is equal and opposite to the total charge on the sphere of volume charge density. Hence, we have

.

Because the total charges on the sphere and the inner surface of the PEC shell cancel, the total charge on the system is also equal to the charge on the outer surface of the PEC shell. Hence, we have



**Part (c)**

The electric field only changes outside the shell, and it is now zero.

 Therefore, we have

a) 

b) 

c)  (since we are inside the PEC)

d) 

**Part (d)**

The surface charge density *ρsb* has not changed. Hence,

.

Grounding removes all of the charge from the outside of the shell, so that

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