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

# Name: SOLUTIONS

#### ECE 2317

#### Applied Electricity and Magnetism

**Exam 1**

#### Oct. 27, 2014

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 (30 pts.)

A circular annulus of uniform surface charge density *ρs*0 is shown below. An observer is on the *x* axis at a point *x* = *x*0, where 0 < *x*0 < *a*. Find the electric field vector at the observation point.

You do not need to evaluate any integrals that appear in your result, but your result should clearly indicate what direction the electric field vector is in.

*x*

*y*

*h*

*x*0

*a*

*b*

*ρs*0

**Room for Work**

From Coulomb’s law we have

.

We have



Hence,



or



so



or, putting the integrand in cylindrical coordinates,



Problem 2 (35 pts.)

An infinite slab of uniform volume charge density *ρv*0 exists in the region -*h*/2 < *y* < *h*/2. At the top of the slab (*y* = *h*/2) and at the bottom of the slab (*y* = - *h*/2) there is an infinite sheet of uniform surface charge density *ρs*0. The surface charge density *ρs*0 is chosen so that the entire system is electrically neutral (no net charge).

a) Find the value of *ρs*0 in terms of*ρv*0.

b) Find the electric field vector outside the slab, in the region *y* > *h*/2.

c) Find the electric field vector inside the slab, in the region -*h*/2 < *y* < *h*/2.

d) Apply the differential form of Gauss’s law to the electric field inside the slab, to find the charge density inside the slab. (If you do this correctly, your result should be the same as the known charge density that you started with inside the slab.)

*ρs*0

*ρs*0

*ρv*0

*x*

*h*

*y*

**Room for Work**

a) Find the value of *ρs*0 in terms of*ρv*0.



so

.

b) Find the electric field vector outside the slab, in the region *y* > *h*/2.

Because the system is neutral, the electric field outside the slab is zero.

c) Find the electric field vector inside the slab, in the region -*h*/2 < *y* < *h*/2.

Pick a Gaussian surface that has a top just above the top of the structure, and a bottom surface that is at the observation point at *y*.



so



or



or

.

Hence,

.

Alternatively, pick a Gaussian surface that has a top surface at *y* and a bottom surface at *y* = 0. We then have

.

This gives

.

Using the answer to part (a), the two answers are seen to be equivalent.

d) Apply the differential form of Gauss’s law to the electric field inside the slab, to find the charge density inside the slab. (If you do this correctly, your result should be the same as the known charge density that you started with inside the slab.)



so



so



Hence,



Therefore, we have

.

Problem 3 (35 pts.)

A coaxial cable has an inner PEC wire with a radius of *a* and an outer PEC shield with an inner radius of *b* and an outer radius of *c*, as shown in the cross-sectional view below. Assume that there is only air between the two conductors and outside the coax.

Assume that the voltage drop between the inner wire and the outer shield is *V*0 [V], with the inner wire being at the higher voltage. Also assume that the coaxial cable is electrically neutral.

a) Find the effective line charge density *ρl eff* on the wire (putting your answer in terms of *V*0).

b) Find the electric field vector in the following regions (putting your answers in terms of the effective line charge density on the wire):

a) *ρ* < *a*

b)  *a* < *ρ* < *b*

c) *b* < *ρ* < *c*

d) *ρ*  > *c*

c) Find the surface charge density *ρsb* on the inner surface of the shield at *ρ* = *b* and the surface charge density *ρsc* on the outer surface of the shield at *ρ* = *c* (putting your answer in terms of the effective line charge density on the wire).

d) How do the answers to part (c) change if the shield is then grounded?

*q*

PEC

*b*

*a*

*c*

PEC

**Room for Work**

a) Find the effective line charge density *ρl eff* on the wire (putting your answer in terms of *V*0).



so



or



so

.

b) Find the electric field vector in the following regions (putting your answers in terms of the effective line charge density on the wire):

a) *ρ* < *a*

b)  *a* < *ρ* < *b*

c) *b* < *ρ* < *c*

d) *ρ*  > *c*

a) 

b) 

c) 

d) 

c) Find the surface charge density *ρsb* on the inner surface of the shield at *ρ* = *b* and the surface charge density *ρsc* on the outer surface of the shield at *ρ* = *c* (putting your answer in terms of the effective line charge density on the wire).

The total charge (per unit length) on the inner surface of the shield must cancel that on the wire, and the total charge (per unit length) on the outer surface of the shield must cancel that on the inner surface of the shield.

Hence, we have





d) How do the answers to part (c) change if the shield is then grounded?

The electric field would remain the same on the inner surface, and it would vanish on the outer surface (it would get sucked off of the outer surface of the coax and go down to ground).