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

#### ECE 2317

#### Applied Electricity and Magnetism

**Exam 2**

#### April 30, 2015

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 power line has a radius of *a*. The center of the power line is at a height of *h* above the ground, at *x* = 0 and *y* = *h*. (The power line runs parallel to the *z* direction, and is infinite in this direction.) The surface of the earth at *y* = 0 may be considered to be a perfect electric conductor.

a) Give an expression for the potential Φ(*x*,*y*) for an observation point in the air region, assuming that the earth is at a potential of zero volts. Express your answer in terms of the effective line charge density *ρ*l0 for the power line.

b) Using your answer from part (a), find the electric field vector at an point on the surface of the earth that is located at *y* = 0 and arbitrary *x*. Express your answer in terms of the line charge density *ρ*l0 for the power line. Your answer should clearly indicate what direction the electric field vector is in.

*h*

Earth

*x*

*y*

**Room for Work**

The potential is

 .

The electric field is

.

There is only a *y* component, so

.

This gives









.

Problem 2 (30 pts.)

A surface charge density *ρs*= cos*φ* lies in the *z* = 0 plane (where *φ* is the usual angle in cylindrical coordinates). The surface charge density occupies half of the interior of a circle of radius *a*. The half of the circle that has *x* > 0 is the region where the charge is.

a) Find the potential function Φ along the *z* axis at (0,0,*z*), assuming zero volts at infinity, using the potential integral formula.

b) Find the potential function Φ along the *z* axis at (0,0,*z*) if the potential is zero at the origin.











**Room for Work**

When we have zero volts at infinity, we have













We then have

.

When we have zero volts at the origin, the answer changes to



Problem 3 (40 pts.)

A spherical metal conductor of radius *a* is surrounded by a dielectric shell of inner radius *a* and outer radius *b*. The relative permittivity of the dielectric is *εr*. The dielectric has a critical breakdown strength of *Ecd* while the air has a critical breakdown strength of *Eca*, with *Ecd* > *Eca*.

a) Find the maximum charge *Q*1 that can be put on the spherical conductor before the dielectric will break down.

b) Find the maximum charge *Q*2 that can be put on the spherical conductor before the air will break down.

c) Derive the capacitance of the metal sphere surrounded by the dielectric shell, assuming the outer conductor is at infinity.

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**Room for Work**



so

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so

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For the capacitance, assume a charge *Q* on the sphere.

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We then have

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