# Midterm Examination, ECED 3300

**Instructor:** Sergey A. Ponomarenko.

**Place, Date & Time:** Sexton Gym; October 15, 2019; 11:35 am to 1:35 pm

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

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

## Problem 1 (20pts)

Given the electrostatic potential (in Volts)

$$V(\mathbf{r}) = \rho \cos\phi,$$

in a region of **free space** defined by the boundaries $0 \leq \phi \leq \pi$, $0 \leq \rho \leq 2$, and $0 \leq z \leq 1$, answer the following questions.

a) What is the **volume** charge density in the region?

b) Determine the electrostatic energy stored in the region.

*Hint: Hereafter you may leave your answers in terms of* $\epsilon_0$.

## Problem 2 (30pts)

A solid sphere of radius $R$ and dielectric constant $\epsilon_r$ has a uniform **volume** charge density $\rho_0$. Determine the electrostatic potential at the **center** of the sphere.

*Hint: It is convenient to take an infinitely remote point as a reference point to determine the potential relative to.*

## Problem 3 (20pts)

The potential in the upper half-space $z > 0$ is given by the expression

$$V(z) = V_0 e^{-z/a},$$

where $V_0$ and $a$ are known constants. The upper half-space, $z > 0$, is filled with a dielectric of permittivity $\epsilon$. The lower half-space, $z < 0$, is a perfect conductor.

a) Determine the electric field everywhere.

b) Find the **surface** charge density on the conductor.

## Problem 4 (30pts)

Find the electrostatic potential at the **center** of an infinitely thin charged ring of radius $b$. The line charge on the ring is distributed as

$$\rho_l = \rho_0 \cos^2\phi,$$

where $\rho_0$ is a constant. The ring is located in free space.