##### DO NOT BEGIN THIS EXAM UNTIL TOLD TO START

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

#### ECE 2317

#### Applied Electricity and Magnetism

**Exam 1**

#### Oct. 23, 2013

1. This exam is closed-book and closed-notes notes. A formula sheet is provided. 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

FORMULA SHEET















































**TABLE OF INTEGRALS**

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TABLE OF COORDINATE SYSTEM FORMULAS

 

 

 

 

 



























Problem 1 (30 pts.)

A cloud of electrons exists everywhere in space, and has an electron density (number of electrons per cubic meter) *Nv* given in cylindrical coordinates by

.

Each electron has a charge of -1.602 ×10-19 [C]. The electrons are moving in the *z* direction with a velocity of *v*0 [m/s].

Calculate the total current that flows upward through a circle of radius *a* that lies in the *z* = 0 plane, centered at the origin.

*z*

*y*

*x*

*a*

ROOM FOR WORK

Solution

The volume charge density is

.

The current density is

.

The current through the circular disk is then



Hence, we have

.

Problem 2 (30 pts.)

A semi-circular annular disk of uniform surface charge density *ρs*0 lies in the *z* = 0 plane, centered at the origin, as shown below. The inner radius of the disk is *a* and the outer radius is *b*.

Find the electric field vector at the origin.

*a*

*x*

*y*

*b*

*ρs*0

ROOM FOR WORK

Solution

The electric field is given by



We next have



From this we then have



and

.

Therefore, we have



Hence,

.

Problem 3 (40 pts.)

An infinite cylindrical tube of uniform surface charge density *ρs*0 [C/m2] of radius *a* is surrounded by a perfectly conducting metal shield (PEC) that has an inner radius of *b* and an outer radius of *c*. The structure is infinite in the *z* direction.

a) Assuming that the metal shield is neutral (no net charge), find the electric field vector in all four regions: *ρ*  < *a*, *a* < *ρ*  < *b*, *b* < *ρ*  < *c*, and *ρ*  > *c*.

b) Assuming that the metal shield is neutral (no net charge), find the surface charge densities *ρsb*and *ρsc* on the inner and outer surfaces of the PEC shield.

c) Find the surface charge density *ρsc* on the outer surface of the shield assuming that the metal shield is now grounded.

d) For the grounded case in part (c), find the voltage drop *VAB*, where *A* is at the origin and *B* is at infinity.

PEC

*b*

*c*

*ρs*0

*a*

*x*

*y*

ROOM FOR WORK

Solution

We can use Gauss’s law for this problem, where the Gaussian surface is a cylinder of radius *ρ* and height *h*. We have



This gives us

.

Inside the PEC we do not need Gauss’s law to find the electric field: it is zero.

**Part (a)**



Hence we have:



**Part (b)**

Applying Gauss’s law to a Gaussian surface that is inside the PEC, we conclude that the total charge on the inner surface is the negative of the charge on the tube. Hence we have

,

so that

.

Since the PEC is neutral, the total charge on the outer surface is the negative of the total charge on the inner surface. Hence we have

,

so that



or

.

**Part (c)**

After grounding, the charge on the outer surface of the PEC shield is drained away and lost at infinity. Hence we have

.

**Part (d)**

The voltage drop is given by

.

After grounding, there is no electric field outside the shield. There is also no electric field inside the shield, or inside the charge tube. Hence, we have

.

This gives us

.

The answer is then

.

ROOM FOR WORK