Symmetries and Idealizations Homework 4
Due Friday 10/9

Problem 4.1 Surface of a cone (practice) Using integration, find the surface area of a cone.

Problem 4.2 Potential of a cylinder (practice) Consider a finite (hollow) cylinder of charge with uniform surface charge density σ on its sides (but not its ends).

a) Find the electric potential on the axis of symmetry, far from the cylinder. Please keep the first two non-zero terms.

b) Does your answer make sense? Why?

c) What ratio of height to width would make this cylinder look most like a point charge, when measured along its axis of symmetry?

Problem 4.3 Cosmic Asimov You are part of the team building *Cosmic AC*, Asimov's ultimate, universe-sized computer. Your job is to fabricate a charged disk, 10 meters in radius and 1 cm thick. The charge density on the disk should be:

$$\rho = \alpha e^{-\beta r^2} \cos(\gamma z)$$

a) What is the total charge on the disk, in terms of the parameters α, β, and γ?

b) What are the dimensions of α, β, and γ?

c) Design specifications indicate that: the maximum charge density should be 27 $\frac{\mathrm{C}}{\mathrm{cm}^3}$, only one-half period of the $\cos(\gamma z)$ term spans the whole height of the disk, the upper and lower circular surfaces are to have zero charge density, and the maximum values of the charge density on the circumference of the disk should be 10 percent of the maximum in the center. Find values for α, β, and γ.

d) What is the total charge on the disk?

e) Estimate how much error your would make in your calculation of the total charge if you assumed that the disk was infinitely wide.

f) What is the surface charge density of the disk?

Problem 4.4 Finite disk

a) Starting with the integral expression for the electrostatic potential due to a ring of charge, find the value of the potential everywhere along the axis of symmetry.

b) Find the electrostatic potential everywhere along the axis of symmetry due to a finite disk of charge with uniform (surface) charge density σ. Start with your answer to part (a)

c) Find two nonzero terms in a series expansion of your answer to part (b) for the value of the potential very far away from the disk.

Problem 4.5 Potential of a cone [1] A conical surface (an empty ice-cream cone) carries a uniform charge density σ. The height of the cone is a, as is the radius of the top. Find the potential at the point in the center of the opening of the cone), letting the potential at infinity be zero.

[1] based on GEM 2.27