# Midterm Examination, ECED 3300

**Instructor:** Sergey A. Ponomarenko.

**Place, Date and Time:** Sexton Campus; Wed, October 30 2013, 9:30-11:30 am.

**Closed Books:** Formula sheets are provided; no calculators are allowed.

**Hint:** Make sure to justify all your answers to get full credit.

## Problem 1 (10pts)

Determine the volume charge density generating the following electric flux density field

$$\mathbf{D}(\rho, \phi, z) = e^{-|z|} \sin\phi \, \mathbf{a}_\rho + e^{-|z|} \cos\phi \, \mathbf{a}_\phi + e^{-\rho^2 - z^2} \mathbf{a}_z, \quad \text{C/m}^2.$$

## Problem 2 (30pts)

A point charge $Q$ is located at the point $A(0, 0, h)$ **above** an infinite, grounded conducting plane $z = 0$. Answer the following questions:

(a) **Justify** your choice of the magnitude(s), sign(s), and locations(s) of all image charge(s);

(b) Find the magnitude and direction of the force experienced by the charge $Q$.

(c) Determine the electrostatic energy of the system;

(d) Find the work done to move a probe charge $q$ from far away to the point $B(a, a, b)$, where $b > h$.

## Problem 3 (40pts)

The upper half-space $z > 0$ is a dielectric medium with the permittivity $\epsilon$. There is a volume charge density in the dielectric, distributed as

$$\rho_v(z) = \rho_0 e^{-z/a},$$

where $\rho_0$ and $a$ are known constants. The lower half-space $z < 0$ is an ideal conductor.

(a) Determine the electrostatic potential in the dielectric.

(b) Determine the electric field everywhere.

(c) Find the **surface** charge density induced on the conductor.

## Problem 4 (20pts)

A spherical capacitor consists of two concentric spheres of radii $a$ and $b$, ($b > a$). The space in between the spheres is filled with a dielectric with the permittivity

$$\epsilon(r) = \begin{cases} \epsilon_1, & a \le r \le c; \\ \epsilon_2, & c \le r \le b. \end{cases}$$

Determine the capacitance of the capacitor.