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

#### ECE 3318

#### Applied Electricity and Magnetism

**Exam 1**

#### March 22, 2016

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

Problem 1 (15 pts.)

**Give short answers to the questions below.**

1) Give two reasons why a grounded system is better than an ungrounded one.

For safety and to reduce noise.

2) What is the purpose of a GFCI interrupt circuit?

To break the circuit in case of a ground fault, meaning that there is current flowing down to ground.

3) Is it safe to operate a double-insulated device without grounding it? Why or why not?

Yes, a double-insulated device does not need to be grounded. It does not have an exterior metal casing.

4) Name two things that grounding a metal object will do for us, in term of charge and electric field.

It will remove the charge from the object, and it will remove the static electric field coming from the object.

5) Is the ground prong on a wall outlet always at the same voltage as the neutral prong? Why or why not?

Not necessarily. It will be at a slightly different voltage when there is current flowing through the circuit.

Problem 2 (25 pts.)

A cylindrical column of electrons that are moving in the positive *z* direction forms an electron beam in free space. Assume that each electron is 1.0 [μm] from a neighboring electron, and that the electrons are arranged on a cubical lattice. The electrons are so small and so close together that they approximately form a uniform volume charge density *ρv*0.

The electron beam has a radius of *a* = 1 [mm]. The electrons are moving at a speed of 107 [m/s].

a) Calculate the volume charge density *ρv*0 inside the electron beam.

b) Calculate the current density vector *J* inside the electron beam.

c) Calculate the current in Amps that flows in the *z* direction through a circle that is inside the beam, defined by *ρ* = 0.5 [mm].

d) Calculate the electric field vector *E* inside the electron beam. Leave your answer in terms of *ρv*0.



Electron beam

**Room for Work**

Part (a)





Part (b)





Part (c)





Part (d)

From Gauss’s law:



We then have



Problem 3 (25 pts.)

A hollow spherical conducting shell of radius *a* has a total charge of *Q* [C] on it.

a) Find the voltage drop *VAB*, where *A* is a point that is at a distance of 2*a* from the center of the shell, and *B* is a point that is at a distance of 3*a* from the center of the shell.

b) Find *VAB* if the same shell is now above the earth, and the shell is grounded.



Conducting shell



**Room for Work**

Part (a)

From Gauss’s law, the electric field outside the spherical conducting shell is

.

We then have

.

So, we have

.

Part (b)

After the shell is grounded, there will be no electric field, and hence no voltage drop. Therefore,

.

Problem 4 (35 pts.)

A hemisphere of uniform surface charge *ρs*0 [C/m2] having a radius *a* is centered at the origin as shown below.

Find the electric field vector at a point on the *z* axis at *z* = *h*, where *h* > *a*.

HINTS:

You might wish to consider which direction the electric field vector is in at the observation point before you do any calculations, to save yourself some time.

Also, you might find the substation *u* = cos*θ* helpful in evaluating an integral that might arise.



Hemisphere



**Room for Work**

.

We have



This distance is then



The electric field at the observation point is in the *z* direction, so we only need to worry about this component. We have for *Ez*

.

Since the integrand has no *φ*′ dependence, we can write



or

.

Using

,

we have

.

Simplifying the denominator, we have

.

Next, let

.

Then the integral becomes

.

This may be written as



We then have



Simplifying, we have

